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Board of Scientific Advice for India

for the year 1907-08

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ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR

1907-08.

SUMMARY OF PROCEEDINGS.

Twelfth Meeting held at Calcutta on the 14th February 1908.

CORRESPONDENCE between the Secretary of State for India and the Government of India with reference to the postponement of a general revision of the Dictionary of Economic Products, and between the Director of the Geological Survey and Mr. D. W. Freshfield on the progress of the Survey of Himalayan Glaciers was read and recorded.

The Board considered the Report of Sub-Committee B, on the preparation of a Manual of Indian Cultivated Plants, wherein the scope of such a manual and the agency by which it should be compiled were discussed, and resolved to adopt the Report and forward it to the Government of India.

The Report of the same Sub-Committee in which were discussed at considerable length proposals for the reorganisation of the Botanical Survey of India, and the Report of a special Sub-Committee on the future organisation of the Department of Economic Products, were considered by the Board, which resolved to adopt both reports and forward them with strong recommendations to the Government of India.

The Board had under consideration the remarks of the Advisory Committee of the Royal Society on the Report of the Board for 1905-06

and its Programme for 1907-08. The subjects discussed included the submission of the Board's Programmes for the consideration of the Advisory Committee; the preparation of a Hand list of the species of the Flora of India; agricultural subjects generally and in particular Economic and Industrial Chemistry and the limits of the Imperial Mycologist's research work; proposals for an increase of staff of the Zoological section of the Indian Museum, and the relation of the Museum to other departments engaged in Zoological research; anthropological work in India; the collecting of properly named wood specimens by the Forest Department; the work of the Civil Veterinary Department; the organisation of the work and staff of the Geological Survey, and proposals for a special report on the progress of that Survey.

The conclusions arrived at by the Board in these several matters were that as regards the preparation of a Hand list of the Flora of India, although its importance was recognised, lack of staff and presence of more immediately necessary work precluded its preparation forthwith; that as regards Agricultural subjects generally, Economic and Industrial Chemistry and the work of the Imperial Mycologist in particular, expression of opinion should await the results of the discussion of those subjects by the Board of Agriculture for India; that as regards Zoological subjects, reference should be made as far as possible to the Zoological Section of the Indian Museum by other departments; that as regards the increase of staff the Board understood that proposals had already been forwarded by the Government of India to the Secretary of State; that as regards anthropological work, it did not come within the province of the Board as at present constituted; that as regards the collection of wood specimens the attention of the Inspector-General of Forests should be drawn to the subject; that as regards Veterinary subjects both the remarks of the Advisory Committee of the Royal Society and the note of the Inspector-General of the Civil Veterinary Department on previous remarks should be referred to Sub-Committee E for report at the next meeting of the Board.

With regard to the Geological Survey the Board were of opinion that no undue proportion of time or of officers was taken up in answering economic enquiries as such enquiries were dealt with only by officers at headquarters. The Board agreed with the Director of the Geological Survey in thinking that a further immediate expansion of the Department was inadvisable and that there was no officer available for the

increase of work that the preparation of a special report on the progress of the survey would necessitate.

After consideration of a letter from the Superintendent of the Natural History Section of the Indian Museum the Board resolved that it should be stated in the Annual Report of the Board that the teaching of Medical Zoology being without the province of the Board was not considered in its Annual Report.

The other items discussed were formal.

Thirteenth Meeting held at Simla on the 11th May 1908.

An endorsement from the Government of India forwarding a letter from the Director of the Botanical Survey on the preparation of a Manual of Indian Cultivated Plants and a Hand list of the Indian Flora and another endorsement forwarding correspondence from the Royal Society of London on various meteorological subjects were read and recorded.

The Report of Sub-Committee E on the work of the Civil Veterinary Department with reference to the remarks of the Royal Society's Advisory Committee was considered. The Board resolved to endorse the report of Sub-Committee E and to forward it to Government with an expression of opinion that the staff of the Civil Veterinary Department was being utilised to its full extent and was working on right lines. A letter on the same subject from the Inspector-General of the Civil Veterinary Department forwarded by Government was referred to the same Sub-Committee for report at the next meeting of the Board.

The Programmes for 1908-09 of the various Scientific Departments except that of the Geological Survey were discussed. The Board resolved that in view of the overlapping of certain subjects the combined programmes of the Director of the Imperial Institute and the Reporter on Economic Products and the programme of the Forest Department should be revised under the guidance of Sub-Committee D; also that it was unnecessary to include in the programme of the Imperial Institute the investigation into Indian Turpentine and oil-seeds and into the rubbers of *Ficus elastica* and *Ceara* so far as it referred to work for India, as the Forest Department was also conducting researches into Turpentine and oil-seeds and was endeavouring to dispose of its rubber plantations.

A letter from the Director-General of Observatories forwarded under Government endorsement embodying a report on the recommendations

of the Advisory Committee of the Royal Society on certain items in the programme of meteorological research in India was read. The Board resolved to accept the modifications in the programme of the Meteorological Department proposed in the above letter.

Correspondence between the Government of India and the Director of the Geological Survey forwarded under Government endorsement concerning the suggestions of the Royal Society's Advisory Committee as to the expansion of the Geological Survey Department and other subjects connected therewith was read and recorded. The correspondence was practically to the same effect as the resolution of the Board on the same subjects passed at the former meeting of the Board and referred to in the preceding summary.

A letter from Dr. M. W. Travers on the proposed removal of the Civil Engineering College from Sibpur to Ranchi was read and recorded.

Fourteenth Meeting held at Calcutta on the 22nd December 1908.

The Board considered a letter from the Government of India in which the opinion of the Board was requested as to the possibility of arranging future programmes so as to distinguish between continuance of investigations already in progress and entirely new lines of work. The Board agreed that as far as possible this should be done, but were of opinion that it could not necessarily undertake to give an account in the programme of the stage at which any particular investigation had arrived as this would involve practically the preparation of a subsidiary report.

Correspondence with the Royal Society on meteorological subject was read and recorded.

A despatch from the Government of India to the Secretary of State forwarded under Government endorsement reporting on the action taken on the previous recommendations of the Royal Society's Advisory Committee on various subjects was read and recorded.

Correspondence regarding the collection of properly identified wood specimens in which was embodied a circular issued by the Inspector-General of Forests on the subject, and correspondence regarding the addition of sections to the Annual Report of the Board were read and recorded.

The Draft Annual Report of the Board for 1907-08 was then discussed and the Board resolved to adopt the report with modifications

in some of the sections. The report on work done at the Imperial Institute arrived in India too late for consideration by the Board assembled and it was resolved to circulate copies to members of the Board for consideration.

The report of Sub-Committee D on the overlapping of programmes of the Forest Department and of the Reporter on Economic Products and the report of Sub-Committee E on the work of the Civil Veterinary Department were read and accepted by the Board.

Copy of a Despatch from the Government of India to the Secretary of State forwarded under Government endorsement reporting on the action taken on the recommendation of the Advisory Committee by the Royal Society relating to Veterinary subjects was read and recorded.

ANNUAL REPORT FOR 1907-08.

INDUSTRIAL AND AGRICULTURAL CHEMISTRY.

BY

J. W. LEATHER, PH.D., F.I.C., F.C.S.,
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AND

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Oils and Oil-Seeds.—In the Indian Museum some attention has been given to the investigation of the lesser known oil-seeds of India and the properties of the fixed oils extracted from them. Many oils are used in the country but not exported, and their examination has been considered necessary to complete a chemical survey and indicate the uses to which they may be put. The first group examined was the Terminalias or Myrobalans.

Terminalia Catappa.—Country Almond. The kernels of the seeds yielded 48·3 per cent. of a non-drying oil. Specific gravity at 15°C, 0·9206 ; acid value, 7·77 ; saponification value, 205·04 ; iodine value, 81·8 ; fatty acids, per cent., 95·2 ; titer test, 42.

Terminalia Belerica.—Nuts from the Central Provinces are stated to yield 25 per cent. of Baheda oil, which is odourless and tasteless, clear, and yellow in colour. Two samples had the following characters : specific gravity, 0·9168 and 0·9193 ; acid value, 2·48 and 3·97 ; saponification value, 205·8 and 205·3 ; iodine value, 79·04 and 85·38 ; Reichert-Meissl value, 0·76 and 0·78 ; fatty acids per cent., 94·2 and 93·6 ; titer test, 39° and 38°.

Terminalia Chebula.—Chebulic myrobalans gave only a small proportion of kernels which yielded 36·71 per cent. of yellowish, semi-drying oil. Acid value 8·91 ; saponification value, 192·66 ; iodine value, 87·5 ; fatty acid, 96·2 per cent.

Cucurbitaceous seeds. Cucurbita Pepo.—The seeds of the pumpkin or vegetable marrow, yield to solvents about 25 per cent. of fixed oil. Two samples had the following characters: specific gravity, 0·926 and 0·928 ; acid value, 12·78 and 10·86 ; saponification value, 195·7 and 196·2 ; iodine value, 126·0 and 129·6 ; Reichert-Meissl value, 0·43 and 0·52 ; fatty acids, 94·9 and 94·7 per cent. ; titer test, 31° and 32°.

Cucurbita maxima or squash gourd seeds yield oil with the following characters: specific gravity, 0·919 to 0·926; acid value, 6·38 to 17·65; saponification value, 194·9 to 197·1; iodine value, 88·7 to 133·4; Reichert-Meissl value, 0·47 to 0·67; fatty acids per cent., 94·3 to 95·8; titer test, 32° to 38°.

Cucumis sativa or cucumber seeds gave a pale yellow slowly drying oil. Two specimens had the following characters: specific gravity, 0·924 and 0·923; acid value, 11·49 and 10·68; saponification value, 195·6 and 196·9; iodine value, 117·6 and 118·5; Reichert-Meissl value, 0·52 and 0·52; fatty acids, 94·2 and 94·6; titer test, 35·5°.

Luffa ægyptiaca seeds gave a dark greenish oil with a high acid value, slowly drying. Specific gravity, 0·921 to 0·926; acid value, 33·0 to 36·4; saponification value, 193·0 to 195·8; Reichert-Meissl value, 0·49 to 0·52; fatty acids, 93·5 to 94·2; titer test, 34° to 35°.

Citrullus Colocynthis.—Colocynth seeds from Baluchistan gave 17·8 per cent. of drying oil: acid value, 5·94; saponification value, 202·9; iodine value, 129·3; fatty acids 92·2; titer value, 29°C.

Mesua ferrea.—The iron wood tree, Nagkesur or Nahor of Assam bears seeds yielding 41·6 per cent. of fixed oil, the kernels alone giving 72·9 per cent. It is deep yellow or brown, bitter to the taste, and deposits a white crystalline fat at ordinary temperatures. Specific gravity, 0·9166 to 0·9359; m. pt., 16·5° to 26·7°; acid value, 38·4 to 115·0; saponification value, 203·7 to 205·8; iodine value, 87·0 to 89·1; Reichert-Meissl value, 7·7 to 11·5; fatty acids, 92·2 to 94·1 per cent.; titer test, 33·5 to 35·5. The solid fatty acids consist mainly of stearic acid.

Sterculia fœtida.—Java almonds yield 34 per cent. of bland, light yellow, non-drying oil; specific gravity, 0·919 at 30·5°; acid value, 6·5; saponification value, 199·3; iodine value, 83·0; fatty acids, 95·6 per cent.; titer value, 31·5.

Chrozophora verbascifolia, or Tannoom seeds, yield about 35 per cent. of an oil said to be used by the Bedouins of Arabia instead of ghee. The oil is thick, yellowish and drying. Acid value, 3·3; saponification value, 200·2; iodine value, 137·0; titer value, 30·5°.

Lawsonia alba.—The Mehndi or Henna plant. The seeds afford a very small quantity of fixed oil—10·5 per cent.—to volatile solvents. This is of a green colour and possesses drying properties.

Himalayan Black Bear (*Ursus torquatus*).—The fat of this animal is supposed to have curative properties and is sold in Northern India. It consists of olein, palmitin and stearin in nearly the same proportions as pig's lard.

Tamarindus indica.—The seeds deprived of their brown covering afford a nutritious and palatable food. They are not oil-seeds. The Agricultural Ledger No. 2 of 1907 furnishes full information on the uses of these seeds in times of scarcity, and gives the composition of the seeds and kernel.

Dyes—Indigo.—The correct determination of indigotin in commercial indigos, and of indican in the fresh leaf of the plant, has been the subject of two more communications from Messrs. Bergtheil and Briggs and from Messrs. Gaunt, Thomas and Bloxam, respectively (*Journal of the Society of Chemical Industry*, Vol. XXVI, 1907, pp. 1172-1185), but these are chiefly concerned with notice of improved details of their processes or with criticisms. The "isatin" method of determining indican in the leaf is said by Mr. Bloxam and his colleagues to yield considerably higher results than the "persulphate" method recommended by Mr. Bergtheil, and the former therefore conclude that the potentiality of the dye yield of the plant is greater than has been supposed. Mr. Bergtheil on the other hand found in his laboratory that the persulphate method yields, if anything, the higher value. Mr. Bloxam and his colleagues quote certain determinations of the proportion of leaf on the plant, which indicate *circa* 62 per cent., whereas Mr. Bergtheil, as the result of other determinations, considers 40 per cent. to be the average figure.

Datisca cannabina.—Korezynski and Marchlewski have continued their investigations of the dye stuffs from the roots of this plant. The glucoside from which datiscetin is derived has the composition $C_{21}H_{22}O_{12}$. On hydrolysis it yields 56 per cent. of datiscetin and 33 per cent. of dextrose. A new compound, tetraben-zenesulphoyl-datiscetin, has been separated in white crystals, melting at 188°C.

Morinda citrifolia.—The wood and root-bark of this well known Indian dye stuff have been re-examined by Drs. Oesterle and Tisza of Berne. From the root-bark the following substances were separated and analysed. (1) Morindin, $C_{27}H_{30}O_{15}$ melting at 210°; (2) Trioxy methylanthrachinon monomethyl ether, $C_{16}H_2O_5$, melting at 172°; (3) Morindadiol $C_{15}H_{10}O_4$, melting at 244°; (4) Soranjidiol, $C_{15}H_{10}O_4$ melting at 276°; and a wax $C_{18}H_{28}O$ melting at 124·5°.

Nyctanthes arbor-tristis.—E. G. Hill and A. P. Sirkar, of Allahabad, have separated a red crystalline colouring matter and mannitol from the flowers of this tree. The colouring matter was found to have the formula $C_{20}H_{27}O_4$, and appeared to be acid in character,

and to contain one hydroxyl group and one or more methyl groups. The name nyctanthin is suggested for it.

Drugs.—Garcinia pedunculata.—The sliced and dried fruits are used as a mordant in dying, as an adjunct in food, as a refrigerant drink or sherbet. The drug is called "Heibung" in Manipur and "Metlin" in Burma, and belongs to a class of acid vegetables used in the East to which the name "Amsul" is applied. Three samples in the Indian Museum contained respectively 13·29, 18·04 and 19·7 per cent. of malic acid. The dried fruits retain their acid property for several years without deteriorating.

Amphicome Emodi.—The root and stem of this plant are known in Jammu and Kashmir as "Kaur" or bitter, and are prescribed for fever. The drug was found to contain an alkaloid, an acid fat, a wax, yellow colouring matter and sugar. The alkaloid is intensely bitter and is probably the active medicinal agent of the plant.

Alcoholic Liquors and other Exciseable Articles.—The reports from the Central Excise Laboratory for India, Kasauli, under the control of Major C. H. Bedford, I.M.S., deal as usual with the solution of many problems connected with the manufacture of and trade in alcoholic liquors and other articles subject to Excise and Customs duties. The special enquiries for the Government of India included a complete revision of Sikes's Tables which are used by the Excise and Customs for estimation of spirit strengths. At the high temperatures usually prevailing in India and with the low strength spirits issued, the under-estimation of alcoholic strength by the use of the old tables was considerable. New tables for the accurate reduction and blending of spirits were also published and will allow of most efficient and rapid work being effected in these processes.

The amount of obscuration of the alcoholic strength arising from various causes was investigated. The obscuration due to casking spirits for various periods, to the practice of compounding spirits with colouring and flavouring agents, and to the addition of caramel and sugar solutions, formed the subject of numerous experiments upon which reports were furnished to Government. Other enquiries embraced the subject of standards for Beers in India, allowances for spirit wastages during transit in India, the alcoholic strength of toddy (tari) at different stages after being drawn from the palm-trees, new methods for denaturation of spirit in India, and the average spirit-yielding capacity of mahua, gur and other fermentative bases.

'Enquiries for Local Governments include such matters as the standardisation of excise hydrometers, thermometers and saccharometers; analyses of factitious and of imported and Indian distillery spirits; of samples of Indian hemp, opium and cocaine; reports on disposal of Distillery-effluents, and on certain cases in which explosions in distilleries have occurred; estimation of the amount of copper-salts in spirits; the fermentative activity of Chinese yeasts in Burma; causes of defective yields during spirit manufacture, etc.

Major Bedford was on duty in Burma for six weeks during 1907 to investigate certain Excise problems, and a "Report on the Manufacture, Quality, etc., of Alcoholic Liquors in Burma" was furnished to that Government. "A technical Excise Manual" embodying the results of the special enquiries made at the Central Excise Laboratory is being prepared for publication.

Solubility of Calcium Carbonate in natural waters.—In relation to some work which is in progress at the Agricultural Research Institute, Pusa, on the concentration of certain soil constituents in the water of the soil, a correct knowledge of the relation which holds between calcium carbonate, carbonic acid and water when exposed to an atmosphere containing carbon dioxide gas was necessary. Apart from odd determinations of the amount of calcium carbonate dissolved, previous work on this subject is limited to that of Schloessing [*Comp. rend.* 74 (1872) 1552] and of Treadwell and Reuter [*Zeits. f. anorg. chem.* 17 (1898) 170]; in both cases the investigation was limited to one temperature (16°C. and 15°C, respectively) and the results obtained were in themselves divergent. The system has accordingly been subjected to a careful quantitative examination at temperatures varying from 15° to 40°C., and with partial pressures varying between ·5 and 35 per cent. CO_2. A general formula has been deduced and the data are about to be presented for publication as a Memoir.

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FOREST CHEMISTRY.

BY

PURAN SINGH, F.C.S.,

Acting Imperial Forest Chemist.

The office of the Imperial Forest Chemist was opened in July 1907 and the investigations commenced during the year from June 1907 to July 1908 are detailed below together with a summary of the progress made.

A chemical investigation of several samples of cutch was made, and the existing method of detecting adulterants in cutch by estimating its alcoholic extract has been supplemented by one more direct, namely, the estimation of a methyl alcohol extract. Although the presence of catechin, which itself is a dyeing agent, makes up to a greater or lesser extent for the deficiency of catechu tannin in poorer samples of cutch, yet in a cutch which is fairly rich in catechu tannin, the presence of much catechin is distinctly detrimental to the quality of cutch as a dyeing agent. It has therefore been recommended that as much catechin as possible should be extracted from cutch, for in this way not only is the quality of the latter improved but *katha* which consists essentially of catechin is obtained as a "bye-product."

Investigation into the causes which lower the value of cutch as a dyeing agent and the possibility of improving its quality.

The method hitherto adopted for isolating catechin from cutch has been to crystallise the former out from a solution of the latter in hot water. In this method a considerable quantity of valuable catechin is decomposed into the less valuable tannin. To avoid this loss a scientific method of isolating catechin from catechu-tannic acid has been suggested in substitution of the very crude customary method referred to above. Further as a result of a protracted chemical investigation, some new properties of the chief constituents of cutch, catechin and catechu-tannic acid have been discovered by the aid of which it has been possible to propose more accurate and speedy methods of cutch analysis, employing methyl alcohol or wood spirit instead of water to effect the separation of catechin and catechu-tannic acid from cutch, and substituting for acetic ether a mixture of ether and carbon disulphide (termed "catechin mixture" by the writer), for the accurate estimation of catechin and catechu tannin. Finally owing to the prospective distillation of wood spirit on a large scale in India, the possibility has been indicated of applying these improved methods to the refining of cutch and to the commercial manufacture of good *katha* and even chemically pure catechin.

Two logs of *Acacia catechu* growing in the Goalpara Division of Assam, near the Aie river, which were submitted to the Institute for analysis and report have been subjected to a complete chemical examination with very promising results. The general belief that *Acacia catechu* growing in moist localities contains no catechin has been shown to be without foundation, for one of the samples of the wood yielded on

The possibility of extracting on a commercial basis *Katha* or Cutch or both from Acacia Catechu growing in moist climates.

analysis about three per cent. of catechin and the other gave about five per cent. of the same. Further, though the Katha-boilers of Kumaon and Burma declared such wood to be unsuitable both for *katha* and cutch making, the chemical analysis permitted the conclusion that the wood is suitable for the manufacture both of *katha* and cutch. This conclusion (at least as regards the extraction of cutch) has been confirmed by the results of experimental manufacture of cutch from the Goalpara wood. Further, the quality of the cutches so manufactured has been experimentally investigated and the laboratory results have been substantiated by actual trials of these, that is by performing dyeing experiments with them on a large scale.

The native system of rejecting certain wood of *Acacia catechu* as useless for *katha* and cutch-making has been shown to be unsatisfactory and a simple scientific process by which a preliminary assay of the wood can be easily effected has been proposed to ascertain whether or not a tree is suitable for *katha* manufacture.

An interesting point has been brought out in connection with this investigation, namely, that catechin as occurring in the *Acacia catechu* growing in moist localities is amorphous, while in trees from other localities it exists as crystals. The crystalline variety of catechin is decomposed in contact with boiling water, while the other variety rather assumes its crystalline form by contact with water.

As a result of this investigation, the Assam khair forests appear well adapted for the manufacture of *katha* and cutch, and suggestions have been made for improving the quality of these products from these forests.

The possibility of refining seedlac into shellac with greater economy and ease than is possible in the existing method, *viz.*, trituration of seedlac with water.

Before raw seedlac is manufactured into shellac, it has to be refined at present by triturating or washing it with water. This process of trituration, it is well known, is extremely tedious and wasteful, and besides, involves a large amount of labour. Again during the process of melting the washed lac to turn it into shellac there is a further loss in the quantity of this important resin in the form of *gand*. A more economic and convenient method has been proposed of refining all forms of raw seedlac by means of wood spirit, and an apparatus (a modification of the extracting apparatus of Dr. Wilhelm Nag Ngai of Tokyo) has been designed, by means of which the whole of the pure lac resin can be easily extracted from raw lac. The results

obtained in the Laboratory by refining crude lac with wood spirit have no doubt been promising, but, in order to confirm these, further experiments require to be made with large quantities of crude lac. For this purpose a capacious model of the apparatus referred to above is to be constructed. It is not, however, claimed that the proposed method can supersede the existing method with advantage, until wood distillation is started in India on a commercial scale.

Utilization of "Coagulated" seedlac.

Two samples of lac (one called Phunki and the other Coagulated or "clogged-up"), received from the Central Provinces have been submitted to chemical examination. It has been shown that the varieties, though widely different in physical appearance, furnish nearly equal amounts of pure lac resin, and thus the popular belief that in coagulated lac most of the pure resin is decomposed and irrecoverably lost is groundless, and consequently the lac dealers' practice of rejecting it as useless for shellac-making is not justified. It has further been shown that the defects in the appearance of the coagulated lac are due to purely physical causes, and that they are remediable.

The possibility of preparing shellac of a uniform quality and character from all the different qualities of raw seedlac.

Some experiments on the extraction of pure lac resin from various forms of crude seedlac have been made on a small scale, but it has not yet been possible to determine the relative value of the different refined extracts owing to the insufficiency of material available for investigation. The subject will be taken up, when the proposed apparatus referred to above which is under construction is received.

Extraction of Ngai Camphor from *Blumea balsamifera* D. C.

Fresh green samples of *Blumea balsamifera* were analysed in Burma, and the total volatile matter (consisting chiefly of camphor and oil) in their etherial extracts was determined at Toungoo and Mawhan. A large quantity of *Blumea balsamifera* leafy branches was baled and sent to Dehra Dun from Mawhan.

The air dried samples were again analysed at Dehra Dun both by other extraction and by steam distillation. From these different laboratory experiments, the total percentage of camphor and volatile oil present in the wood was determined. During the distillation of the wood with steam, crystals of camphor were noticed in the receiver. These crystals were separated and identified as those of l-borneol (Ngai camphor). The Chinese method of extracting camphor from the weed

was also tried successfully, but the camphor thus prepared was not very pure.

All the experiments show the possibility of the *Blumea balsamifera* of Burma becoming an important commercial source of Ngai camphor. Experiments on a commercial scale, however, have yet to be made with the experimental camphor-still designed by the Forest Chemist for the purpose. The still being under construction, a final report on the subject will be made later on.

Burmese varnish (the sap of *Melanorrhœa usitata*) and its constituents.

The sap of *Melanorrhœa usitata*, which has never been chemically examined before, has been subjected to a complete chemical examination, and it has been shown that it furnishes the same constituents as the well-known Japanese lacquer, which is the sap of *Rhus vernicifera*. The commercial varnish of Burma is a slow drying varnish as compared with that of Japan. The Burmese are known to adulterate their varnish with sesamum oil. Chemical investigation has shown this practice to be detrimental to the drying capacity of the varnish. As a result of this investigation, suggestions have been made for improving the quality of the Burmese varnish and the lacquering industry in Burma.

Indian Turpentine.

An interesting series of experiments started some time back by Mr. P. H. Clutterbuck, Deputy Conservator of Forests, Naini Tal, with the object of improving the quality of turpentine distilled at present at the Bhowali Government Turpentine Distillery, has been completed during the year. Fractional distillation of various samples of Indian turpentine prepared under different conditions were made by the Imperial Forest Chemist. At present the turpentine oil distilled from *Pinus longifolia* at Bhowali contains only about 50 per cent. of low boiling terpenes. By repeated experiments in conjunction with Mr. Clutterbuck, it has been finally settled that by redistilling a certain fraction of oil and mixing it up with the other fractions, a good oil with 90 per cent. of low boiling terpenes can be obtained. A joint report on the subject by Mr. P. H. Clutterbuck and the writer is under preparation.

Podophyllum Emodi and the soils in which it grows.

An enquiry into the relative differences in amounts of resin contained in the *Podophyllum Emodi* growing in different localities in Jaunsar and Hazara has been completed, together with the analysis of the soils from which the different samples of Podophyllum analysed were collected. The Hazara samples were found to be much richer in resin

than those collected in Jaunsar. The Hazara soils contain a greater percentage of humus and organic matter than the Jaunsar soils.

List of Publications.

PURAN SINGH . . A Note on Cutch Analysis and the preparation of Pure Catechin.

PURAN SINGH . . A Note on the Utilization of Khair Forests in Eastern Bengal and Assam.

PURAN SINGH . . A Paper on the Future of Cutch and Katha Manufacture (read at the Provincial Forest Conference held at Lahore in January last).

ASTRONOMY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith and the Assistant Director Mr. J. Evershed. Mr. Michie Smith was on leave from the 1st April 1907 to the 2nd January 1908. The chief instruments are:—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and shall so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the

prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed', *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904. These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with special occulting shutters for regulating exposures in spot spectrum work.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are

sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

2. In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins of the observatory are issued. Of these thirteen have appeared, the last including the prominences observed up to the 31st December 1907.

3. A new spectroheliograph has been designed and partly constructed at the observatory for photographing the sun's disc in the hydrogen radiations. Recent work in this direction by Professor Hale has shown the importance of securing records in the hydrogen radiation H_α. It is hoped that daily photographs in H_α will be taken with the new spectroheliograph when a grating and a suitable collimating lens have been obtained.

4. Photographs of spot spectra are now made in which different exposures are given for the spot and for the adjacent photosphere so that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out clearly the characteristic features of the spot spectrum. The parabolic grating spectroscope has been remounted in a more convenient form and a number of excellent photographs obtained with it. Arrangements have also been made by which the slit of this spectroscope can be replaced by negative lens and enlarged images of sunspots obtained on a scale of about one metre to the sun's diameter.

5. A series of spot spectra taken during the year with the parabolic grating spectrograph give an excellent record of the spectrum between D and F, and the measurements are now completed of about 1,000 lines specially affected in the spot as compared with the photosphere spectrum. Measurements of the displacements of certain iron lines most affected by pressure have been made and these indicate that no difference of pressure exceeding a quarter of an atmosphere can exist between the absorbing gases of spots and those of the photosphere. The result has an important bearing on the vexed question of the level of sunspots, since in the spots photographed there is probably no difference of level between the absorbing layer in the spots and the absorbing layer of the photosphere.

6. Provisional values of the wave length of the hydrogen lines δ and ε have been determined from photographs of the spectrum of the sun's east and west limbs using the 3-inch grating spectrograph. The results which are accurate to 0.01A show conclusively the very close accordance of the values of these lines with the theoretical values derived from Balmer's formula, and differ from the measures of the lines made by Rowland in the ordinary solar spectrum. In the course of this work on the hydrogen lines an interesting fact was brought to light, namely, the higher rotational speed of the gases of the upper chromosphere as compared with the low-lying metallic vapours. This feature has since been discovered independently by Hale and Adams.

7. The 3-inch grating spectrograph has now been modified so as to photograph the east and west limbs simultaneously and under very high dispersion. A considerable number of measureable plates were secured during the fine weather and the research into the movements of the higher gases of the chromosphere is being continued.

8. Large scale photographs of selected regions of the sun's surface are now taken with the 12-inch photovisual lens using a positive enlarging lens and a special absorbing screen for limiting the light used to the region F to G, this region having a uniform focus with the 12-inch lens whilst beyond G the focus lengthens and at K is 8 mm. beyond the visual focus. Some very promising plates have recently been secured showing minute details in spot structure, etc.

9. In view of the importance of a knowledge of the variations in the solar radiation a scheme of observation has been devised which will be independent of all the methods at present in use and free from some of the uncertainties attending them. Variations in the amount of light given out by the sun will cause corresponding variations in the light of the full moon and a comparison of the latter with the light of certain stars whose light is known to be approximately constant should enable the variations in the light emitted by the sun to be determined. In view of the accuracy with which the relative densities of photographic images may be determined with a suitable photometer, changes of not less than 1 per cent. should be capable of determination in this manner. With this end in view apparatus has been prepared for obtaining out of focus images of bright stars on the same plate with similar images of the full moon. In order to reduce the moon's light to an amount comparable with that of a star and to employ the full aperture of the lens for both stars and moon, the latter is reflected at a known angle from a convex quartz

plate. In this way the intensity can be reduced any desired amount and the out-of-focus image formed from the integrated light of the whole disc of the moon becomes a circular disc of uniform density similar in all respects to that produced by the star. The relative densities can then be easily measured. The moon and stars are photographed at altitudes of not less than 60° and for each plate as nearly as possible at the same altitudes.

The only sources of uncertainty to which this method seems subject are want of uniformity in the transparency of the sky near the zenith and possible small variations in the magnitudes of the stars chosen for comparison. A series of photographs taken during each lunation before and after full moon during good atmospheric conditions should eliminate the former uncertainty, whilst errors arising from the latter could be neutralised by taking a sufficient number of comparison stars.

10. The observatory is now co-operating with the "International Union for Solar Research."

11. There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are:

(*a*) A Foucault siderostat with an 8-inch image lens for use with a spectroscope which is now being improved in England.

(*b*) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal-plane ultra-violet spectrograph is now in complete adjustment and it is proposed to employ it for stellar spectra.

The twelve 'most widened' lines in sunspot spectra are observed daily and the results forwarded to Sir Norman Lockyer, and a close agreement is maintained with the observations made at South Kensington. The observatory is also co-operating with the International Union for Solar Research, and is observing the region 5,300 to 5,500 for all lines affected in sunspots.

Solar Radiation.—Of the three Angstrom pyrheliometers previously in use in Simla one was taken in January 1908 to the Solar Physics Observatory at Kodaikanal for employment there. The operation of these instruments in Simla and Kodaikanal is difficult and intermittent on account of cloud and atmospheric dust and the results obtained are consequently

less valuable than the apparatus is capable of affording. The Royal Society have recommended that these and other solar instruments should be used at a very high altitude in the Himalayas, in a position free from atmospheric dust, but it is at present impossible for the department to make the necessary arrangements.

At Calcutta and Bombay there are Callendar electric sunshine recorders, and a third, which has been purchased for use in Simla, will shortly be brought into use.

The following list gives in absolute units the values of radiation as measured at Simla from April 1907 to August 1908 inclusive :—

Month.	Solar radiation in gr. calories per sq. cm. per min.			Number of observations
	Maximum.	Minimum.	Mean.	
April 1907	1·55	1·47	1·51	2
May "	...	...	1·42	1
June "	1·39	1·22	1·33	8
July "	1·29	1·23	1·26	3
August "	...	...	...	...
September "	...	...	...	...
October "	1·49	1·48	1·49	3
November "	1·60	1·38	1·46	18
December "	1·53	1·34	1·43	15

Month.	Solar radiation in gr. calories per sq. cm. per min.			Number of observations.
	Maximum.	Minimum.	Mean.	
January 1908 . .	1·53	1·43	1·47	10
February „ . .	1·56	1·40	1·47	12
March „ . .	1·55	1·36	1·47	12
April „ . .	1·49	1·35	1·42	11
May „ . .	1·43	1·20	1·33	12
June „ . .	1·41	1·13	1·27	13
July „ . .	No observations on account of cloud.			
August „ . .				

METEOROLOGY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Investigation of the Upper Air.—In view of the absence on leave of the head of the Department, work with kites could not be undertaken, but much was done to devise and improve methods of obtaining meteorological records of the air by means of balloons carrying light instruments.

2. As a first step for such work it was necessary to design recording instruments which should be light enough to be sent up to 60,000 feet without great expense in balloons and hydrogen, and cheap enough in themselves to justify the anticipated loss of 90 per cent. of them for the

sake of the 10 per cent. which it was expected to recover. As a result of experimental work an instrument was evolved which, while weighing complete only half an ounce, would inscribe on a silvered glass plate accurate records of pressure and air temperature up to a height of 60,000 feet or more, and of humidity throughout the lower half of that distance from the ground surface. Such a record in a light instrument is necessarily small, actually one centimetre square, and requires reading under a microscope with micrometer scales: also the film of silver is fragile, and as it would be damaged by the lightest touch of the fingers until it has been fixed by varnishing, it requires protection from meddling or inadvertent handling by the finder. To effect this protection the impact of the instrument with the ground after descent has been made to release the record plate and its holder, and to allow it to spring away into a narrow dark space in the framework of the instrument; when the record is thus concealed only a critical examination by an unusally inquisitive person would be sufficient to discover it.

3. With regard to the arrangements for use in the field it was expected from what was already known of the upper winds of India, that the general drift of the balloons would be easterly, and that descent would occur in the quadrant lying between N.E. and S.E. boundaries radiating from the place of liberation. The conditions to be satisfied in the choice of a starting place were accordingly that the country for 150 to 200 miles in the quadrant from N.E. to S.E. of it should be fairly open, flat and well populated; and Jhang in the Punjab was selected as answering to that description, being also reasonably accessible from Simla.

4. With the permission of the Local Government, and by the courteous assistance of Deputy Commissioners, the villages in several districts to the east of Jhang were informed, by means of 7,000 illustrated vernacular circulars, of the action that was to be taken by finders of instruments after descent, and of the rewards which were offered for recovery. Each instrument was to carry a label, printed in Urdu, Nagri and Gurmakhi, to remind the finder of the reward that was payable for recovery, and of the steps to be taken to secure it. In June and September 23 complete sets—consisting of balloon, instrument and in most cases parachute—were liberated, the adjustments being such that at the maximum height attainable the balloon should empty itself automatically; or, where parachutes were used, should disengage itself from the parachute and its attached recording instruments, and allow them to fall to earth. In the result it was found that the measures which had been taken for retriev-

ing instruments were considerably more successful than had been anticipated, and up to date (November 24th) 10 of the 16 instruments liberated in September have been recovered: they all afford readable records, which are now under examination.

5. **Electrical Condition of the Atmosphere.**—Considerable progress has been made with the investigations undertaken for the purpose of studying the electrical condition of the atmosphere. The apparatus which has been constructed for obtaining a continuous record of the conductivity and ionisation of the air is now in fair working order, and it is hoped that when the office has moved to its new quarters a series of curves will be obtained which will throw light on the diurnal and annual changes in these quantities, as well as upon the variations in the ionisation of the air during disturbed weather. The instrument itself is of a somewhat complicated character and has only been brought to completion after a considerable amount of experiment and change from the original design.

6. The automatic record of the electrical potential gradient in the atmosphere has led to some interesting and unexpected results, and as far as can be seen from the curves already obtained the observations made in Simla will help to explain some of the outstanding difficulties connected with the daily variation of the potential gradient. It has been found that the "fine weather potential gradient" is greatly affected by the dust which drifts up to Simla from the plains during the hot weather, large values of negative potential gradient nearly always accompanying a heavily dust laden atmosphere. Owing to several unavoidable breaks in the curves caused by bad weather and lack of a sufficiency of suitable apparatus it has been decided to postpone publication of the results until further observations have been taken.

7. An exhaustive series of measurements has been made of the electrical charges brought down by the rain during the pre-monsoon thunderstorms and during the monsoon proper. Nearly 115 rainstorms of different intensities and durations have been investigated and the quantity of electricity brought down by the rain in each two minutes was automatically registered. At the same time the number of lightning discharges and the sign of the potential gradient were also recorded. Thus simultaneous records were obtained of the four quantities: (*a*) the amount of rain, (*b*) the charge on the rain, (*c*) the number of electrical discharges, and (*d*) the sign of the potential gradient. At the time of writing the observations are being reduced and prepared for publication in the

departmental memoirs. In connexion with this work a series of experiments has been made in the laboratory at the Simla Office with the object of determining the question as to the source of the electricity which gives rise to the violent electrical discharges during thunderstorms. The results of this work appear to be very satisfactory and will be published with the discussion of the measurements of the electricity associated with the rain as soon as the discussion is completed.

8. **The question of permanent changes of climate in India.**—In view of the widespread impression that there has been a change of climate in north-west India, an examination has been made of the meteorological records with the view to ascertaining whether there has been any apparently permanent change in the amount and distribution of the rainfall over the different large areas of India. Whatever conclusions may be derived from geological or historical data it appears that no satisfactory evidence of change can be derived from the meteorological records now available.

9. Prior to 1890 the raingauges in use were of different patterns, of which some were inaccurate, and in a number of cases errors were introduced by the use of measure glasses of the wrong size: the sites also were frequently unsuitable. But none of these causes of failure were as serious probably as ignorance and carelessness on the part of the observers. If attention be confined to the stations selected in 1886 for their reliability by Mr. Blanford, and the monsoon rainfall of India be tabulated for the years 1841 up to date, it would appear from the records that there were failures of the rains in 1855 and 1848 which were as bad as, or worse than, those of 1877 and 1899, and that in a number of other early years the rains were very scanty. These results are entirely negatived by the report of the Indian Famine Commission. In confirmation of the unreliable character of the early data may be quoted the fact that the pressure measurements at Madras, Bombay and Calcutta may be trusted to give the average pressure over India for a long series of years; and that the fairly close relations which hold between the records of pressure and rainfall in the later years do not hold in the earlier.

10. At Madras the mean annual rainfall of the past 30 years has been $49''\cdot51$ while that of the previous 65 years, which may be trusted, was $48''\cdot79$; and at Bombay the mean of the past 30 years has been $72''\cdot71$ while that of the previous 31 years was $70''\cdot21$.

11. The question of the criteria to be employed before any changes of climate can be regarded as permanent has next to be considered. Of

the countries affected by the monsoon the only area for which reliable data extend over a satisfactorily long period is Egypt, where the Nile data extend back as far as 1737 except for a break from 1801 to 1884: of these records the series of 83 years from 1825 is known to be very fairly accurate since there were for almost every year at least two gauges which were simultaneously recording the river levels. Inasmuch as the Nile flood is determined by the monsoon rainfall of Abyssinia, and as the moist winds which provide this rainfall travel in the earlier portion of their movement side by side with those which ultimately reach the north of the Arabian Sea, there is a tolerably close correspondence between the abundance of the Nile flood and that of the monsoon rains of north-west India; it would thus appear legitimate to utilize the Nile data for indicating, at any rate approximately, the character of the variations to which the Indian monsoon is liable. There have been fairly long periods of deficiency followed by complete recovery. Thus in the 17 years from 1781 to 1797 the Nile was below normal in every year with one exception, and there is a series of 15 years from 1825 to 1839 all of which, except two, were in defect: the average flood of the 15 years was 8 per cent. below normal. It may thus be inferred that a shortage of rain cannot be regarded as establishing a permanent change of climate unless it extends over thirty years at the very least. The means for the last thirty years of the first class observatories cannot be quoted in favour of a permanent change; and apart from these the number of years for which reliable data exist is unhappily only about forty, so that even if the last twenty years were to differ materially from the first twenty, it would not be sufficient to establish a permanent change.

12. Tabulations have been effected of the rainfall of the separate provinces, beginning at the earliest year for which a satisfactory number of stations are available and ending at 1907; and records of the same stations have been considered throughout the period in order to avoid introducing fortuitous changes into the rainfall of the province by adding stations whose normal rainfall may have differed from that of the stations already employed. The monsoon rainfall of the Punjab, Rajputana, and Gujarat increased to a maximum in 1893 or 1894, diminished to a minimum in 1899 and since then has in general improved. In Bombay and Central India there has been on the whole a slight diminution in rainfall. In the United and the Central Provinces, Hyderabad, Mysore, Madras, Bengal, Eastern Bengal and Assam, and Burma, there is no appreciable indication of climatic change. When seeking an explanation

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of these changes in north-west India, the maximum in 1893-4 and the minimum in 1899 appear to negative any explanation in terms of a factor of steadily increasing importance such as the increase of irrigation. The direct influence of forests upon rainfall is, I believe, almost universally regarded by specialists as small; and it seems impossible to explain the character of the variations of rainfall during the past twenty years in terms of it.

13. One other explanation has still to be considered. A statistical examination of the data of the monsoon rainfall and the temperature and pressure of India in May shows that these Indian conditions have no perceptible influence; but conditions in the south Indian Ocean, where the monsoon winds take their origin, and in the subequatorial region have a considerable effect. It would, therefore, seem natural to ascertain whether the tendencies in question have not been associated with abnormal features south of the equator. And as the changes in India are confined to the northern half of the field of the Arabian Sea current it would seem natural if this cause be the true one to expect corresponding changes in Abyssinian rainfall and in the height of the Nile. Such is in fact the case. In the Nile, as in north-west India, there was a rise to a maximum in 1894 followed by a rapid fall to 1899, since which time to 1907 a marked deficiency has prevailed. This latter period has been associated with abnormally large ascensional movement at the equator, with high pressure in the Indian Ocean and low pressure in South America. Thus it seems natural to attribute the variations in north-west India to unusual features in the larger movements in the atmosphere and not to any local causes in India.

14. **Publications.**—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay, and Madras, the Monthly Weather Reviews, the Annual Summary, and various administrative pamphlets the following memoirs have been published departmentally:—

(1) A discussion of the anemographic observations recorded at Allahabad from September 1890 to August 1904, and a discussion of the anemographic observations recorded at Lucknow from July 1878 to October 1892, by Sir John Eliot, M.A., F.R.S., K.C.I.E., late Meteorological Reporter to the Government of India and Director General of Indian Observatories. (Memoirs of the Indian Meteorological Department, Vol. XVIII, Part III.)

(2) Kite flights made at Belgaum during pre-monsoon and monsoon periods in 1906, by J. H. Field, M.A., Imperial Meteorologist. (Memoirs of the Indian Meteorological Department, Vol. XX, Part II.)

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TERRESTRIAL MAGNETISM.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Colaba and Alibagh*).—Further progress has been made by the Director, Mr. N. A. F. Moos, with the computing and discussion of the sixty years' series of magnetic observations at Colaba, and these should shortly be complete. The work of printing has begun.

2. *Dehra Dun, Kodaikanal, Barrackpore and Toungoo.*—These observatories were started as base stations in connection with the Magnetic Survey of India and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip circles earth-inductors of the Schulze pattern have been set up at each observatory. All the instruments have given good results through the year with the exception of the vertical force instrument which was erected at Kodaikanal over a year ago and had previously given trouble :

of these changes in north-west India, the maximum in 1893-4 and the minimum in 1899 appear to negative any explanation in terms of a factor of steadily increasing importance such as the increase of irrigation. The direct influence of forests upon rainfall is, I believe, almost universally regarded by specialists as small; and it seems impossible to explain the character of the variations of rainfall during the past twenty years in terms of it.

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a new magnet was fitted but the instrument still appeared unstable. The dip at Kodaikanal is only about $3\frac{1}{2}°$ and the force to be measured extremely small; it was therefore considered advisable to make the magnet more stable by lowering the small gravity bob, and excellent results are now being obtained. The temperature co-efficients of the new vertical force instruments mounted at Barrackpore and Kodaikanal in December 1907 were satisfactorily determined as $-3{\cdot}0\gamma$ and $+5{\cdot}2\gamma$ per 1° F. respectively. The base mirror of the declination magnetograph at Barrackpore had been attacked by fungoidal growth and it has been renewed. The mean values of the magnetic elements for 1907 at the observatories are as follows:—

	Declination.	Horizontal Force.	Vertical Force.	Dip.
Bombay . .	1° ·3′·8 E.	·36862	·15843	23°·14′·5N.
Dehra Dun .	2°·38′·3 E.	·33324	·31736	43°·36′·1N.
Barackpore .	1° ·9′·9 E	·37288	·21967	30°·30′·2N.
Kodaikanal .	3°·40′·7W.	·37431	·02259	3°·27′·2N.
Toungoo .	0°·39′·3 E.	·38754	·16461	23° ·0′·7N.

3. Magnetic Survey.—The preliminary survey of India for which sanction was given was to involve:—

(*a*) Observations for declination, intensity and dip at about 1,100 stations, whose distance apart was to be comparable with 35 or 40 miles, the "density" being one station to 1,300 square miles.

(*b*) Observations in successive years of the magnetic elements at 23 "repeat stations" in order to make possible the elimination of secular variation.

(*c*) Data from absolute and self-registering instruments at Bombay and the four special base stations already mentioned.

A beginning was made with field work in November 1901 and the operations up to the end of the year 1906-07 have been described in previous reports: by that time 1,110 stations had been occupied and 22 repeat stations established, in addition to 25 stations on the Seistan trade route where declination had been observed. During the year 1907-08 the preliminary survey was continued by four detachments, three being employed in Burma, while the fourth was occupied in filling in gaps in Berar, Orissa and Assam. One of the Burma detachments was withdrawn from magnetic work for three months in order to carry out some triangulation for the Chin-Lushai-Arakan boundary, and another, owing to the early break of the monsoon in south Burma, could not complete its programme. For these reasons the outturn of new stations, 80, was small compared with the 152 stations of the previous year.

The field season commenced on the 21st October, 1907, and the party proceeded to recess quarters on the 4th May 1908. The total number of stations occupied to date is 1,214 with 22 repeat stations; observations have also been repeated at 31 old field stations.

Captain R. H. Thomas, R.E., was in charge up to the 31st March 1908, and Lieut. H. I. Couchman, R.E., after that date; Lieut. H. T. Morshed, R.E., was posted to the party in August 1908.

4. The Officer in charge, with his assistant, took observations at all the repeat stations and also at several old field stations, with a view to obtaining further values of the secular change in the magnetic elements. Comparative observations were also taken at the four observatories of the Survey, and at Alibag, to determine the differences from the Survey standard instruments at Dehra Dun.

5. During the recess season the computation of the field work and the reduction and tabulation of the base station results for 1907 have been completed. The whole of the H. F. observations taken since the beginning of the survey have been recomputed by applying mean values of m (the amount of the magnet) to the value of m H obtained in the deflection observation. These mean values of m have been obtained by dividing the values into groups and taking means of groups. Where the means of several groups agree a further mean has been taken, and where not the individual values have been carefully scrutinized to discover when the change occurred. This recomputation was undertaken originally to improve the monthly mean values of the base lines of H. F. magnetographs, and as this was achieved, the method has been extended

to all H. F. observations, and has provided new values of the instrumental differences, which will be used in the reduction.

Charts have been prepared showing the Indian isomagnetics (lines of equal declination, dip and horizontal force). These charts will be useful in indicating the more obviously disturbed areas, but as they are based on uncorrected observations they can only be considered as approximate.

The correction of the horizontal force and declination observations for diurnal variation and instrumental difference is being started, the repeat stations being dealt with first. The correction to be applied for diurnal variation will be computed by the latitude formula mentioned in the last report, using the diurnal variation figures of the three nearest base stations, and taking a mean of the two values of the correction found. With regard to the instrumental correction in horizontal force, since the correction to be applied bears a constant ratio to the force as measured, its amount will vary slightly over the area of the survey.

Investigations into the question of the correction for disturbance are still being made, but no satisfactory empirical formula connecting these corrections at the base stations has as yet been discovered, and it would seem that an approximate correction will have to suffice, at any rate for the horizontal force observations.

6. During the next field season it is intended to begin the detail survey by examining a few of the more obviously disturbed districts in Rajputana and Central India. One such district occurs near Pokaran, in the Rajputana desert, where the declination alters by 3° in 40 miles, while another lies near the Nerbudda river, south-west of Indore, where values of horizontal force of ·32 C. G. S. and ·38 C. G. S. have been found at contiguous stations 35 miles apart, the normal value of the district being about ·365 C. G. S. It is considered advisable to commence the detail survey in these abnormal localities, in order to gain experience in selecting stations which will reveal the loci of disturbance, and not to attempt as yet to pourtray the geological features of a district which has not been shown as obviously abnormal by the uncorrected observations of the preliminary survey. The survey of the northern edge of the Deccan trap, mentioned in last year's report, will therefore be left for the present. Two detachments will be available for the detail survey throughout the field season. Two others will be employed in completing the preliminary survey of the coast of Burma for the greater part of the season, and will then assist in the detail survey.

GEOLOGY.

BY

SIR THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.,

Director, Geological Survey of India.

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INTRODUCTION.

The geological results summarised below include those available for publication up to the end of the year 1907. The results obtained during the remainder of the field season have still to be supplemented by

work in the Laboratory before their value can be safely estimated. In addition to the questions for research included in the programmes published with the Annual Reports of the Board for 1906-07 and previous years, it will be noticed that certain results of special interest have been obtained as bye-products during the course of the sanctioned surveys and enquiries of economic importance.

GEOLOGICAL SURVEYS.

Central India.

Area surveyed.

The officers in the field continued the survey in a general westerly direction from the area done last year, with the result that the following Standard Sheets on the 1″ = 1 mile scale have now been added to the completed list:—Nos. 212, 276, 277, 306 and 334; whilst portions of the following have been mapped:—Nos. 211, 213, 242, 243, 244, 274, 275, 303, 304 and 335. Of these the western area, included in Nos. 211, 212, 213, 242, 243 and 244, was surveyed by Messrs. Walker and Heron, and the eastern area, included in Nos. 274, 275, 276, 277, 303, 304, 306 and 334, by M. M. Ry. Sethu Rama Rau. The latter also entered sheet 335, and revised portions of it with special reference to the iron-ores of the Sendrani neighbourhood.

Connection with previous surveys.

Omitting areas belonging to the Gwalior State, the Central India survey has now linked up with the previous survey of the Lower Narbada valley by Mr. Bose (*Mem. Geol. Surv. Ind.*, Vol. XXI, Pt. 1, 1884) and with that of the Dhar State by Mr. Vredenburg, all of which region lies to the south and south-west of the area just completed. During the present field season it is hoped similarly to link up (with possible revision) with the areas mapped by Messrs. Hacket and Kishen Singh, which lie to the west and north-west of the area now in progress.

Western Area.

The western area surveyed by Messrs. Walker and Heron lies within lat. 22° 30″—23° 30′ and long. 74° 30′—75° 20′. This area included the whole of the Pitlawad pargana of the Indore State, the greater portion of the Jhábua State and parts of Rutlam State.

Disposition of Rock Formations.

Rocks of the Arávalli series occupy the south-western corner and a portion of the western side of this area, which lies entirely in Jhábua territory. Along the southern and a part of the eastern margin of this Arávalli outcrop, platforms of Lameta beds lie horizontally and unconformably on the schists and granites. The remainder of the country surveyed is occupied entirely by Deccan Traps.

The Aravalli Series.

The position of an outcrop of Arávalli rocks as an inset in the margin of the Deccan Trap leads one to infer that it was at one time covered by Deccan Trap. This view is strengthened by the fact that several rivers which flow from the basalts on to the Arávallis have cut back the former and exposed tongues of the latter. The sameness in the general maximum level of the Arávalli rocks is what one would expect as a result of the removal of the basalts. Streams have cut up the surface into low, round-backed hills. The chief rock types represented are—Sericitoid-phyllites, quartzites, quartz-schists, granites and limestones. Locally gneisses are met with. Mr. Walker notes that many of the granites contain large quantities of pale-brown sphene. In the west (Walker), and also in the east (Heron), the occurrence of an amphibole-quartz-rock in conjunction with granite masses has been described. Further it has been found that in one place in the west the above rock passes into an amphibolite. Actinolite also is an occasional constituent in this series (Walker). A more definite relationship of amphibole rock to granite could not be determined owing to the occurrences being much obscured by soil. The limestones are interesting; for Mr. Heron reports one containing green epidote, and another, found in the west, has such an amount of sericitoid material as to warrant it being named a calc-schist. Throughout the Arávalli series the predominant characteristic is the exceeding acidity of the rocks. The phyllites have well developed white quartz lenticles and veins, and even the limestones are thickly traversed by veins of quartz. Muscovite is the chief mica in the granites; biotite is not common. To the north of the outcrop and along its eastern face the general strike is E. 20°—30° S. This changes to S 20° E. in the south and west. The rocks are much folded, often steeply, and the dips are high, irregular, and often vertical. The phyllites still preserve traces of bedding, and the granites also retain to a large extent their original structure.

The Lameta Series.

As in the case of the Arávalli series, the Lameta rocks are exposed only in Jhábua State. The peculiar distribution of these rocks is worthy of note. One small isolated patch of Lameta rocks was found lying horizontally and unconformably on the Arávallis at the northern end of the exposure. They occur fringing the margins of the Deccan Trap outliers in the neighbourhood of Jhábua City, but do not underlie the margin of the main basalt flow in this area. A few miles to the south the Lametas crop out between the Arávalli rocks and basalts. From this point they crop out almost without break; and to the south of the Arávalli exposures they form platforms of large extent. Not only is the distribution peculiar, but so is the change in lithological character. The northern exposures are of the type previously referred to as Lameta; being described as generally calcareous, pale in colour, containing much sandy admixture, occasionally cherty, and with an uppermost layer characterised by well-rounded pebbles of quartz, quartzite, and bright-red jasper (*Rec. Geol. Surv. Ind.*, XXXV, p. 55).

As one follows the outcrop to the south, one finds a great increase in the conglomerate beds. Grits occur very frequently, and locally the rocks are entirely silicified and very cherty. In places fossiliferous, siliceous limestones were found and a few patches of true fossil-limestone were discovered. Among the fossils found were specimens of *Rhynchonella*, *Terebratula*, *Ostrea*, several genera of *Lamellibranchiata*, *Gastropoda* and *Bryzoa* (Walker). Thus, in this area a change similar to that described by Mr. Vredenburg in the Dhar Forest [1]—from beds of estuarine type (Lameta) to those of marine type (Bágh) has been seen.

Mr. Heron notes that near Dhandalpura a bed of coarse grit occurs which is burnt by the basalt capping it. This bed is in small gentle folds. Mr. Walker also remarks on an outcrop of Lameta limestone to the south of Piplade where dips of 4° were measured. Cases in which the Bágh beds have been eroded [2] previous to the outflow of the basalts and in which the basalts rest immediately on the Aráballis and at a lower level than the surrounding Bágh beds, have been described (Walker). The base of the series has not been seen, but the maximum thickness developed in this area appears to be not more than 30 feet.

[1] General Report, *Geol. Surv. Ind.*, for 1902-03, p. 20.

[2] Geology of India, 2nd Ed., p. 275.

Deccan Trap.

Although the major portion of the area surveyed during the field season is occupied by Deccan Trap, very little new information concerning these enormous masses has been obtained. Three beds of what appears to be fragmental volcanic ejecta were found intercalated with the normal basalts of the Deccan Trap. The uppermost one is near the top of Kukinda hill (Jhábua State) at a height of 1,450 feet (Walker). The other two occur to the N.E. in the Pitlawad pargana of the Indore State. The upper one of these is at a height of 1,300 feet, is about 3 feet thick and is the middle member of the basalt series forming the small hills surrounding Bamnia Railway Station. The lower is to be met with in the bed of the Larki river at Pitlawad town and in the neighbouring streams. The bed, which is between 4 and 5 feet thick, consists of small angular blocks of the normal vesicular and amygdaloidal basalt of the district, in a matrix of finer materials; the whole is much decomposed, contains numerous cavities lined with calcite and various zeolites, and is in many places stained red and green. These two beds have been found at intervals over an area of about 130 square miles, the approximate centre of which is Pitlawad town.[1]

A small lenticular sill of quartz-felsite was found near Banri (Walker). An interesting dyke was found at Patbarli. The dyke-rock is an augite-plagioclose rock and shows ophitic structure (Heron). Olivine has not been met with during the course of the season's work.

Alluvium and Soil.

Except on the Malwa plateau the rivers and streams run for the most part in rocky beds with local bands of drift pebbles, and pebbly conglomerates. In places along the Mahi river shelves of alluvium 20 feet in thickness are to be found. On the Malwa plateau the streams run most frequently between banks of cotton soil and kankar-gravel. The soil on the Arávallis and Lametas is thin and poor and exceedingly quartzitic. The phyllites give thicker and more argillaceous soil, but this is usually impoverished by the admixture of large quantities of quartz. On the slopes of the ghâts the soil is red and scanty, and thickly littered with trap fragments. In the flatter valleys and on the Malwa plateau there is usually a fair thickness of grey and black cotton soil. To the north and east of Rutlam town the soil is very thick and there are few rock exposures. However, water can be obtained from wells at depths between 30 and 40 feet, even at the end of the dry season (Heron).

[1] Mr. Middlemiss thinks the agglomeratic character of these beds may have been acquired by movement in a partially and irregularly consolidated flow of trap.

Economic Geology.

The examination of the previously-named portions of the Indore and Rutlam States has shown that there are no deposits of minerals of economic value; and concerning Jhábua State it has been found that the Arávalli series includes the only rocks that carry mineral deposits.

The undermentioned known deposits were visited:—At Amlamál the

Manganese-ore.

manganese-ore occurs as psilomelane in a fine-grained spessartite-quartz rock. The lode is thin and is ill-defined and the ore is mixed with quartz. The manganese-ore at Tumdia is found in veins and lenticles of white quartz, the surrounding rocks being sericitoid phyllites. The ore-bearing band is between 2 and 3 feet in thickness and about 200 yards long. In parts the ore is good, but on the whole is too quartzitic.

At Pipal Kotha, which lies midway between the manganese mines of Kájlidongri and Rambhapur, there are two outcrops, in line, of a pale-lavender coloured quartzite carrying an ore-band of psilomelane mixed with pyrolusite. The outcrop is never more than one yard wide and the total length exposed is about 100 yards. The ore is of good quality, but there is too large a percentage of quartz for the deposit to be of economic value. Two deposits of manganese-ore and one of an iron-manganese-ore were found in the Pitol district. All of these are small and poor in quality. Traces of manganese-ore were found in five other places. These were usually pyrolusite in the white quartz veins of the phyllite series.

Reported deposits of mica occurring near Kanás and Ránápur

Mica.

were found to be derived from medium-grained pegmatite veins. They are of no value.

The ironstone deposit at Piplade, and also that in the Sánár river

Iron-ore.

between Parwet and Gadwara, are too small and of too low a quality to admit of successful working.

A supposed China-clay from Ránápur is a fine-grained, white, siliceous limestone.

The eastern area surveyed by Sub-Assistant M. M. Ry. Sethu Rama

Eastern area.

Rau lies entirely within lat. 22° 30′—23° 30′ and long. 75° 30′—76° 30′, and is contained in the Mehidpur, Indore and Nimawar districts of the state of Indore. It embraces irregular areas of the Malwa plateau of Deccan Trap stretching north and north-east of Mhow, and a narrower area to the east of Mhow, where the Malwa plateau descends in a southerly direc-

tion by three fairly well-marked terraces or scarps to the lowlands of the Narbada valley. The range of altitude is between 2,100 and 950 feet. It is only in the area to the east of Mhow that formations older than the Deccan Trap emerge from beneath the latter in the wide valley of the Narbada.

Older formations: Archæan, Bijawar and Vindhyan.

The older formations form part of the same complex which further west has been recently mapped in detail by Messrs. Vredenburg and Fermor (see General Report, Geol. Surv. of India for 1902-1903, p. 20), following on the older survey of Blanford (*Mem., Geol. Surv. Ind.*, Vol. VI, Pt. 3, 1869) and Bose (*Mem., G. S. I.*, Vol. XXI, Pt. 1). Of these the Archæans are represented by granitic and mottled hornblendic gneiss, and hornblende-chlorite schists, exposed to the east of Satwas and occupying the low country between the base of the Deccan Trap and the Narbada river as far as the limits of sheets 334 and 335 go in that direction; the foliation strike being N. 10° W.—S. 10° E. near Kathargaon and Bagda, but near the Narbada being nearly E.—W. The Archæans are traversed by many doleritic dykes which near Kathargaon generally keep a direction N.W.—S.E. They are crystalline and fine-grained, and with semi-glassy selvages, and appear to be different to the basalts, etc., of the Deccan Trap. Quartz veins also traverse the gneiss, in some of which, such as those at Tamkhan,[1] copper pyrites with malachite alteration products are present, and also iron pyrites.

Copper-ore.

The Tamkhan veins run N.—S. and are 4-5 feet thick and about ½ mile long. They are situated on the Narbada (lat. 22° 28′, long. 76° 52′) and were quarried and smelted about 150—200 years ago by the ruling chiefs. The pits are now filled in with fallen material and it was impossible to learn whether the whole of the ore-body had been worked out or not, but the sides of the vein seem to have been richer in pyrites than the middle. Other veins between Kharia and Jinwani (lat. 22° 19′, long. 76° 45′) also run nearly N.—S. and show tourmaline and a few copper stains, but pyrites is not seen *in situ*. The exposures were however very jungle-covered. No gold was found in these quartz veins.

Bijawars.

The Bijawars in sheets 334 and 335 occur firstly as inliers in the form of small hills rising from among the basal bed of the Deccan Trap, as seen in the neighbourhood of Sukras (22° 40′, 76° 52′), and secondly further south forming an L-shaped

[1] Referred to by P. N. Bose, *loc. cit.*, p. 69.

outcrop among the Archæans between Sendrani (22° 28′; 76° 40′) and Piplia on the Narbada. The lower division, consisting of coarse upper and fine conglomeratic quartzites, is exposed in the Sukras area, and the division of brecciated jaspideous quartzite and cherty limestones in the Sendrani-Piplia area. The upper division is said to lie unconformably upon the Archæans, but the brecciated bands, always found at the junction with the granitic gneisses in the southern area, might be understood to indicate an intrusive action of the Archæans. The problem here appears to be a repetition of what is found in other parts of India where similar rocks occur; and the apparent irrationalities of the dip indications are also not in favour of a simple superposition theory for the Bijawars.

Vindhyans.

A system of sandstones, shales and conglomerates occurring as inliers among the basal bed of the Deccan Trap, and also as a large connected outcrop to the west of Satwas, probably belong to the Vindhyan system and perhaps to the Lower Vindhyans. They are inclined at moderate angles, generally towards the south-west. Their exact horizon is not yet clear. Bose has marked them as Upper Vindhyan, whilst Vredenburg has marked their western extension as Lower Vindhyan.

Deccan Trap, etc.

As seen in sheet 324, the Deccan Trap begins with a lowermost bed which occupies the flat plains for several miles before the upper beds which compose the scarp appear. This lower bed makes no special orographical feature with the older rocks of the Vindhyans, Bijawars and Archæans, above which it is described as lying unconformably, and without the intervention of any Lametas, such as occur in other neighbouring areas to the west. Above this the scarped edge of the Malwa plateau rises more than 1,000 feet in beds of softer and harder Deccan Trap, some of which are columnar, and some containing the usual geodes full of siliceous or zeolitic material. Deccan Trap occupies the rest of the country surveyed, with the exception of a very few cappings of laterite, some further exposures of the subrecent calcareous concrete noticed in the last General Report (*Rec. Geol. Surv. Ind.*, XXXV, 57), together with alluvial stretches in the valley systems, cotton soil and calcareous tufa.

Sendrani Iron-ores.

The Sendrani (22° 28′; 76° 40′) iron-ores were specially investigated, and the positions of the old mines recorded on the map by Sethu Rama Rau. The ores were found to be exposed in ancient pits at several places scattered over the

Bijawar area to the south and south-east of Satwas, and also along the junction between the Bijawars and the Vindhyans. The original rock appears to have been a hæmatitic shale at the base of the latter, but the ore also occurs lining hollows and fissures in the underlying Bijawar breccia, from which it has again been accumulated in the form of nodules and lumps scattered about in the disintegrated surface rock. In competition with imported iron the industry has gradually died out in later years.

Central Provinces.

During the field season Mr. P. N. Datta completed a survey of the previously unmapped areas in the Bhandara district. The only features of geological interest deserving special mention are the large outcrops of post-Vindhyan diabase, possibly connected with the Deccan Trap eruptions, and the sections which clearly show the great unconformity between the Vindhyan sandstones and the vertical beds of Dharwar schists below. No fossils were obtained from the Gondwana rocks exposed in Bhandara and adjoining parts of Chanda, and no new occurrences of valuable minerals were recorded.

Burma.

Surveys carried out in the oil-fields of Minbu, Magwe, Myingyan and Pakokku districts are referred to under *Petroleum*, while the exploratory work done in Mergui is reviewed under *Tin-ore*.

Northern Shan States.

The survey of the Northern Shan States was continued by Messrs. T. D. LaTouche and J. Coggin Brown in two separate areas, (*i*) that comprised in Sheets 331 and 332 of the one-inch Topographical Survey, lying along the valley of the Nam-Tu above Hsipaw, and including the tract north of Sheet 331 in which the silver-lead mines of Bawdwin are situate, which has not yet been surveyed on the one-inch scale; and (*ii*) the hill ranges between the Shan plateau and the Salween extending southwards from the Loi-len range E. of Lashio to the plains of Kehsi Mansam in the Southern Shan States, comprised in Sheets 433, 434, 435, and 436 of the one-inch survey. The whole area mapped was about 3,300 square miles.

The geology of the Nam-Tu valley had previously been studied by Messrs. Datta and Pilgrim, and to some extent by Mr. LaTouche, but

Mr. Datta had confined his attention mainly to the upper Palæozoic and Mesozoic rocks, and the discovery of hitherto unrecorded beds containing characteristic fossils has necessitated several changes in the mapping of the boundaries laid down by Mr. Pilgrim. The most interesting of these discoveries was that of a band containing graptolites, of the same type as those which had been found during the previous season in the Kehsi Mansam district at the base of the Namhsim sandstones at Panghsapyé, a village about 8 miles north-west of Hsipaw. These graptolites are of quite a different type from those of the Zebingyi beds, described by Mr. Cowper Reed in the *Palæontologia Indica*, and belong to an older horizon, probably of Llandovery age. The beds in which they are found immediately overlie a band of purple shales, which was formerly considered as the base of the Silurian Namhsim sandstones, but the graptolite zone must belong to the much greater thickness of purple and grey shales found last year on the eastern flanks of the Loi Twang range in Kehsi Mansam, from which Ordovician trilobites were obtained. The purple band of Panghsapyé and the neighbourhood must therefore be considered as the uppermost member of the Naungkangyi group of beds. There is no apparent unconformity in the Nam-Tu valley between the Naungkangyi beds, Purple band, Graptolite band, and Namhsim sandstones, and if the graptolites (which have not yet been examined by a trained palæontologist) should turn out to be Llandovery forms, we should have here a complete succession from Lower Ordovician to Silurian strata.

The Graptolite and Purple bands were traced northwards from Panghsapyé across Sheet 331 and were of great assistance in mapping the boundaries of the formations. The Purple band also extends from Panghsapyé to the south-west as far as the head of the Gokteik Gorge, but the Graptolite band above it appears to be absent in this direction, or at any rate has not yet been detected. It is for this reason that the connection of the Purple band with the Naungkangyi beds below was not previously recognised.

Along the gorge of the Nam-Tu above Hsipaw the succession of the rocks is normal, the Naungkangyi beds occurring along the slopes of the valley on the west side and in the bed of the river, followed at the base of the precipitous scarp on the east side by the Purple and Graptolite bands. These are succeeded by the Namhsim sandstones, which form the whole of the scarp overhanging the river, and are capped by the Plateau limestone, which forms a strip of undulating, high ground

parallel to the gorge, and in its turn disappears to the east beneath the red sandstones of the Namyau series, the dips throughout being easterly. But to the west of the river the Naungkangyi beds, instead of being followed by the older unfossiliferous rocks of the Chaung-Magyi series, are found overlying, with apparent conformity, a series of sandstones in which Namhsim fossils, among others *Orthonota* and *Encrinurus*, have been found. The boundary line is almost straight, running nearly due north and south, and it is evident that the Naungkangyis have been pushed up along the line of a fault above the sandstones. Within a few miles to the west the dip of the sandstones becomes less, and their lower beds are found resting quite unconformably upon the upturned edges of the Chaung-Magyi rocks, entirely overlapping the Naungkangyis.

The great fault mentioned above has been traced northwards into the Bawdwin area, where it inclines somewhat to the west of north and, leaving the fossiliferous Palæozoic rocks, traverses the rhyolitic tuffs and rhyolites of Bawdwin, which form the uppermost member of the Chaung-Magyi series. To the intense crushing and disturbance caused by this great dislocation is probably due the opportunity for the mineralization of the Bawdwin rocks. A separate report on this subject will be published in the *Records, Geol. Surv. of India.*

The geology of the hill-ranges east of the plateau, though in general sequence similar to that of the western portion of the Shan plateau, exhibits several important differences in detail. The low ground separating the various ranges is invariably occupied by the Plateau limestone, with an occasional outlier of the red Namyau sandstone, or of the Tertiary coal-measures, resting upon it. The limestone tracts invariably present the same aspect of undulating, thinly-wooded plateau, generally at a lower elevation than the older rocks forming the core of the ranges, but sometimes rising on their flanks into precipitous scarps facing the axis of the range, or in some cases arching completely over them, thus proving that the limestones participated in the orogenic movements resulting in the elevation of the ranges. The structure of these is similar in all cases, consisting of an elongated dome, more or less modified by subsequent faulting. In the centre of each dome is a core of ancient rocks, belonging to the Chaung-Magyi series, and generally forming the highest elevations. The great mass of Loi Ling, the highest peak in the North Shan States, rising to 8,771 feet above the sea, is entirely formed of these rocks. Along the flanks of the core is found a zone occupied by the lower Palæozoic fossiliferous rocks, but the facies of

these is not quite the same as in the western sections. The Naungkangyis are reduced to a band of calcareous sandstones of no great thickness (with *Rafinesquina* and other characteristic fossils belonging to that group), whereas the thickness of the overlying purple shales is enormously increased. These latter beds in this area probably include a portion of the Naungkangyi group of the western sections, since they contain *Pliomera insangensis* Reed, one of the characteristic trilobites of the upper Naungkangyis, but the fossils from the purple beds have not yet been determined. They include many large trilobites belonging to the *Asaphidæ*, as well as *Ampyx*, *Bronteus*, etc.

The Graptolite band of Panghsapyé has been found in several localities overlying the purple shales, and has helped considerably in unravelling the complicated structure of these ranges. The great development of sandstones (Namhsim sandstone) which succeeds it on the Nam-tu appears to be absent, but some marly beds, which are found at the top of the sandstones in the west, are found in places immediately below the Plateau limestone, and appear to be the only representatives of the Silurians in this area.

At the top of the Chaung-Magyi series, and immediately underlying the Naungkangyi beds, a series of volcanic ash beds, with thin flows of rhyolite, were found in several localities among these ranges. These correspond closely, both in position and petrological characters, with the tuffs and rhyolites of Bawdwin. In some places a conglomerate of well-rolled pebbles occurs at their base, apparently shore deposits, accumulated in the interval between the consolidation of the Chaung-Magyi rocks and the beginning of the Naungkangyi epoch. The blocks of quartz-porphyry, noted by Dr. Noetling in the bed of the Namma river, in his account of the coalfields of the North Shan States (*Rec., Geol. Surv. Ind.*, Vol. XXIV, Pt. 2, p. 110) are derived from these beds, which occur at the crest of the range east of Lashio, on the north side of the Nampawng, a tributary of the Namma.

As the survey of this area may be interrupted by urgent requests elsewhere, it may be desirable to summarise the chief stratigraphical results obtained by Mr. La Touche and his colleagues. The geological reconnaissance has now been carried over 24 sheets of the one-inch map covering an area of 13,000 square miles, though much still remains to be done in working out the details of the geological structure of the plateau and its surroundings.

The formations that have been identified by means of their fossils, with their European equivalents, are the following:—

Local names.	European equivalents.
Late Tertiary freshwater silts with coal, Lashio, Namma, etc.	Late Pliocene or Pleistocene.
Namyau beds,—Red sandstones with bands of limestone near base	Jurassic (exact horizon not yet known).
Napeng Shales	Rhætic.
Fusulina and Productus Limestone	Permo-Carboniferous.
Plateau Limestone	Carboniferous and Devonian.
Zebingyi graptolite beds	Silurian.
Konghsa Marls	
Namhsim Sandstones	
Panghsapyé graptolite band	Ordovician.
Hwe Mawng Purple Shales	
Naungkangyi beds	
Chaung-Magyi series	? Cambrian.
Archæan schists and gneisses.	

The Chaung-Magyi series is composed of slaty shales and quartzites, which may be of Cambrian age, but in which no fossils have as yet been found; these rocks rest upon the Archæan mica-schists and gneisses of the Ruby-Mines District.

In Ordovician and subsequent times the older rocks, the Archæan gneisses and mica-schists, with the Chaung-Magyi series, formed a tract of land, extending along the north-western border of the position now occupied by the Shan plateau, with perhaps a few islands, composed of similar rocks, to the south-east of the old coast line. Along the borders of these land areas the Ordovician and Silurian rocks were deposited, followed by a great accumulation of reef deposits, now represented by the limestones covering the greater portion of the plateau, and extending to the south at least as far as Tenasserim. This period closed with the deposition of limestones containing *Fusulina* and *Productus*, probably contemporaneous with the Middle Productus Group of the Salt Range.

The succeeding formation, the Napeng Shales, has been found to contain a peculiar fauna, consisting almost exclusively of Lamellibranchs, of Rhætic age. These shales apparently filled up hollows in the plateau limestone, either due to original inequalities in its surface, or to irregular solution of the limestone during the period that had elapsed since its deposition. Another break then occurred, during which denudation of the

limestone took place, indicated by the presence of conglomerates, with pebbles derived from it, at the base of the succeeding formation. This latter, the Namyau series, consists of red sandstones, interstratified in their lower portion with bands of limestones containing Jurassic fossils. Hitherto no fossils have been found in the upper portion of this series, and it is uncertain whether any part of the Cretaceous period is represented.

After the accumulation of the Namyau beds marine deposition ceased entirely over the whole area, none of the lower or middle Tertiary formations being present. In all probability the great earth-movements at the opening of the Tertiary period converted the whole of Burma east of the Irrawadi and Sittang valleys into dry land, subject to aërial denudation, and the late Tertiary silts with coal, occupying a series of basins surrounding Loi Ling, the highest ground in the States, were evidently deposited after the main drainage features of the plateau had been marked out. Indeed, these beds of silt may be of Pleistocene, or even sub-recent age.

It is somewhat surprising that igneous rocks are of extremely rare occurrence over the whole of this area. The ancient rocks near Mogok (Ruby-Mines) are traversed by great bands of granite, and there are indications of volcanic conditions, consisting of rhyolites and rhyolitic tuffs, along the borders of the Ordovician land surface; but throughout the whole sequence of Palæozoic and Mesozoic strata there are no traces whatever of volcanic activity. In late Tertiary times there was, however, a feeble manifestation of these agencies, for in one locality the silts were found to be traversed by dykes of basalt, resembling that of the sub-recent volcano of Hawshuenshan, near Tenghueh (Momein), in south-west Yunnan.

Mount Popa, Myingyan district.

Mr. E. H. Pascoe has made a geological reconnaissance of the volcanic region of Popa in the Myingyan district [Programme for 1907-08 (4)], and has outlined a scheme for more systematic survey during the current field season.

Mineralogy.

New Group of Manganates.

During the course of his exhaustive study of the manganese-ore deposits of India, which will shortly be described in a memoir now in the press, Mr. L. L. Fermor has made special studies of certain new minerals that have been

discovered. In studying the constitution and relations of the ill-defined species psilomelane, he concludes that there is now enough material to distinguish as a special family the manganates of barium, lead and other bases, corresponding to the hypothetical acid H_4MnO_5. In this family occur, besides the amorphous *psilomelane*, the fibrous lead-manganate described by W. Lindgren and W. F. Hillebrand in 1904[1] as *coronadite*, and the barium-iron manganate, *hollandite*, originally found at Kajlidongri, Central India, and afterwards obtained at various localities in the Central Provinces and largely worked at Sitapar, Chhindwara district, for export as an ore of manganese. The chemical constitution of these minerals is discussed in a special paper published in *Records, Geol. Surv. Ind.*, Vol. XXXVI, Part 4.

An account of the mode of occurrence of manganite in the Sandur State, with a discussion of the origin of the mineral has been published by Mr. A. Ghose (*Trans., Manchester Geol. and Mining Society*, Vol. XXX, p. 307, 1908.)

Petrology.

Jadeite deposits, Myitkyina district.

An interesting investigation of the valuable jadeite-deposits in the Myitkyina district, Upper Burma, was undertaken by Dr. A. W. G. Bleeck. The full results are published as a separate paper in volume XXXVI of the *Record, Geol. Survey*. Dr. Bleeck examined the jadeite occurrences at three localities in the Kachin hills, namely, Tawmaw, Hwéka and Mamon. At Tawmaw he describes the mineral as occurring in a metamorphosed igneous dyke, intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke, both minerals being found together with the jadeite at Tawmaw. The change would be represented chemically as follows:—

$NaAlSiO_4$ (Nepheline) + $NaAlSi_3O_8$ (Albite) = 2 $NaAlSi_2O_6$ (2 Jadeite).

Under certain conditions of crystallization nepheline-albite rock might form, while under conditions of high pressure during consolidation or after, jadeite, which has a much lower molecular volume, would be produced, the residual molecule forming albite or nepheline according to which molecule was in excess in the original magma. In the neighbourhood of Tawmaw occur various crystalline schists which are

[1] *Amer. Journ. Sci.*, 4th Ser., XVIII, 448–451.

intruded into by granite. The granite is traversed by veins of aplite and pegmatite (products probably of the same great eruption) and masses of crystalline limestone are found associated with the granitic rocks, containing various minerals characteristic of contact-metamorphism. The relations of the granite to the crystalline limestone in this region are similar to those of Mandalay Hill, Sagyin, and Mogok in the Ruby Mines district, where similar contact minerals, including the different varieties of corundum, are found in the metamorphosed limestone. The crystalline schists include chloritic schists with well-formed crystals of magnetite, actinolite schists and glaucophane schists. These are all regarded by Dr. Bleeck as the metamorphic products of basic igneous rocks affected by the adjoining granitic intrusions. The serpentines form a long narrow ridge, flanked on one or both sides by saussuritic-gabbros, saussuritic glaucophane-schists and chloritic schists. These rocks are traversed by granite and veins of quartz: all the rocks are regarded as genetically related, and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock and the siliceous end-products of granite and quartz.

Relation to Tertiary Sediments.

In addition to the crystalline and igneous rocks there are exposures in this area of a sedimentary series, consisting of sandstones and conglomerates, with shaly layers and thin coal-seams. These beds were regarded by Dr. F. Noetling,[1] as miocene in age, and, although no fossils of stratigraphical value were found, Dr. Bleeck accepts the formation as belonging to some stage of the Tertiary system; but he differs radically from Dr. Noetling's views as to the relative ages of this sedimentary series and the serpentine-jadeite complex. Dr. Noetling[2] stated that the Tertiary strata are pierced by the basic igneous rocks that include the jadeite veins; but Dr. Bleeck finds that the eruptives, including the jadeite, are prominently represented among the boulders in the Tertiary conglomerate, and thus must have become weathered to contribute to the Tertiary sediments. These conglomerates are worked at Hweka for the jadeite-boulders, which are also collected among the recent alluvial deposits of the Uru river near Mamon.

Rubies of Naniazeik.

Dr. Bleeck also took the opportunity, while in the Myitkyina district, of examining the ruby-bearing deposits near Naniazeik. In all essential respects the

[1] *Records Geol. Surv. Ind.*, XXVI, 1893, p. 28.

[2] *Loc. cit.*, p. 28.

occurrence resembles the well-known area of Mogok described by Professor J. W. Judd and Mr. C. Barrington Brown.

Rubies are found in the soil and alluvial accumulations around the village of Naniazeik as well as in the river-gravels on the eastern slopes of the mountain ranges between Naniazeik and Manwe. This mountain range is composed mainly of granite and crystalline limestone, the latter having obtained its crystalline characters probably as stated before, through the intrusion of the granite. The limestone contains various minerals as the result of contact-metamorphism—garnet, spinel, chondrodite, graphite, forsterite, and other accessories, besides the valuable rubies and sapphires. The contact of granite and marble, exposed on the road from Sikaw to Naniazeik, shows the granite to assume a pressure structure near the margin, and to contain large quantities of phlogopite, which is a prominent mineral also on the marble side of the contact. The marbles, when freshly broken, have the characteristic evil smell of many limestones charged with nitrogenous organic matter. The marble is thus probably the result of the metamorphism of an ordinary sedimentary limestone of chemico-organic origin, but no data are obtainable to determine its age. Dr. Bleeck's paper is published in *Records, Geol. Surv. Ind.*, Vol. XXXVI, Part 3.

Palæontology.

Lower Eocene Mollusca.

The Mollusca from the Ranikot stage (Lower Eocene) are being described by Messrs. Cossmann and Pissaro of Paris, and the first instalment of their elaborate work, describing about 100 species of cephalopods and gastropods, has been received and translated by Mr. Vredenburg for publication in the *Palæontologia Indica*. On receipt of the description of the lamellibranchs it will be possible to estimate the stratigraphical significance of this work.

Intertrappean fossils in the Cretaceous of Baluchistan.

Mr. Vredenburg has sorted the valuable collections of Upper Cretaceous fossils from Baluchistan, and, during the course of this work, has discovered that the well-known freshwater gastropod *Physa Prinsepii* Sow. so characteristic of the freshwater beds intercalated in the Deccan Traps, occurs in marine beds containing Upper Cretaceous

(Mæstrichtian) ammonites. An account of this occurrence has been published as a special paper in the *Records, Geol. Surv.* (Vol. XXXV, p. 114, see also *Records*, Vol. XXXVI, p. 178, foot-note). The specimens have been found in the collections from the Des Valley, as well as in those from Mazar Drik, and all the essential features of the species are unmistakably displayed. The shells, therefore, must belong to individuals that were carried out to sea from the land on which the Intertrappean beds were laid down. The associated marine fossils fix the age of the beds with reasonable precision as upper Mæstrichtian, and we have thus an important piece of evidence to fix the age of the great Deccan Trap eruptions more precisely than was possible before.

Nummulitic rocks of the Palana coal-field.

A small collection of fossils obtained by Mr. Jervis from the Palana coal-field in the Bikaner State, Rajputana, has enabled Mr. Vredenburg to show that the coal-bearing series in this area corresponds to the Laki series of Lutetian age. In reviewing the fragmentary evidence regarding other post-Gondwana coal-fields in India, Mr. Vredenburg concludes that in most cases there is a balance of evidence in favour of a Laki age; he points out that there are many doubtful features in the evidences adduced for the existence of Cretaceous and of post-Nummulitic coal. This point, if confirmed, will give a valuable horizon for stratigraphical work, especially in Assam and Burma, where there are so many isolated small coal-bearing basins.

Study of Ostrea multicostata, Deshayes.

Among the Palana fossils occur specimens of *Ostrea multicostata*, Deshayes, a species about which there has been considerable confusion in geological literature. Mr. Vredenburg, having examined the descriptions of this and other close-ribbed *Ostreæ*, comes to the following conclusions:—

(1) The previous citations of *O. multicostata* in India refer to the following six species: (*a*) *O. angulata*, J. de C. Sowerby (Upper Nari and Gaj); (*b*) *O. latimarginata*, Vredenburg (=*O. flabellula*, Lamk., according to Sowerby; Upper Gaj); (*c*) *O. cubitus*, Deshayes (Lower Nari); (*d*) *Gryphæa Esterhazyi*, von Pavay (age uncertain); (*e*) *Ostrea turkestanensis*, Romanowski. (Nari in the lower Zhob valley); (*f*) *Exogyra* sp. (probably Cretaceous).

(2) The specimen regarded as eocene and figured in 1883 by d'Archiac and Haime as *Ostrea multicostata*, Desh., var.,

again figured under the same name, but as a miocene form, in both editions of the Manual (1879 and 1893), regarded, by Mayer-Eymer, in 1871, as the type of eocene species *O. orientalis*, is an incomplete, and consequently unsatisfactory specimen of the Aquitanian species *O. angulata*, J. de C. Sowerby.

(3) The true *O. multicostata* occurs in India in the middle eocene, and characterises the same beds as in Egypt and Southern Europe.

(4) The other close-ribbed species of *Ostrea sensa stricto* in the Indian Tertiary, are (*a*) *O. Fraasi*, Mayer-Eymer (Lower Nari), (*b*) *O.* n. sp. related to *O. Fraasi* (uppermost Gaj), (*c*) *O. digitalina*, Eichwald, var. *Rholfsi*, Fuchs, (Hinglaj series in the beds with *O. Virleti*), (*d*) *O. promensis*, Noetling [Yenangyaung series with (*e*) *O. peguensis*, Noetl., probably identical with *O. Virleti*].

(5) The Burdigalian stage, whose existence in Asia had been ascertained only over a very limited area, is found to be widely distributed in India, and includes the greater part of the Hinglaj series in the Mekran, the Yenangyaung series in Burma, and possibly the Cuddalore series, and other Tertiary beds in the coastal regions of the Peninsula.

Cretaceous Foraminifera.

Mr. Vredenburg has examined the collections of *Orbitoides* from the Cretaceous beds. These are found to agree generically, and in some cases specifically, with the forms known in Europe, while their stratigraphical distribution follows the European sequence. The Indian localities of the specimens examined are the Mari hills, and the province of Jhalawan in Baluchistan, Western Sind, the Suleiman range, and the Coromandel coast; the specimens occurring amongst Mr. Hayden's collections from Tibet have also been examined. It is in Dr. Noetling's collections from the Mari hills that the zonal sequence has been established in greatest detail. Mr. Vredenburg has identified a number of the associated fossils from this series, constituting the principal basis of the correlation which he has adopted.

In a general way three horizons are recognised—a lower one characterised principally by *O. media*, a middle one with *O. socialis*, *O. Hollandi* and *Omphalocyclus macropora*, and an upper one with *O. minor*. The lower zone is regarded by Mr. Vredenburg as principally Campanian,

the two others as Mæstrichtian. *Orbitoides media* and *Omphalocyclus macropora* are the two commonest species, and neither of them is entirely restricted to the zones above mentioned, *Omphalocyclus macropora* descending into the lower zone, and *Orbitoides media* rising into the middle one, but in a general way, *Omphalocyclus* is the newer form, rising into a horizon never reached by *O. media*, and *vice versâ*.

Mr. Vredenburg has noticed that in all the Indian occurrences *Omphalocyclus macropora* is represented by both forms megaspheric and microspheric. The existence of the dimorphism has for the first time been established only quite lately (December 1907) by Professor A. Silvestri in his study of the specimens occurring both at Mæstricht and in the neighbourhood of Palermo.[1] The constitution of the megasphere in the specimens from Baluchistan is identical with that of the Maestricht specimens figured by Silvestri. It is suggested that the close resemblance between *Orbitoides socialis* and the genus *Lepidocyclina* may be a case of "convergence."

Correlation of Baluchistan and Coromandel Cretaceous.

The identification of the fairly numerous ammonites from the Mari Hills and Jhalawan has enabled Mr. Vredenburg to attempt a correlation of the Baluchistan beds with the Ariyalur of Southern India: both the Valudayur and Trigonoarca beds are regarded as the equivalents of the lower part only of the ammonite-bearing beds of Baluchistan, those which have generally been spoken of as the "Hemipneustes-beds," and include the bulk of the two lower *Orbitoides*-bearing zones. The uppermost ammonite-bearing zone of Baluchistan (of which the leading fossils are *Sphenodiscus Ubaghsi*, *Indoceras baluchistanense* and *Cardita subcomplanata*) does not appear to be represented by any fossiliferous beds in the type region of the Coromandel. It possibly corresponds with the unfossiliferous sands, which, in the Trichinopoly area, intervene between the fossiliferous Ariayalur and Niniyur beds; but the stratigraphy of the Niniyur series has not been investigated sufficiently closely to allow of a strict correlation, though it certainly corresponds, in part at least, with the uppermost Cretaceous beds of Baluchistan and Sind, the "Pab sandstones" or "*Cardita Beaumonti* beds". In Western Persia, in the districts of which the geology has been unravelled by de Morgan and by Douville,[2] the "Echinoid beds" of these authors correspond principally with the Hemipneustes-beds of Baluchistan, while the "Cerithium-beds" are mainly the equivalents of the zone of *Cardita subcomplanata*. Mr.

[1] *Atti della Pontifica Acc. N. Lincei*, LXI, pp. 17—26.

[2] *Mission scientifique en Perse: mollusques fossiles, 1904.*

Vredenburg has suggested that the latter zone, unknown in the Trichinopoly and Pondicherri areas, may be represented further north along the east coast by the fluvio-marine intertrappeans of Rajamahendri, several of whose leading fossils, such as *Cerithium Stoddardi*, *Irania fosiformis* and *Physa Prinsepii*, are among the characteristic forms of the zone of *Cardita subcomplanata* in Baluchistan and Persia.

In consequence of the definite reference to well-known horizons resulting from a study of the Baluchistan fossils, Mr. Vredenburg is of opinion that the term "Pathanian," introduced by Dr. Noetling, becomes unnecessary as it clashes with the long established name "Mæstrichtian" (or "Dordonian").

Cretaceous Pseudofucoids near Fort Munro.

Mr. Vredenburg has studied a number of interesting specimens collected in the Suleiman Range by Mr. H. J. Maynard, I.C.S., the Revd. Mr. Lee-Mayer, Major F. W. Pirrie and Captain F. C. Nicolas. Among these are various markings of the kind well known in the Flysch formations of Europe, and formerly ascribed with doubt to algæ, but now generally regarded as tracks and trails of marine animals. The specimens of this nature from the neighbourhood of Fort Munro were obtained in rocks that have been correlated with the Pab series of uppermost Cretaceous age in Jhalawan, Baluchistan. Some of the markings are of a kind that might be made by various kinds of animals, and thus they show a general sameness of character in rocks of various ages, from Cambrian and possibly pre-Cambrian times to the miocene. Although these structures are consequently of no assistance in determining stratigraphical horizons, they are interesting because they characterise the so-called *Flysch* facies of formations in various periods, and the occurrence of similar structures in the Vindhyan sandstones of Peninsular India suggests that this peculiar formation has also originated *à la Flysch;* to this, perhaps, is due its mysterious barrenness from the palæontologist's point of view. Mr. Vredenburg's description of the material from Fort Munro is published in *Records, Geol. Surv. Ind.*, Vol. XXXVI, Part 4.

Napeng (Rhaetic) beds: Northern Shan States.

The collections made during the progress of the survey of the Northern Shan States by Messrs. La Touche and Datta from the Napeng shales have been examined and described by Miss Maud Healey, and the results will appear as a special Memoir in the *Palæontologia Indica* (New Series, Vol. II, *Mem.* No. 4). The work has presented

considerable difficulty, owing partly to the state of preservation of the fossils, which are almost without exception mere casts, and partly to the fact that the great majority of them are lamellibranchs, with no trace of the rich cephalopod or brachiopod fauna of the Himalayan Mesozoics. The stratigraphical position also of the beds, in which the fossils occur, could not be determined with accuracy, since they are found in isolated patches on the surface of the Shan Plateau, and their relations to the rocks both above and below are very obscure.

Although the general facies of the fauna seemed in the first instance to Messrs. La Touche and Datta to indicate a Mesozoic horizon for these fossils, the recognition of a *Conocardium* among them by Dr. Nœtling pointed to a much earlier position, and they were consequently at one time referred with much doubt to the Devonian period, especially as the stratigraphical evidence available seemed to point in that direction. Subsequently other interpretations were accepted for the fragmentary evidence obtainable.

The researches of Miss Healey have now placed it beyond doubt that the Napeng beds are Rhætic, since they contain numerous specimens of the characteristic Rhætic form *Pteria* (=*Avicula*) *contorta*, in addition to *Grammatodon Lycettii* and *Gervillia præcursor*, while many other specimens closely resemble Rhætic species. It is, however, a fact that the Palæozoic genera *Conocardium* and *Modiolopsis* are represented, in addition to *Palæoneilo*, which is also found in the Devonian shales of Wetwin.

Exotic Blocks of Malla Johar, Kumaon.

In the Central Himalayas of the Kumaon division the younger Mesozoic beds that form the complicated syncline of the Chitichun area are capped in places by massive limestone blocks which either appear to rest conformably on, or are embedded in, the soft Jurassic shales. They are partly of Palæozoic and partly of Lower Mesozoic age, and the anomalous position of these blocks above younger strata has given rise to a considerable amount of controversy. On account of the way in which they are weathered out as picturesque crags, rising in abrupt pinnacles above the younger rocks around, similar occurrences in the Carpathians and Alps have long been known as *Klippen*, and with reference to their origin, as *exotic blocks*.

The first comprehensive account of the geology of the Central Himalayas of Kumaon is due to the late C. L. Griesbach (*Mem.*,

Geol. Surv. Ind., XXIII). In a short paper referring to the preliminary results of a special expedition undertaken by himself, Professor C. Diener and Mr. C. S. Middlemiss in 1892, Mr. Griesbach referred specially to these exotic blocks (*Rec., Geol. Surv. Ind.*, XXVI, p. 22), and explained their occurrence by faulting. Professor C. Diener (*Mem., Geol. Surv. Ind.*, XXVIII, pp. 1—27) subsequently gave a general account of the fossils found during the 1892 expedition, and discussed more fully the origin of the exotic blocks, generally endorsing Griesbach's views. The late Dr. von Krafft extended the survey of the frontier district between Hundes and Malla Johar in 1900, and published a special memoir (*Mem., Geol. Surv. Ind.*, XXXII, Part III) on the exotic blocks, which, as remarked by Diener in his memoir on the "Cephalopoda of the Triassic limestone crags of Chitichun" (*Pal. Ind.*, XV, Vol. II, Pt. II, Chap. 3), he considered to differ from the "Klippen" of Europe in being intimately connected with igneous extrusions; but von Krafft admitted the difficulty of offering a satisfactory explanation of where the blocks had come from and how they had reached their present position.

Professor Diener has now completed a detailed description of the Upper Triassic and Liassic fossils obtained mainly by von Krafft, and has applied his results to the theories in existence regarding the origin of these remarkable phenomena. Professor Diener's results prove to be of most unusual interest. He confirms von Krafft's conclusion that the Permian and Triassic beds in the blocks belong to facies quite different to those of the beds of corresponding age found in the normal sections in this area: the former von Krafft termed the *Tibetan* and the latter the *Himalayan* Series. Professor Diener now notices that, in the carnic and liassic beds of the Tibetan series, there are remarkable agreements with their homotaxial equivalents in the Mediterranean region, the agreement being often lithological as well as faunistic. The fossils of Lower Triassic and Muschelkalk age in the exotic blocks show small affinities with the Alpine Trias, and more nearly resemble those of the Himalayan region; but there is still a certain lithological contrast. But the carnic fossils of the Tibetan series differ largely from those of the Himalayan series, and show very close affinities to the zones of *Trachyceras Aonoides* and *Tropites subbullatus* in the Eastern Alps. Among the liassic fossils of the Tibetan series Mediterranean affinities are still more marked, the identity of species being almost complete in some blocks; in fact, the difference between the liassic faunas of Wurtemberg or Eng-

land and the Alps is even more conspicuous than between the latter and the lower liassic fossils of the Tibetan series found in the exotic blocks. It is generally accepted that to the north of the main region of the Himalaya there existed a part of the ancient ocean, known as *Tethys*, which was in direct communication with the European area, and while local peculiarities existed in Triassic times sufficient to distinguish the assemblages of fossils of the Tibetan series from those of the Mediterranean region, the conditions in these widely separated parts of *Tethys* were almost obliterated in liassic times. It is assumed that the exotic blocks of Malla Johar were brought from somewhere further north in the Tibetan region; but we still are unable to identify the region, and this discovery by Professor Diener of the remarkable agreement between the "Tibetan" and Alpine carnic and liassic fossils adds considerably to the interest of the question. Professor Diener's memoir is now in the press and will be issued as Vol. 1, Part I, Series XV, of the *Palæontologia Indica*.

Cambrian fossils: Spiti.

The description of the Cambrian fossils collected in the Parahio and Pin valleys in Spiti during the years 1898-1901 has recently been received from Mr. F. R. Cowper Reed and is of very considerable interest. The fauna comprises ten genera of trilobites, five genera of brachiopods, one of pteropods (*Hyolithes*), one echinoderm (*Eocystites*) and one zoophyte (*Coscinocyathus*). The trilobites constitute by far the greatest proportion of the fauna, and embrace thirty-one species, of which almost all are new, only one being definitely identified with a hitherto described species; while three others are either identical with, or closely allied to, previously known forms. Next in importance come the brachiopods, of which there are 14 species, only ten being sufficiently well preserved for specific determination: of these ten species, six are new and four closely allied to, or identical with, North American forms.

In the Parahio valley, whence most of the specimens were obtained, six horizons have been recognised; and it is a remarkable fact that the fauna of each horizon is peculiar to it, no single species having been found in any two horizons. The lowest horizon is characterised by the presence of small brachiopods (*Lingulella* and *Billingsella*) and the remaining five by trilobites, of which two genera, *Ptychoparia* and *Olenus*, largely predominate; the latter genus is restricted to the uppermost horizon, whilst *Ptychoparia* is absent from this, but occurs in all the remaining four.

The only trilobite that has been definitely identified with a known species is *Redlichia Noetlingi* Redl., a single specimen of which was found in the Pin valley near Muth. It has not been found in the Parahio sections, and its position in the sequence is not completely established, but it is almost certainly not higher than that of the lowest horizon with *Billingsella* and *Lingulella*. The presence in Spiti of this well-known Salt Range species is of great interest, since it is the only form known to be common to these two areas. Its presence, however, leads Mr. Cowper Reed to conclude that the beds in the Pin valley, from which it was derived, are of uppermost Lower Cambrian age.

The remaining trilobites, with the exception of those found in the highest, or Olenus, horizon, as well as the brachiopods and other fossils, are remarkable for their dissimilarity to either Salt Range or European types. On the other hand, they show decided affinities to genera from the Middle Cambrian beds of Western North America; and Mr. Cowper Reed, therefore, regards them as of Middle Cambrian age, concluding that at that period Spiti formed a part of the North American province.

The highest horizon is especially characterised by the presence of the genus *Olenus* and the absence of *Ptychoparia*, and is regarded as of Upper Cambrian age.

The general conclusions arrived at by Mr. Cowper Reed, as expressed in his own words, are—

"(1) the main mass of the beds must be referred to the Middle Cambrian, and the palæontological affinities of the fossils in these beds are with the Rocky Mountain province of America;

"(2) the Lower Cambrian is probably represented in Spiti, and the sole species which it has yielded is identical with one occurring in the Eastern Salt Range;

"(3) the Upper Cambrian is found at the top of the Parahio sequence, and contains a small assemblage of fossils of indefinite affinities, but includes a member of the genus *Olenus*, thereby suggesting a connection with the northern European province."

These results have an important bearing on the classification adopted for the oldest Palæozoic systems of the Himalaya. In Spiti the trilobite beds are separated from the next overlying rock group by a marked unconformity, and the fact that the Upper Cambrian is represented by only the uppermost part of the trilobite beds leads to the inference that this system must either extend up into the overlying conglomerate and red

quartzite hitherto regarded as Ordovician, or that almost the whole of the Upper Cambrian was removed before the deposition of the latter formations. The apparent absence of this unconformity in the Garhwal and Kumaon Himalaya, and the presence below the red quartzite of a bed of limestone, regarded by Mr. Griesbach as of Ordovician age, points rather to the latter view as the correct one. The fossils from this limestone, which are now in Mr. Cowper Reed's hands, have not yet been critically examined, but it is hoped that they will enable us to define the upper limit of the Cambrian system of the Himalaya.

To find the lower limit of the system will be more difficult. The lowest known fossiliferous horizon in Spiti is that of *Redlichia Noetlingi*, which is presumably of uppermost Lower Cambrian age; consequently the rest of the system must be looked for in the underlying "red quartz shales," defined by Mr. Griesbach as the uppermost member of his Haimanta system. It seems hardly probable that the whole of the Haimanta system, which is many thousands of feet in thickness, is of Lower Cambrian age, and Mr. Cowper Reed's work thus confirms Mr. Griesbach's suggestion that his Haimantas include also pre-Cambrian beds.

Gondwana plants: Kashmir.

The problems connected with the plant-bearing beds underlying the Zewan stage of Kashmir are discussed fully in Mr. Hayden's paper on "the Stratigraphical Position of the Gangamopteris beds of Kashmir.[1]"

Professor A. C. Seward kindly examined the additional fossil plants collected by Mr. Hayden in 1906, and found that while the species previously recognised are generally repeated, the new material serves to confirm the previous provisional determination of a new species of *Psygmophyllum* and some imperfect remains of *Cordaites*.[2] The evidence of this new material does not affect Mr. Hayden's conclusion "that the *Gangamopteris* beds are not younger than Upper Carboniferous and may belong to the base of that sub-division, or even to the Middle Carboniferous."

A systematic survey of these beds is now being undertaken by Mr. C. S. Middlemiss, who will keep especially in view the important questions regarding the stratigraphical relationship of the plant-bearing series to the volcanic rocks below, and the apparently conformable

[1] *Rec., Geol. Surv. Ind.*, XXXVI, pp. 23—39, 1907.

[2] Prof. Seward's results are published in Part I of *Records, Geol. Surv. Ind.*, Vol. XXXVI.

passage of Permian into Triassic beds above. The discovery of further representatives of the Gondwana flora will also be of the greatest interest in determining the geological age of the Peninsular coal measures.

ECONOMIC ENQUIRIES.

Copper.

During the field season 1906-07 Mr. K. A. K. Hallowes continued his survey of the copper-bearing belt in the Singhbhum district, and the area was inspected during 1907-08 by Mr. L. L. Fermor. In consequence of the favourable results said to have been obtained in the past by prospecting operations on the area leased to the Rajdoha Company, observations were first directed with a view of finding a suitable site for diamond drilling, to be undertaken on the completion of the operations in progress in the Kharsawan Estate.

Mr. Hallowes reported two parallel outcrops of the copper-impregnated schists striking approximately N.W.—S.E. and showing at intervals from Matigara at the south-east end of the Rajdoha property to near Rajdoha on the north-west. The copper-bearing zones and the enclosing schists dip towards the N.E. at angles varying from about 52° to 35°, and sites were selected to the north of the outcrop for later determination of the lodes by drilling. A similar survey of the copper-bearing band was made in the Dhalbhum Estate and in Suraikela.

The diamond-drilling accomplished during the year included—

(*a*) Kodomdiha, north of Amda in the Kharsawan State: a hole to the depth of 1,093 feet. This hole was intended to test the persistence of the lode previously cut further south at a depth of 392—404 feet. At this place the lode was about 8 feet thick, and carrying 5·102 per cent. copper;[1] it was struck by the diamond drill further north at a depth of 1,069 feet, but was there found to carry only 1·825 per cent. copper for a thickness of about one foot.

(*b*) Regadih (Galudih), 5 miles west of Kodomdiha.

In this place a shallow hole was drilled to test the copper lodes that have been extensively quarried on the outcrop.

[1] Mr. Hallowes is responsible for this and the assay results quoted below.

Drilling was extended to a depth of 430 feet. Specks and stringers of copper pyrites were found at various depths from 131 feet to 294 feet; but there was nowhere a concentration of ore. The nearest approach to concentration was at a depth of 293 feet, where a portion of the core 13 inches long only gave 0·606 per cent. of copper.

(*c*) Landup (Nadup) near Kalimati in the Dhalbhum Estate. Drilling was continued to a depth of 465 feet, but the only concentration of ore was found at about 197—198 feet, where for a thickness of 14 inches the lode yielded 3·335 per cent. copper.

So far as they go these borings demonstrate a drawback that is a common failing among the ore-deposits in Peninsular India, namely, abundant material widely disseminated instead of concentrated in a way that would permit of economic exploitation. The diffused character of the ore accounts for the apparently extensive nature of the ancient workings that mark the outcrop. The conspicuous, highly-coloured carbonates probably occurred scattered over wide zones; but no one now knows how much copper was obtained from these quarrying operations, of which no historical record is preserved. Another feature shown by the diamond-drilling is the general constancy in dip of the copper-bearing bands; had there been more disturbance of the rocks, however, there might possibly have been developed the compensating feature of richer concentration.

The most favourable results obtained in 1907 were those at 392—404 feet in the Kodomdiha Drill-hole; but it is impossible to say without further work along the strike whether this is a mere local swelling of the lode or a fair representation of it in this locality. Similarly, the less favourable results elsewhere may give an unfair idea of the deposits tested: it will be the business of those who take up concessions to extend the Geological Survey work by further prospecting where, as at Kodomdiha, the expenditure of more money would be a reasonable venture.

Further borings are now in progress near Matigara and Laukisra, and the completion of these will finish the programme as far as the Geological Survey is concerned.

A large quantity of material has been collected and on the completion of the work in the Laboratory a full description of the lodes and associated rocks will be published.

Gold.

The small gold-field on the Namma, a tributary of the Salween some 50 miles east of Lashio, was visited by Messrs. LaTouche and Brown. An abortive attempt had been made during the previous year to recover the gold in this field by means of a steam dredger, but the character of the deposit was found to be unfitted for this method of exploitation. It consists of gravel and boulders imbedded in a stiff clay, hardened by the deposition of calcareous tufa derived from thick beds of limestone forming the sides of the valley, and not sufficiently loose to enable the buckets of the dredger to excavate it. Some form of hydraulic mining would seem to be more suitable and promising, as there is an abunbant supply of water (which could easily be obtained at high pressure) available on the spot.

The Namma, Northern Shan States.

The gold appears to have come from the ancient rocks forming the crest of the range on the north side of the valley, for the lower slopes on this side, and the whole of the southern side of the valley, are composed of limestone.

Manganese-ore.

Mr. L. L. Fermor was deputed to South India to inspect certain recently opened-up deposits of manganese-ore with a view of completing the data for his memoir on Indian manganese. The deposits examined included those of Sandur in the Bellary district, Chitaldrug, Kadur, Tumkur and Shimoga in Mysore, and various occurrences in the Belgaum district.

South India.

Most of the deposits in South India differ in an essential character from those of Nagpur and adjacent districts in the Central Provinces: in the latter area the ore-bodies now appear to be an integral part of the crystalline complex, although it is probable that they have attained their present character as bodies composed mainly of clean oxides by alteration of manganese-silicates, possibly through the agency of subterranean water of meteoric origin; in South India, however, as in parts of Jubbulpore, the ore-deposits are more superficial, and appear to be residual products from the surface alteration of the various lithological elements that constitute the Dharwar system of schists. The manganese-ores occur irregularly associated with litho-

marges, ochres and wads, sometimes taking the form of nodules and concretions, and sometimes of more extensive masses. The Kumsi deposit in the Shimoga district of Mysore is an exceptionally large example of such surface accumulations of ore; but most of them are of small depth and comparatively low in quality.

Sandur.

Enormous quantities of the so-called superficial kind of ore occur also in the Sandur State, where they were noticed long ago by R. Bruce Foote,[1] who also described the great syncline of Dharwar schists forming the Sandur hills. Mr. Fermor concludes that the manganese and associated iron-ores are formed as weather-products from hematitic schists and slates similar to those on which the ore-deposits now lie. In spite, however, of the fact that the ore-bodies must be described as superficial, there is no doubt that millions of tons are available on the Ramandrug plateau: it has yet to be proved that the ores of the Central Provinces will be more lasting than some of these so-called superficial deposits, for those that in the Central Provinces form a part of the crystalline complex probably pass down into silicates unsuitable for the requirements of the metallurgist. We have no idea as to the depths to which the pure oxides extend in any case. Like the so-called superficial deposits, many of these have obviously greater resources than will be affected by mining operations in the near future, and their owners are not at present sufficiently anxious about the distant future to share with Government the expense of testing their ore-bodies by diamond-drilling. Mr. Fermor's report on the occurrences in Sandur State has been sent to the General Sandur Mining Company, which has leased the principal deposits.

Inspection of Mines, Central Provinces.

Mr. Fermor was also deputed to the Central Provinces to make a second inspection of the manganese-ore quarries. The rapid development that followed the rise of prices in 1906, and the accessibility of the ore-bodies, have attracted a certain number of workers whose experience in the methods of mining hardly enable them to carry out the covenants made in their leases and licenses; it was partly in order to assist such workers with advice and criticism, partly to ensure development without unnecessary waste and destruction of the ore-bodies, that these informal inspections have been ordered.

[1] Geology of the Bellary District, *Mem., Geol. Surv. Ind.*, XXV, p. 194, 1895.

During h. st tour Mr. Fermor inspected the following deposits:—

Chhindwara district:—

Gowari Warhona, Sitapar, Gaimukh, Lakhanwara and Kachi Dhana, all worked by the Indian Manganese Company, Limited.

Nagpur district:—

Kodegaon, worked by the Indian Manganese Company; Gumgaon and Lohdongri, worked by the Central Provinces Prospecting Syndicate; Kacharwahi and Mandri, worked by the Central India Mining Company.

Bhandara district:—

Miragpur, worked by the Central India Mining Company, Hatora and Chikla, worked by the Central Provinces Prospecting Syndicate.

During his work Mr. Fermor received, as before, the courteous assistance of the Managers, and his report has been submitted to the Central Provinces Administration for communication to the Companies concerned. The criticisms made indicate a general improvement in the system of operations, an improvement that is the natural outcome of prosperity and consequent ability to entertain more highly qualified Managers. The disadvantages due to open cast workings, that were developed in the initial stages, before the Companies were assured of success, are now being generally recognised, and work is being planned for underground mining. The recent fall in prices will naturally limit the operations in a large number of cases, but a reasonable rest after the feverish rush to meet the heavy demands for ore that prevailed last year will not be wholly disadvantageous to the industry.

Mining Association.

The formation of the Central Provinces Mining Association is an incident welcomed by all interested in the progress of the manganese-mining industry; the recently settled question of adjusting the royalty charges to meet the rapid and great variations in ore-values is but one of the many problems, bearing on the industry, in which a representative Association can assist the aims of Government to maintain conditions equitable to the mining community, as well as to the previously established interests of other tax-payers.

Petroleum.

Upper Burma.

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marges, ochres and wads, sometimes taking the form of nodules and concretions, and sometimes of more extensive masses. The Kumsi deposit in the Shimoga district of Mysore is an exceptionally large example of such surface accumulations of ore; but most of them are of small depth and comparatively low in quality.

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Petroleum.

Upper Burma.

With the assistance of Mr. G. de P. Cotter, Mr. E. H. Pascoe was deputed for a second season to Burma for the supervision and further examination of

the oil-fields. Besides reports to the Burma Government regarding the local regulations, the geological work included :

(i) *An examination of the faulted area to the south of Beme village in the Yenangyaung Oil-field.*—Indications of faulting had been observed by Mr. Davies of the Burma Oil Co., and on examination Mr. Pascoe established a fault of some magnitude extending obliquely N.N.E. to S.S.W. across the outcrops of the various Miocene beds from close to the crest of the anticline for some distance into the Pliocene. Other adjacent faults —probably minor ones—render the elucidation of this area difficult in the extreme. Whether the large fault extends completely across the Miocene outcrop or ends in the numerous veins of mud which have honeycombed the crest-beds is a point which, it is hoped, will be cleared up by further work. There appears to be some connection between this faulting and the failure to find anything in appreciable quantities but gas south of Beme.

South Yenangyaung field.

(ii) *A survey of the Minbu Hills on a scale of 8 inches to a mile.*—This anticline of Miocene and Pliocene beds is one of great interest from a scientific point of view. Slightly asymmetric, and sharply folded, it has been very extensively denuded and its deeper structure laid bare. There are many comparatively large faults, one of which appears to coincide with the line of mud-volcanoes near the town of Minbu. In several spots within the 20 demarcated square-mile blocks, boring for oil has been undertaken but with little success. Although there is certainly room for further testing, it is very improbable that any large or richly yielding oil-field will ever be established here. An account of this area will be published later on.

Minbu.

(iii) *Examination of a recently discovered Miocene outcrop near Wetchok, east of Yenangyaung.*—Only the topmost beds of the Miocene are exposed here, and the fold is in the form of a gentle elliptic dome, the longer axis of which runs in the usual direction of Miocene anticlines in Burma, *viz.*, N.N.W. to S.S.E. There are several faults within the area, but the presence of a red alluvial deposit renders the tracing of them and estimation of their magnitude, matters of great difficulty. From the oil-winner's point of view the promising nature of the gentle fold is more or less nullified by the presence of faults, the small vertical depth of Miocene exposed, and

Wetchok.

the distance of the area from what has been termed the "oil-belt." A paper on this area is to be published shortly.

(iv) *Commencement of a resurvey of the Yenangyaung Oil-field.*—

Yenangyaung.

Two beds of marine fossils belonging to separate horizons and a bed containing a new variety of *Batissa*, were discovered. Several small faults not indicated in Dr. Noetling's published map, were found round the margin of the field, and it is chiefly for the mapping of these and the investigation of their effect upon neighbouring wells that a second survey has been undertaken.

Yenangyat.

Mr. Cotter assisted Mr. Pascoe in examining the Yenangyaung oil-field and the method of digging and drilling for oil. Afterwards he commenced work on the Yenangyat field, mapping the eastern and western boundaries of the Miocene outcrop north and south of block 67. The main features of interest here proved to be the narrowing of the Miocene outcrop (due apparently to sharper folding) and the number of ferruginous conglomerate bands on the western flank of the anticline. These bands contain both fossil-wood and selenite, in consequence of which difficulty was experienced in establishing a definite boundary between the Miocene and Pliocene. Mr. Cotter was enabled to confirm Mr. Grimes' and Mr. Pascoe's observations on the inversion of the anticlinal fold here.

Singu.

Mr. Cotter paid a visit to the Singu oil-field and among other fossils found a new species of *Dendrophyllia*, which was also found by Mr. Pascoe at Minbu. This coral is described in a paper published in *Records, Geol. Surv. Ind.*, Vol. XXXVI, Part 3.

Taungtha.

Mr. Cotter also surveyed Taungtha Hill. This anticline of Miocene and Pliocene is saddle-shaped, the crest sinking in the centre between two crest-maxima. Dips are very steep, especially on the eastern flank, and the beds appear to be considerably disturbed and faulted. Owing to this and the distance of the area from the "oil-belt," prospecting would not be very promising. Details of this region are published in *Records, Geol. Surv. Ind.*, Vol. XXXVI, Part 3.

Tatkan.

Later he examined the Yenangyaung blocks around Tatkan, between Singu and Yenangyaung, and pronounced unfavourably upon this tract. He was unable to identify any well-defined anticline here, and agreed with Mr. Grimes in considering the beds to consist of nothing but Pliocene.

Salt.

Rajputana.

Dr. W. A. K. Christie, the Chemist, has been engaged mainly in the examination of brines and river-waters from Rajputana. The investigations into the salt-resources of the Sambhar Lake described in the General Report of the Geological Survey for 1903-04 and 1905 left us in a state of uncertainty about (*a*) the balance of effect due to the artificial manufacture of pure salt and the annual additions of chloride and other sodium salts brought in by the rivers, (*b*) the origin of the large quantities of salt within the drainage basin. Arrangements have been made for the annual sampling of the lake-brine and of subterranean brine from various parts of the lake-bed. Samples of the inflowing "fresh" water during the monsoon are also being collected. It will require some years probably to demonstrate any change in the resources of the Lake due to the opposed agents of loss and gain; but it is hoped that the system now organised for annual sampling and the great precision adopted in analysis will, in a few years, afford data of the greatest value in gauging the prospects of the industry, as well as in estimating the age and nature of the processes by which Sambhar reached its present degree of salinity.

To account for the large quantities of salt in the many isolated basins in the Rajputana highlands, I have suggested the action of the strong south-west winds which blow into the desert region from the salt incrusted Rann of Cutch during the dry hot months that precede the monsoon rains in each year. These winds are very inconstant in velocity, but very constant in general direction, and all movements of sand and salt towards the north-east are positive, until the first fall of rain in June or July washes the accumulated salt-dust into the lowest part of each isolated rock-basin, forming the many small salt-lakes in the desert, where Sambhar, though the largest still above the sandy mantle, is but one of many. To test this theory Dr. Christie has designed an ingenious set of instruments for sampling the desert winds during the hot weather. His results will be awaited with interest, as it is obvious that reliable support of the theory must affect our notions generally regarding the salt-deposits of desert regions, which are in general regions of indraught during hot dry seasons, when the salt crystals can break up into the finest dust. As desert conditions are often so marked in the rocks that accompany the older rock-salt deposits, a theory of this kind, if estab-

lished, would also affect our notions regarding the origin of such deposits. But it is dangerous obviously to speculate on secondary issues while the theory itself is under trial.

Silver-Lead.

Bawdwin, Northern Shan States.

The ancient silver-lead mines of Bawdwin-gyi (Great Bawdwin in Tawng-peng, one of the lesser Shan States, were visited by Messrs. LaTouche and Brown, who studied respectively the geology and mineralogy of that interesting locality. These mines were worked by Chinese from Yunnan for a very long period until about 50 years ago, when they were deserted, and traces of their activity are everywhere apparent, notably in the numerous galleries driven into the hill-sides for the extraction of the ore, and in the enormous heaps of lead-slag which were thrown away after smelting out the portion of the lead containing the bulk of the silver. A Company has been formed for the purpose of exploiting these slags, and is now engaged in laying a steam tramway to the spot in order to bring the material to a convenient locality for smelting.

The ores occur in a zone of intense disturbance, caused by one or more great overthrust faults traversing the rocks, which are felspathic grits and rhyolitic tuffs, probably of Cambrian age. They consist for the most part of argentiferous galena and zinc-blende, with a small quantity of copper-pyrites in minute granules. The crushing and fissuring of the rocks has enabled water or vapours impregnated with mineral solutions to percolate through the mass, the metallic ores replacing by metasomatic action the felspar and other rock-forming minerals originally present. An account of the geology and mineralogy of the locality is now ready for publication.

Tin.

Mr. J. J. A. Page was deputed to make a survey of the tin-mining areas in the Mergui district, mainly with a view of assisting the Local Government in the administration of the industry. After a preliminary examination of the ground, and, after examining at headquarters the data collected during this tour, he made a preliminary report, and commenced a more detailed examination of the district.

The country is thickly covered with jungle and decomposition products which effectually conceal the rocks over great areas, while the

means of communication being still in a primitive condition, exploratory work was necessarily slow.

So far as the geological observations go, no facts were obtained to disturb the general views previously held regarding the structure of the country. The principal hill-ranges, with a N.—S. trend, are mainly composed of granite, with flanking hills cut-out largely of unfossiliferous schists, slates, sandstones and quartzites. The granites appear to be intrusive into the sedimentary rocks, and are exposed in a series of bosses that do not form a continuous outcrop. There appear to be more than one generation of granitic rocks, and they are traversed by quartz-porphyry dykes. The sedimentary rocks are provisionally referred to the so-called Mergui series, but it is impossible to determine their relationship to the adjoining Moulmein series, which includes Carboniferous limestone; hence their true geological age is not certainly known. Isolated patches of strata, probably Tertiary in age, are found resting unconformably on the highly inclined Mergui slates and quartzites. The coal-bearing occurrences of these rocks in the Tenasserim valley have been described already by Mr. P. N. Bose, under the local name of the Tendau group.[1]

The country is largely covered with laterite and recent alluvial deposits.

The only tin-ore worked is cassiterite, which is widely distributed throughout the district, and is invariably found near the granitic hills. The mineral is found under the following four conditions:—

(1) *As a constituent of decomposed pegmatite rich in tourmaline and muscovite, known locally as "Kra".*—This material is found at Yaungwa, at several points along the road to Inner Bôkpyin, at Yengan, Migyaungchaung, Manoron and Yamon. *Kra* was found in the hills east of Mawton, just north of the Tenasserim river; and, although no cassiterite was found here in the pegmatite, it was obtained in the superincumbent soil. Tin-bearing *kra* was also found south of Yaungwa on the new road to Karathuri, and in the Kyoukchychaung to the south of a large isolated hill of granite.

(2) *In massive quartz-segregations in and on the outskirts of granitic hills.*—Some of these segregations are several feet in thickness, and sometimes carry also wolfram, pyrite and chal-

[1] *Records, Geol. Surv. Ind.*, XXVI, p. 153, 1893.

copyrite. Examples: North Hill, Khow Maung (Centre Hill) and Peetolai in the neighbourhood of Maliwun.

(3) *In quartz veins and stringers in ground adjacent to decomposing pegmatite.*—In cases like that at Youngwa it is necessary to remove the matrix with the small stringers for the separation of the cassiterite.

(4) *Hill-side talus accumulations due to the disintegration of classes* (1), (2) *and* (3), extending to gravel deposits along the steam valleys and in alluvial flats. These form the deposits most generally worked by the Chinese and Siamese immigrants.

The following tin-mining localities were examined by Mr. Page :—

(1) *Maliwun area :* (*a*) Klong Bankwa (10° 14′; 98° 38′). Several small workings by Chinese. The only working apparently profitable yields 6 lbs. cassiterite per cubic yard of "dirt." (*b*) Klong Nam Sai (10° 16′; 98° 39′). Only one working, carried to a depth of 42 feet, where rich tin-bearing material is found, but the mine is hampered by the cost of dealing with a great overburden. (*c*) North Hill, Peetolai and Centre Hill, taken up by the Burma Development Company under mining lease. In this area stanniferous quartz segregations are being exploited. (*d*) Hassei Deng (10° 9′; 98° 37′) and (*e*) Klong Glama (10° 12′; 98° 39′). Old abandoned workings only.

(2) *Karanthuri area :* (*a*) Chaungtenaung (10° 53′; 98° 46′). Two workings in alluvium, yielding also small quantities of gold. (*b*) Chaungkapra (10° 55′; 98° 48′). Five workings in alluvium. (*c*) Karathuri (10° 56′; 98° 48′) 22 workings on the hill-sides and low ground.

(3) *Yaungwa to Bôkpyin :* (*a*) To Twe (11° 4′; 98° 46′). Two workings. Tin occurs also in the mangrove swamps below high-tide level. (*b*) Hangpru (11° 1′; 98° 50′). Three active workings, and others abandoned. (*c*) Yaungwa (11° 8′; 98° 52′) to Inner Bôkpyin (11° 14′; 98° 50′). Four native mining leases owned by Messrs. Kinloch and Eglington are being worked; fifteen native workings besides prospecting licenses granted to two European companies who have closed operations.

(4) *Bôkpyin to Yengan :* (*a*) Sadien (11° 23′; 98° 48′). Many abandoned old workings. (*b*) Migyaung chaung (11° 25′; 98° 47′). Workings in pegmatite and alluvium; the deposits are rich, but difficult to work on account of want of water. (*c*) Yengan

(11° 27′; 98° 48′). Seven workings in good alluvium, hampered by want of water. The alluvial flats would be worth testing by borings with a view of pond-dredging from the adjoining creek.

(5) *Manoron area:* Keh chaung and Hesamkong (11° 31′; 99° 12′). Eighteen apparently profitable workings operated only in the rainy season. Stanniferous quartz stringers in one working only, the remainder being alluvial.

(6) *Mergui area:* Yamon (12° 13′; 98° 47′) to Naukle (12° 18′; 98° 47′). Eight workings, all shallow, yielding cassiterite from ½ to 2 lbs. per cubic yard of the stanniferous layer, which varies from 18 inches to 3 feet in thickness. The locality is possibly worth prospecting with a view of dredging.

(7) *Great Tenasserim Valley:* (*a*) Tagu (12° 16′; 99° 4′). One lease being worked besides abandoned old workings. Wolfram in white quartz fragments found with the alluvial tin, but not found *in situ*. (*b*) Theindaw (Tendau) (12° 20′; 99° 10′). Many old workings showing "pay-dirt" at a depth of about 16 feet. Concessions have been granted for working on European lines.

(8) Thabalik (12° 1′; 99° 15′) near the Siamese boundary. Five native leases being worked. The "pay-dirt" appears to be richer than in most places. In the streams wolfram was found in quartz fragments.

Tungsten.

While prospecting for manganese-ore in the Nagpur district Mr. J. Kellerschon, Agent in India for the Carnegie Steel Company, came upon a vein of mineral that proved to be wolfram on determination by Mr. G. G. Narke, a student-apprentice on the Geological Survey. Mr. Fermor was accordingly requested to examine the occurrence during the course of his annual inspection of the manganese-mines in December 1907. Meanwhile, the occurrence was developed by Mr. Kellerschon, to whom we are indebted for more material and full facilities for studying the deposits. According to Mr. Fermor's description, the deposit as exposed lies within the boundaries of Agargaon in the Umrer tahsil, where the wolfram is found as a constituent of quartz-veins intercalated in mica-schists and tourmaline-schists that belong to the Dharwar system. The wolfram-bearing veins are more intimately

connected with the tourmaline-schists, and the formation of the tourmaline was probably due to the same mineralising agencies which gave rise to the deposition of the wolfram and quartz in fissures opened along the foliation-planes of the schists.

The wolfram is irregular in its degree of concentration, and work had not proceeded far enough at the time of Mr. Fermor's visit to settle with certainty the economic prospects of the deposit. Crystals of the wolfram generally vary from ½ to 2 inches in diameter, but some of them measure as much as 4 to 5 inches across. The quartz-wolfram veins are of all sizes, from thin "stringers" to about 18 inches thick, and they permeate a band of "country" that may be 70 feet wide. The schists and included veins strike about W.S.W.—E.N.E., and prospecting licenses have been granted for the extensions in both directions from the original locality in Agargaon. Nothing was found at the surface to indicate this occurrence, and the chance discovery in a prospecting pit, put down because of some black stains supposed to be manganese-ore, gives an idea of how much is hidden in Peninsular India under the monotonous peneplain, in which the rocks are masked by a thin envelope of soil.

Water.

Ajmer.

Owing to the considerable growth of the city of Ajmer, whose prosperity within recent years has been greatly increased by the presence of the Railway workshops, the question of increasing the water-supply has become imperative, as, owing to the increase in the demand, the amount of water supplied by the present scheme threatens to fall short in years of drought. Owing to the elevated situation of the city, there is no hope of being able to furnish the supply by gravitation alone, and Mr. Vredenburg, who was deputed in April 1907, to report on this question, deprecates any scheme relying solely upon artificial or natural lakes, where the evaporation is great and the supply depends largely upon a rather precarious rainfall. The streams are all liable to dry up entirely during part of the year, and Mr. Vredenburg is of opinion that a sufficient supply should be obtainable by sinking large percolation wells through the thick alluvial formation that occupies the neighbouring valley. The fact that wells of this sort suffice to irrigate an area of several square miles in the neighbourhood of the town, even during years of greatest scarcity, is an indication that the

supply must be ample for the needs of the city. For the practical utility of any scheme it is important that the sources of supply be not too much scattered. Experiments are therefore being conducted in the hope of finding some convenient spot from which the whole supply or a considerable fraction of it might be obtained.

Mr. Vredenburg examined a number of wells within a radius of about 12 miles from the city, and came to the conclusion that the valley of the Sagarmati, south of the town, and that of the Sarsuti, west of it, appear the most promising areas, the first-named benefiting by a large drainage area. The wells are now being systematically tested, and experimental borings are also being sunk through the alluvium.

From one of these borings, put down in the month of June 1907 by Mr. Goodwin, in the Sarsuti valley, the water rose above the surface, and has continued flowing ever since, indicating the existence of artesian conditions, and thus reproducing on a small scale those observed in Baluchistan. There is a gentle slope of the alluvial formation from the hill-range bordering the Sarsuti valley on its eastern side, down to the river bed; the alluvial formation includes alternating layers of clay and of sand, the latter being blown sand re-distributed by rain, and it is this alternation of pervious and impermeable strata, combined with the slope of the ground, which accounts for the artesian conditions observed.

The hill ranges and the rocks underlying the alluvium belong to the Aravalli system of ancient schists, which are impervious, or in which water occurs only in fissures that cannot be systematically explored.

Gujarat.

The work of undertaking borings for water in Gujarat [Programme for 1906-07 (*i*)] could not be commenced until the completion of the boring operations in Singbhum. This work has, however, now been commenced by the Bombay Government acting with the advice of the Geological Survey.

Mineral Production.

The statistics of mineral production for the year 1907 have been published in a separate paper in the *Records, Geol. Surv. of India*, (Vol. XXXVII, pp. 57—128). The total value of the minerals, for which fairly reliable returns have been obtained, amounts to a little over seven millions sterling, being an increase on the total for 1906 of 12 per cent. The principal increases in value have been due to coal, petroleum and manganese ore. For the first time the value of the coal produced (reckoned as its sale price at the pitmouth), has exceeded the total

value of gold. The total quantity of coal raised during 1907 amounted to over eleven million tons, 96 per cent. having been obtained from mines in the Gondwana coal-fields of Peninsular India. The Jherria field alone produced over 46 per cent. of the total. Besides the generally satisfactory improvement in production, there has been a remarkably increased activity in prospecting; returns are not available for the licenses and leases that have been obtained by Companies in Native States and in other areas where the mineral rights have been alienated with the surface rights; but, in lands in which Government have reserved the mineral rights, there has been an increase in the number of concessions granted from 252 in 1906 to 600 in 1907.

REPORT ON GEOGRAPHY AND GEODESY.

BY

COLONEL S. G. BURRARD, R.E., F.R.S.

Dr. Stein's explorations in Turkistan.

Dr. M. A. Stein started from India in the spring of 1906, and after an absence of two and a half years he has now set out upon his return journey. During this long interval he has been continuing his geographical and archæological explorations in Chinese Turkistan, his former travels over this desert country having yielded results of great and unexpected value.

The Chiragh Tar Gorge.—On leaving Tashkurgan for Kashgar in June 1906, Dr. Stein detached Rai Sahib Ram Singh, Survey of India, to follow the Chiragh Tar Gorge. This gorge has been cut through the great Kashgar range by the Tashkurgan river, and Rai Sahib Ram Singh is the first geographical explorer who has passed through it. In places the walls of the gorge are perpendicular, and the only method of progress for the traveller is to climb the sheer face of the rock by means of the wooden stakes which have been driven by natives into the wall 100 feet above the torrent. Ram Singh crawled along these stakes for miles, and being unaccustomed to such surroundings he took the precaution to tie himself by ropes to his guides. Subsequently he joined Dr. Stein at Yangi Hissar.

The Hindu Tash pass.—In July 1906, Dr. Stein directed Ram Singh to visit Shahidulla and to cross the Kuen Lun range by the Hindu

Tash pass. Ram Singh decided to penetrate the Kuen Lun by the gorge of the Karakash river, but after following the river for some days he found that its channel became so narrow, and its stream so deep and strong, that his further passage was barred. His guide attempting to cross the river on a yak was swept away, and his khalasee, Jashwant Singh, riding a pony, met with the same fate : neither of the men was drowned, but Ram Singh decided to retrace his steps and select an easier route. After visiting Shaidulla, Ram Singh set out for the Hindu Tash pass. This he succeeded in crossing, and on reaching the first village on the further side he found the villagers filled with astonishment to see him and wondering where he could have come from, as no natives cross over the Hindu Tash now-a-days. Ram Singh describes the pass as only 17,000 feet high and as being buried under glacier ice. He was told by the villagers that in ancient times this pass was the main trade route between India and Chinese Turkistan, but that within the last century heavy falls of snow on the surrounding mountains have created a glacier intersected by crevasses and impassable for baggage animals.

Dr. Stein's movements.—No complete account of Dr. Stein's own exploration will be available until he arrives in India. It is known that during the winter of 1906-07 he was carrying out archæological explorations in the plains round Anshi and Tunhuang, and that in the summer of 1907 he was making geographical surveys of the outer and central ranges of the Nan Shan. In the autumn of 1907 he returned to his archæological investigations in the deserts of Tarim.

In the spring of 1908, he was excavating sand-buried towns in the Khotan and Keriya districts and was fixing their sites on his map.

Dr. Stein has discovered that the low and apparently insignificant hill range of Mazar Tagh, which flanks the Khotan river in the desert, is possessed of considerable length, and is continued throughout the western parts of the Taklamakan desert and beyond the Yarkand river far away to the north-west. The presence of a long continuous range stretching across the sandy floor of the Tarim basin is an interesting geological fact.

In April 1908, Dr. Stein crossed the Tarim desert from Khotan to Aksu, and it is hoped that during this journey he was able to lay down the hitherto disputed course of the Khotan river up to its junction with the Tarim; on leaving Aksu Dr. Stein penetrated the Tianshan mountains to the north.

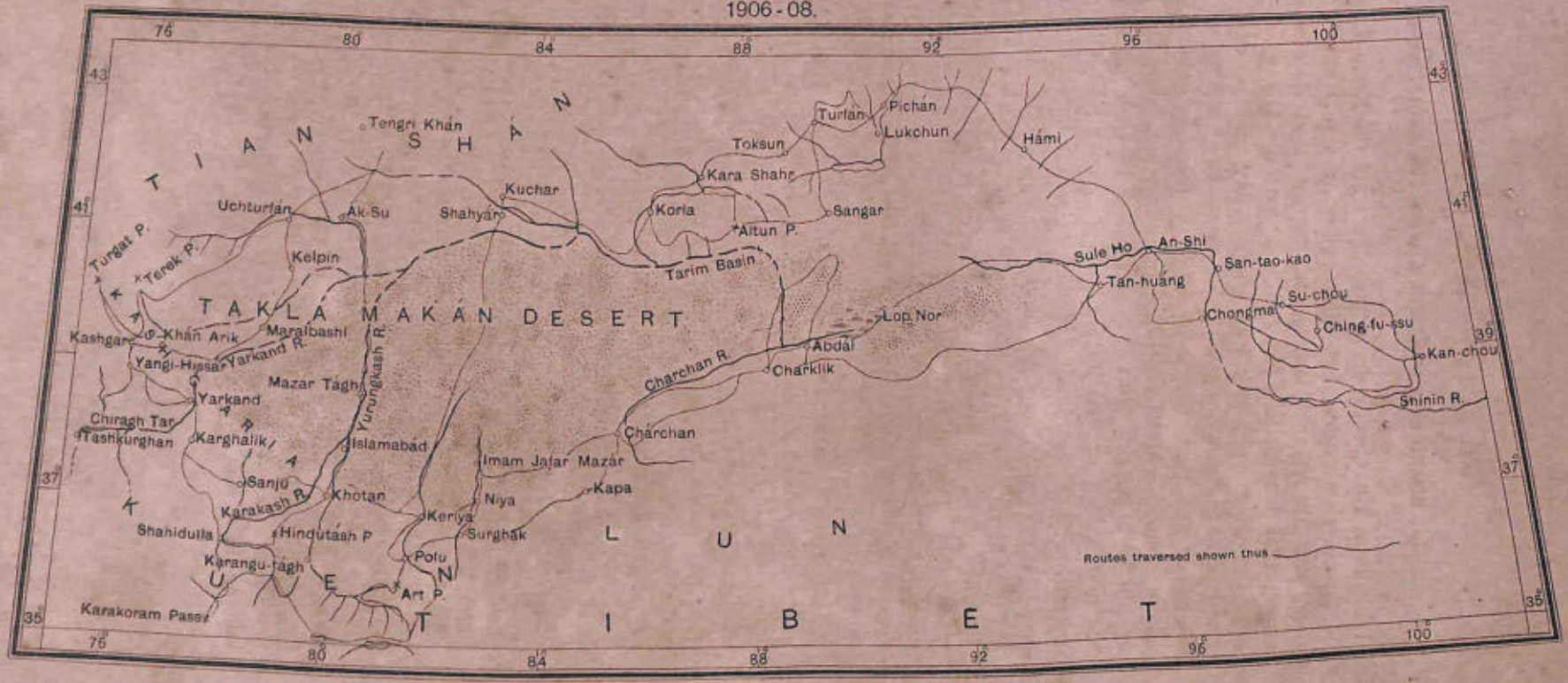
EXPLORATIONS IN CHINESE TURKISTAN & KANSU

BY

Dr. M. A. STEIN AND SURVEYORS RAM SINGH & LAL SINGH

in

1906-08.



Heliozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún.
January 1909.

The length of the Indian Survey Standard.

In view of the possible employment in the near future of a four-metre Invar Standard and of Jäderin wires in the measurement of geodetic bases in India, it was deemed advisable that the Indian Standard Bar A, in terms of which the lengths of all the former Indian bases have been determined, should be sent to Europe to be compared against the new International Metre, so that we should have the means of referring bases of the future to those of the past.

In order to provide ourselves with data, which would enable us to detect any change of length, which might occur during the Bar's journey to Europe and back, rigorous comparisons were made between the standard Bar A and the two Secondary Standards I_b and I_s before the despatch of Bar A to Sevres. These comparisons were carried out at Dehra Dun between November 1907 and January 1908.

The precise object of the observations was the determination of the differences between the lengths of the Bars at a temperature of 62° F. The time available being too short to allow of a satisfactory re-determination of the co-efficients of expansions, it was decided to accept the co-efficients as determined in 1870, and in order to minimise the effects of errors in the adopted values of these co-efficients, the observers arranged that the mean temperature of the bars during the observations should be approximately 62° F. Some weeks before the commencement of the actual comparisons the room in which they were to be made was covered by a protection of thatch, an air space of 4 feet being left between the walls of the room and the enclosing thatch. By the aid of small stoves the temperature of the room was then satisfactorily controlled. Daily thermograph diagrams showed that, when communication with the outer air was stopped, the interior temperature seldom varied as much as one degree in 24 hours.

Bar A was compared against Bar I_s and I_b alternately. The two bars selected for comparison were laid in double walled boxes, thickly covered with wool and felt, and placed side by side on the traveller of the comparator. Each Bar was provided with two thermometers, the bulbs of which were placed in wells in the bar, filled with mercury in the case of the bars A and I_s and with oil in the case of bar I_b.

Forty-two sets of comparisons were made between Bars A and I_s, the temperatures of observation ranging from 6°·88 above to 5°·37 below 62° F. Thirty-eight sets of comparisons were made between Bars A and I_b, the temperatures ranging from 7°·13 above to 6°·34 below 62° F.

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The results of the comparisons were:—

I_a—A at 62°F.=83·12 millionths of a yard.

I_b—A at 62°F.=196·73 millionths of a yard.

The comparisons made in 1867 and 1870 gave—

I_b—A at 62°F.=82·52 millionths of a yard.

I_b—A at 62°F.=213·98 millionths of a yard.

The difference between the old and the new comparisons of I_a—A is thus 0·60 millionth of a yard; this quantity is equal to the six millionth part of the length of Bar A.

The difference between the old and new comparisons of I_b—A is 17·25 millionths of a yard; this quantity is equal to the two hundred thousandth part of the length of Bar A.

On the conclusion of the comparisons at Dehra, Bar A was sent to Sevres for comparison with the International Metre. The results of the observations in France have now been received from M. Guillaume.

The length of Bar A at 62°F. has been found to be 3047·996 millimetres.

From Colonel Clarke's observations made in 1864, the length of Bar A at 62°F. was found to be 3047·984 mm.

The difference between the old and new values of length is thus—

0·012 mm.

or about 13·12 millionths of a yard.

The observations taken both at Dehra Dun and at Sevres increase our confidence in the Indian Standards of length. The comparisons at Sevres show that no sensible change can be detected in the length of the Standard Bar A, and the comparisons at Dehra Dun indicate no changes in the bars I_a and I_b relative to Bar A. Standard Bar A was brought to India in 1830 and the bars I_a and I_b in 1866: within the last twenty years great improvements have been made in the construction of standards of length, and greater accuracy of comparison is attainable with modern than with ancient standards. If the comparative coarseness of the old marks, which define the terminals of the Indian standards, is taken into consideration, no closer agreements can be looked for than those which have been obtained in the recent comparisons.

On the measurement of Geodetic bases.

Many years have elapsed since a base-line was measured in India, and during this interval a complete revolution in the method of precise linear measurement has taken place. That India has not been able

to keep pace with other countries has been due to the lack of personnel for carrying out geodetic measurements. In the United States of America base-lines are being measured at every 100 miles, and in South Africa they have been measured at intervals of 120 miles. Over the plains of Russia there has been an extraordinary development of the use of wires for linear measurements. In India proper there are sufficient base-line measurements, but throughout the whole of the Burma triangulation there is not a single base-line. During the last few years the Indian triangulation has been extended to the west through Baluchistan up to the Persian frontier but here again no bases have been measured.

It was therefore very desirable that information should be obtained as to the latest method of measuring geodetic bases, and for this purpose Captain Turner when in England was deputed to report on the use of Invar.

His report, which was received early in 1907, recommended that Invar wires of the type manufactured in Paris and tested by the Bureau International des Poids et Mesures at Sevres should be used. As these wires were being manufactured in 24 metre lengths, he recommended that the unit of measurement for geodetic surveys in India should be altered from the foot to the metre.

Captain Turner's recommendations have now been approved and a complete measuring apparatus, similar to that used by M. Guillaume, has been ordered from M. Carpentier of Paris. The wires will be standardised and tested at the Bureau International, and M. Guillaume has kindly undertaken to inspect the apparatus before it is despatched to India.

Principal Triangulation.

During the year three detachments were employed upon principal triangulation, and consequently a larger addition than usual has been made to the Geodetic Survey of India.

Western Baluchistan.—In Western Baluchistan Captain Browne completed the Kalat Longitudinal Series up to the Persian border; the new triangulation was 107 miles in length and contained 13 triangles with an average triangular error of $0''{\cdot}35$.

The Kalat series which has now been finished is approximately 480 miles long from its origin on the Indus to its terminus near Persia, and it embraces an area of 11,000 square miles within its triangles.

It is of interest to compare the accuracy of this Kalat Series, which is the latest triangulation of the Trigonometrical Survey of India, with the most recent geodetic work of other countries; the relative accuracies of different surveys may be compared by means of their respective probable errors, the smaller the probable error the greater the accuracy of the survey.

If in any triangulation N be the number of triangles, and $\Sigma\Delta^2$ the sum of the squares of the triangular errors, and if E be the probable error of an observed angle, then $E = \frac{2}{3}\sqrt{\frac{\Sigma\Delta^2}{3N}}$

This formula gives for the Kalat Series

$E = 0''{\cdot}21$

In the recent geodetic triangulation of Rhodesia

E was $0.''44$

In the triangulation of Cape Colony E was $0''{\cdot}34$, and in the triangulation on the 98th meridian of the United States of America E was $0''{\cdot}48$.

When we consider the great difficulties of carrying triangulation through an uninhabited and waterless country like Baluchistan and the hardships, to which the parties are exposed, marching as they have to do over low-lying burning deserts and then encamping on the highest peaks amid unceasing winds, we realise the determination and perseverance, that have been necessary in order to obtain results surpassing in accuracy the best work of Africa and America.

The Kalat series has taken four years to complete, the observers being Captain H. H. Turner, R. E. and Captain C. M. Browne, D.S.O., R.E.; of the 51 triangles only three have an error exceeding 1", and no triangular error is as large as $1''{\cdot}5$.

Five Astronomical Azimuths have been observed at different points of the series; and, if we compare the astronomical values with the values computed from the triangulation, the latter are always found to be too large. The persistency of the excess is a warning to us that our computations are taking the triangulation too far to the south. The error of direction is being gradually accumulated as we get further from the centre of India, because our formulæ for triangulation are derived from a spheroid, which is appreciably smaller than the true Figure of the Earth.

Koh-i-Malik Siah.—The westernmost station of the Kalat series is Koh-i-Malik Siah, the trijunction point of India, Persia and Afghanistan: this point is of interest both from its political importance and from its

being the most westerly limit now reached by the Principal Triangulation of India. The Astronomical Azimuth at this place differs from the value computed through the triangulation by 13″·04, the largest positive difference that has been discovered during the Indian observations. The value of latitude, hitherto accepted for Koh-i-Malik Siah, was found to be 1″·84 too great and the value of its longitude 4″·879 too great; the position on the earth, assigned to Koh-i-Malik Siah, was thus 468 feet in error.

Koh-i-Taftan.—An interesting mountain fixed with care from no less than 10 stations was Koh-i-Taftan. Its summit is formed by two main peaks of nearly equal height, the southern and higher being still an active volcano in more or less constant eruption.

Koh-i-Taftan is a very conspicuous landmark being visible on clear days from the whole country within 150 miles radius: no point within 300 miles of it approaches it in altitude, and it is covered with snow for nearly the whole year.

Its distance from the sea (about 250 miles) is, I think, the greatest of any active volcano in the world.

The co-ordinates of the two main peaks of Taftan are (*a*) south-west peak, (active volcano), Latitude 28° 36′ 0″·49, Longitude 61° 10′ 28″·14, height 12,973; (*b*) north-east peak, Latitude 28° 36′ 28″·63, Longitude 61° 9′ 54″·00, height 12,935.

The geographical positions hitherto assigned to the peaks of Taftan were found by Captain Browne to be in error by over 600 feet, the old positions being north-east of the true.

To the north-west of Taftan are several extinct volcanoes, and the whole region is a most curious mixture of aqueous and igneous deposits. The volcano of Koh-i-Sultan, on which Captain Browne observed for 10 days in 1907, is dying, but is not quite dead; though its huge crater is now floored with debris and silt, Captain Browne found his theodolite constantly disturbed by the tremors and pulsations of the mountain.

Burma.—In Burma the great Salween triangulation was re-started from the point, at which it had been discontinued in 1902-03: its direction has now been made to follow the British boundary so that it may encompass as much as possible of British territory.

Lieutenant Cardew, R.E., was the observer. He completed 14 triangles and extended the series by 55 miles; his average triangular error was 0″·64.

An Astronomical Azimuth was observed at Loi Hpatan, and the difference found between the value so obtained and that computed from

the triangulation was 8″·01. The sign of this difference was negative, which is in accordance with other azimuthal observations in Burma, but which is directly opposed to the observations in Baluchistan.

The country through which the Salween series runs is wooded and mountainous, the stations being generally at an elevation of 7,000 feet.

By this extension into Eastern Burma combined with that into Western Baluchistan the length of the Indian arc of parallel has been increased to 38 degrees of Longitude.

Northern Baluchistan.—In Northern Baluchistan Lieutenant Oakes, R.E, has been at work throughout the hot weather on the new series of triangulation, which is to be carried from Kalat through Toba and Zhob along the Afghan boundary, and which will eventually join the Great Indus Series at Sheikh Budin.

During the coming winter Lieutenant Cardew will commence observations at Sheikh Budin, the eastern extremity of the series, and it is hoped that, with two observers working simultaneously, the whole series may be finished in 1909-10.

Tidal Operations.

During the past year tidal registrations by automatic tide-gauges have been taken at the ports of Aden, Karachi, Apollo Bander (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon and Port Blair.

The tidal observatory at Karachi, which was wrecked in the cyclone of June 6th, 1907, was re-started on October 12th, 1907, and has since been working satisfactorily.

The erection of the tidal cabin at Moulmein was completed in August 1908. The tide-gauge and other instruments will be installed before the end of this year, and registrations will be commenced on January 1st, 1909. Moulmein will now become one of the permanent tidal stations of Indian waters.

Levelling Operations.

The total outturn of double levelling during the field season of 1907-08 was 941 miles, in the course of which observations were taken at 12,094 stations. The Bench marks determined were 8 Standard, 70 Embedded, 667 Inscribed, and 25 belonging to other departments.

The old line of levels between Bombay and Madras, which was executed 30 years ago, had exhibited a closing error of 2·98 feet, Madras being placed 2·98 feet higher by this levelling from Bombay than it had

been shown to be by tidal observations taken in its own harbour. The 800 miles of levelling from Madras to Bombay have now been revised, and the new revisionary line has closed at Madras with an error of +0·607 foot.

The closing error has thus been reduced by 2·37 feet, from 2·98 to 0·607. General Walker, who was Surveyor General of India from 1879 to 1883, always maintained that the discrepancy of 2·98 feet at Madras was due to a steady and imperceptible accumulation of levelling error: the recent revision has shown that his view was entirely correct, and has disproved the theory that the mean sea level at Madras was actually lower than at Bombay.

The new pattern of level.—The levels, used by the Survey of India, have shown themselves trustworthy instruments, but they are of ancient pattern, and since they were made, undoubted improvements have been devised. At the International Geodetic Conference, which met at Copenhagen in 1905, the Superintendent of the Geodetic Survey of the United States of America exhibited a new pattern of level, which seemed to be a great advance upon all previous patterns. Two of these American levels were bought for the Survey of India, and were tried in the field last winter. The trials were entirely successful; and it will now be possible to work both more quickly and more accurately.

The device by which the *speed* of levelling can be increased is a very simple one: the telescope of the level is furnished with three intersecting wires instead of one. At each pointing of the level the staff can thus be read in three places simultaneously, instead of in one. This arrangement dispenses with the necessity both of chaining from the level to the staff, and of reading the *two* faces of the staff. We can now deduce the distance of the staff from the readings of the wires upon it; and the risk of reading the staff incorrectly to a *whole foot* is entirely eliminated by the triplication of the wires. It was merely to obviate this risk that staves were originally given two differently graduated faces. The operation of reversing the faces of the staves greatly prolongs observations, and is a troublesome step, that the levelling officers will gladly see dispensed with.

The plan by which the *accuracy* of levelling can be increased has been designed to get rid of the errors, that are caused by the observer walking round his level, when he wishes to read the bubble after observing with the telescope. When an observer transfers his weight from one side of a level to another, the ground sinks as he approaches and

recovers as he departs, and the bubble of the level responds to these disturbances. The observer is therefore always liable to read his bubble, when it is in a different position to what it was at the instant of his telescopic observation. In the American levels this liability to error has been eliminated: these levels are binoculars, and the two telescopes are viewed simultaneously; one telescope shows the image of the staff with the cross wires upon it, and the other telescope shows the image of the level bubble by reflection. It is easy now to watch both the staff and the bubble at the same instant.

As the instrumental improvements that have been introduced have proved successful, I have considered them to be worthy of mention in this report of progress.

Pendulum Operations.

The absolute value of gravity in India.—From the vibrations of a pendulum we are able to determine the *relative* intensity of gravity at the several places at which we observe, but the *absolute* intensity of gravity can only be deduced from the observations of a pendulum, if we know the latter's length. To measure the length of a pendulum from its bearing knife-edge to its centre of gravity, with any pretence to requisite accuracy, is an operation for which the trigonometrical survey has neither sufficient apparatus, nor suitable observatory. Enquiries have been received during the last year as to how we obtain our *absolute* values of g, and it is therefore desirable to explain.

Major Lenox-Conyngham observed the time of one vibration of each of his four pendulums both at Kew and at Dehra Dun: his results were as follows:—

Time of vibration (in seconds) of the mean pendulum.

October, 1903. At Kew, $0{\cdot}5067001 = S_1$
January, 1904. At Dehra Dun, $0{\cdot}5072524 = S_2$

Then if g be the required force of gravity at Dehra, and 981·200 c. m. be the absolute intensity at Kew;

$$g = 981{\cdot}200 \times \frac{S_1^2}{S_2^2} = 979{\cdot}062.$$

The first question, that may be raised is, what proof exists that the pendulums did not alter in length on their journey from Kew to Dehra Dun? The answer is that Professor Hecker brought independent pendulums from Potsdam to India in January 1905, and having compared them

against Major Lenox-Conyngham's he returned with them to Potsdam; his observations have confirmed those we had already obtained.

The second question, that may be raised is, on what basis does the assumed value rest of g for Kew, *viz.*, 981·200? This value is that adopted by Professor Helmert for the International Geodetic Association: it is not a final value, and will probably have to be modified at an early date. When any modification is introduced, a corresponding change in all the Indian values of g will become necessary.

Of more recent years Major Lenox-Conyngham has had reasons to fear that his pendulums might be changing in length: his results at Dehra Dun have been as follows:—

Date.	Time of vibration in seconds.	Value of g
January . .	1904	0·5072524	979·061
June . .	1904	
November .	1904	0·5072516	979·064
May . .	1905	
November .	1905	0·5072511	979·066
April . .	1906	
November .	1906	0·5072507	979·068
April . .	1907	

From January 1904 to April 1907, the change in the value of g has been persistent, and if this change is still found to continue during the next few years, it will have to be accepted as real. Hitherto the variation, though progressive in character, has been in the aggregate small, and it is still possible to hope that it has been due only to errors of observation.

Pendulum Observations in Southern India.—The work undertaken by No. 23 Party, Survey of India, during the early part of 1908, was the determination of the force of gravity at certain places in Southern India, with the object of ascertaining, whether the intensity would be found to be in defect in the montane and submontane tracts *in the south of Peninsular India* as has been discovered to be the case *in the Himalaya and Northern India.*

The stations visited were,

1. Mysore
2. Bangalore
3. Kolar, Edgar Shaft, surface
4. Kolar, Edgar Shaft, underground

} situated on the Mysore Plateau.

5. Ootacamand — On a summit of the Nilgiri Hills.
6. Yercaud — On a summit of the Shevaroy Hills.
7. Salem — At the foot of the Shevaroy Hills.
8. Kodaikanal — On a summit of the Palnei Hills.

The results of the season's work are given in Table I.

TABLE I.

Station.	Latitude.	Height above M. S. L.	Observed value of gravity $=g$	g reduced to sea-level $=g_o$	Theoretical value at sea level $=y_o$	$g_o - y_o$
	° ′ ″	Feet.	Dynes.	Dynes.	Dynes.	Dynes.
Mysore	12 18 52	2,501	978·045	978·191	978·236	−0·045
Bangalore	13 0 41	3,118	978·025	978·206	978·263	−0·057
Kolar, Edgar Shaft, surface.	12 55 47	2,945	978·076	978·247	978·260	−0·013
Kolar, Edgar Shaft, underground.	12 55 47	328	978·133	978·238	978·260	−0·022
Ootocamund	11 24 37	7,395	977·735	978·171	978·203	−0·032
Yercaud	11 46 56	4,493	977·908	978·180	978·217	−0·037
Salem	11 40 5	948	978·116	978·172	978·212	−0·040
Kodaikanal	10 13 50	7,665	977·643	978·092	978·164	−0·072

Table II is of interest as it shows that the defect of gravity at the stations of South India is considerably less than at places of similar altitudes in Northern India. At the stations, for example, of Ootacamund, Yercaud and Kodaikanal, both the actual deficiency of rock in the crust and the degree of compensation are notably less than at stations at similar heights in the Himalayan mass.

TABLE II.

Region.	Locale.	Stations.	Height.	$g_0 - \gamma_0$ = defect in g.	Corresponding thickness of rock in defect.	Mean deficiency of rock in the crust.
			Feet.	Dynes.	Feet.	
Montane	South India	Ootacamund	7,395	—0·032	910	
	...	Kodaikanal	7,665	—0·072	2,050	For montane stations: deficiency in Northern India = 3,504 feet, deficiency in Southern India = 1,337 feet.
	...	Yercaud	4,493	—0·037	1,050	
	Himalayan	Mussoorie, 1	6,924	—0·109	3,100	
	...	Mussoorie, 2	7,131	—0·115	3,270	
	...	Simla	7,043	—0·119	3,380	
	...	Darjeeling	6,966	—0·143	4,070	
	...	Kurseong	4,915	—0·130	3,700	
Plateau	South India	Kolar, surface	2,945	—0·013	370	
	...	Bangalore	3,118	—0·057	1,620	For plateau stations: deficiency in Northern India = 3,595 feet, deficiency in Southern India = 1,090 feet.
	...	Mysore	2,501	—0·045	1,280	
	Baluchistan	Quetta	5,520	—0·138	3,920	
	...	Mach	3,522	—0·115	3,270	

TABLE II—*contd.*

Region.	Locale.	Stations.	Height.	$g_o - y_o$ = defect in g.	Corresponding thickness of rock in defect.	Mean deficiency of rock in the crust.
	South India	Salem	948	−0·0	1,140	
Sub-montane	Himalayan	Siliguri	387	−0·135	3,840	For submontane stations: deficiency in Northern India = 3,084 feet, deficiency in Southern India = 1,140 feet.
	...	Nojli	879	−0·096	2,730	
	...	Roorkee	868	−0·107	3,040	
	...	Dehra Dun	2,241	−0·121	3,440	
	...	Kalka	2,202	−0·084	2,370	

It will be noticed from Table I that Major Lenox-Conyngham observed his pendulums both at the top and at the bottom of the Edgar Shaft of the Champion Reefs mine: his two pendulum stations were in the same vertical line, and were separated by a vertical distance of 2,617 feet. Major Lenox-Conyngham's results furnish us with data, from which a value for the Mean Density of the Earth can be deduced, but we have so far not decided how to utilise the data. From similar observations in a Welsh coal mine Sir George Airy calculated the Mean Density of the Earth: he determined by direct measurements the absolute density of the rocks of the Earth's crust, situated between his upper and lower stations, and then from his pendulum observations he was able to calculate the ratio between the density of these surface rocks and the density of the Earth as a whole. But modern geodetic research has brought to light certain facts which show Sir George Airy's method to be unreliable: (firstly) he assumed that his measurements of the density of surface rocks gave him a value for the general surface density of the Earth, whereas the density of the Earth's surface has now been found to be different in different regions, (secondly) he omitted to take into account the extraordinary deficiencies and excesses of matter, that have been found to under-

lie many parts of the crust, at depths of from 30 to 70 miles, and that prevent us now from accepting any one locality as normal or typical.

Deflections of the Plumb Line.

Deflections of the plumb line were observed in the regions south and east of Deesa, where marked and sudden changes of density had been previously discovered in the earth's crust underlying flat desert tracts. It was hoped that we should be able to determine *the depth below the surface* at which the changes of density were occurring.

When the programme was designed, it was believed that the variations in gravity near Deesa were due to some *essentially local* cause, and that consequently an investigation of depth would be simpler here than in the Himalaya, where the area involved is so extensive. Captain Cowie's observations have, however, produced results that were not expected and it is now evident that the subterranean disturbing cause is more complex than had been supposed.

The following table shows Captain Cowie's results:—

TABLE III.

	Station.	Longitude.	Height above M. S. L.	Astronomical Latitude.	Geodetic Latitude.	Deflections of gravity.
			Feet.			
1	Tiki . .	73° 53′	2,369	24° 55′ 34″·52	24° 55′ 38″·24	—3″·72
2	Lakarwas .	73 52	2,574	24 31 41·05	24 31 47·99	—6·94
3	Morali .	73 0	466	23 25 17·47	23 25 23·18	—5·71
4	Kainath .	73 1	1,385	23 51 14·99	23 51 23·79	—8·80
5	Kardo .	72 46	807	23 57 2·17	23 57 10·02	—7·85
6	Dhamanva	72 33	397	23 32 2·66	23 32 8·40	—5·74

List of Publications of the Survey of India during 1907-08.

1. Account of the operations of the Great Trigonometrical Survey of India, vol. XVIII—*Astronomical Observations for Latitude made*

during the period 1885 to 1905, and the deduced values of the Deflections of the Plumb-line, Dehra Dun, 1906.

2. General Report on the Operations of the Survey of India during 1906-07, by Colonel F. B. Longe, R.E., Calcutta, 1908.

3. Report on the treatment and use of Invar in measuring Geodetic Bases, by Captain H. H. Turner, R.E., London, 1907.

4. A sketch of the Geography and Geology of the Himalayan Mountains and Tibet by Colonel Burrard and Mr. Hayden. Parts I, II, and III, Calcutta, 1907.

BOTANICAL SURVEY.

BY

W. W. SMITH, M.A.,

Acting Director, Botanical Survey of India.

Eastern India.—*Bengal.*—It was not found possible during the year to depute any European officer for survey work in Eastern India. The Superintendent, the only officer of the survey available, was too fully occupied with other duties and the Garden staff was too limited to permit of a subordinate officer being thus engaged. Several native collectors were employed in various localities, chiefly for seeds required in India and abroad. In the garden and in its immediate neighbourhood a beginning was made of a photographic survey of types of vegetation with very satisfactory results.

The usual collections of both plants and seeds were made in the Darjeeling District and in Sikkim; these were distributed chiefly to European and American Botanic Gardens and Herbaria. Mr. I. H. Burkill contributed to the Calcutta Herbarium a series of plants collected on the Singlela ridge. The Herbarium is also indebted to Captain F. H. Stewart, I.M.S., for a large collection of Tibetan plants from the neighbourhood of Gyantse.

Eastern Bengal and Assam.—Mr. A. Meebold visited various Districts on behalf of the Survey and obtained valuable collections from this area which are being incorporated into the Herbarium. From the neighbourhood of Manipur native collectors forwarded living specimens chiefly of Orchideæ.

Burma.—Mr. Meebold collected in various localities from Rangoon to Mandalay. Mr. I. H. Burkill added to the Herbarium valuable specimens from Arracan---a District hitherto poorly represented in our collections. Forest officers continue to send interesting specimens and native collectors forwarded Orchideæ from the Shan Hills.

Western India.—Mr. G. A. Gammie, Economic Botanist, has completed another part of his work on the Orchids of the Bombay Presidency and has written a note on the introduction of American Cottons in the Bombay Presidency, and a note on the Setarias.

Tours.—Mr. H. M. Chibber, Assistant Professor of Botany, toured through Kathiawar, Panch Mahals, Ahmedabad, Khandesh, Satara, and Belgaum districts. Messrs. R. K. Bhide, G. B. Patwardhan, and H. P. Paranjape, Assistants to the Economic Botanist, toured through Belgaum, Ratnagiri, Thana, Nasik, Ahmednagar and Poona Districts, the junior staff, Messrs. L. D. Garade, L. R. Khomne, S. R. Jogadeo and R. G. Jawlekar accompanying them.

A note on the flora of Thana is almost ready for publication. The specimens of the indigenous fodder grasses kindly supplied by the several District Officers of the Presidency have nearly all been identified together with the millets under cultivation and descriptions accompanied by drawings of them will shortly be published.

Southern India.—No special systematic survey was made owing to the absence of Dr. Barber in England. The subordinate staff collected in the Circars and in Tinnevelly and Madura Hills. Dr. Barber continued his studies in root parasitism and the results are published in the Botanical series of the Agricultural Memoirs. Mr. C. E. C. Fischer of the Forest Department forwarded to the Calcutta Herbarium collections made in North Coimbatore and North Malabar, in continuation of his previous systematic work in these districts. Mr. I. H. Burkill contributed a series of Deccan grasses. The South Indian flora is inadequately represented in the Calcutta Herbarium and additional contributions are very much desired.

North-West India.—From this area the Survey is indebted to the following for valuable contributions :—

Sir H. A. Deane, K.C.S.I., Chief Commissioner of the North-West Frontier Province, forwarded several collections from Peshawar and Afghanistan; Mr. I. H. Burkill, a series of Baluchistan plants, collected by the Gazetteer staff under the direction of Mr. R. Hughes Buller, I.C.S., and a collection from Simla; Colonel J. M. Carpendale, plants from

Kashmir; Mr. James Marten of the Forest Survey Department plants from Bannu; Mr. T. F. Main from Umballa; Mr. A. R. Tucker of the Department of Revenue and Agriculture, a further collection of North-West Himalayan plants.

The Botanical Survey suffers a severe loss in the death of Sir H. A. Deane, who for the last few years has been a constant contributor and correspondent, and has added much to our botanical knowledge of the Frontier Province.

General.—The list of publications at the end of this report sufficiently indicates the research work which comes within the scope of this review. Rev. Father E. Blatter, S.J., continues his studies on flowering season and climate, and Mr. Burkill his on the modes of pollination of certain Indian plants.

The Economic Botanists of the various provinces have, as in previous years, given as much time to Survey work as they could spare, but their own special duties are becoming more and more onerous and thus it is to be feared that in future the Survey will be unable to rely on their assistance. This reduces the actual staff on the Survey to one man—the Director—and emphasises the need of an adequate organisation and staff, if any progress whatever is to be made.

Publications.—Of the Records of the Botanical Survey there were published No. 3 of Vol. III (Professor L. Radlkofer's *Sapindaceæ novæ indicæ et malaicæ*), and No. 4 of Vol. III. (Professor C. deCandolle's *Revision of the Indo-Malayan species of Cedrela*). No. 5 of Vol. III, an index completing the volume, has also been published.

Another part of Dr. Cooke's *Flora of the Presidency of Bombay* has been issued bringing the work down to the beginning of *Araceæ*.

Of the two volumes of the Annals of the Royal Botanic Garden, Calcutta, Vol. VI, part II, Messrs. West's *Fresh water Algæ from Burma*, and Vol. XI, part I, Professor Beccari's *Monograph of the species of Calamus*, reported last year as still in the Press, the former has been issued and the latter is about to be issued. Parts 19 and 20 of Sir George King and Mr. J. S. Gamble's *Materials for a Flora of the Malayan Peninsula* were issued and bring the work to the end of *Plantagineæ*. The *Flora of Chittagong* by Mr. R. L. Heinig has been published and also a further note on the *Orchids of the Bombay Presidency* by Mr. G. A. Gammie, as already mentioned.

The other publications on Indian Botany published during the year are given in the list appended to this report.

A list of papers on the Botany of India published during 1907-08.

ANONYMOUS . Patchouli. (*Kew Bull., 1908, p. 78.*)

BARBER, C. A. . Parasitic trees in Southern India. (*Proc. Cambridge Philos. Soc., xiv, 3, pp. 246—256, with plates.*)

BARBER, C. A. . Studies in root parasitism. The Haustorium of *Santalum album*, part 2, the structure of the mature Haustorium and the inter-relations between host and parasite. (*Memo., Dept. Agri. India, i, 1, 2, pp. 1—58, with plates.*)

BARBER, C. A. . The Haustorium of Olax scandens. (*Memo. Dept. Agri. India, 1, No. 4.*)

BEDDOME, R. H. . Notes on Indian Ferns. (*Journ. Bom. Nat. Hist. Soc., xviii, 2, pp. 338—342, 1908.*)

BLATTER, E. . Contributions to the Flora of North Coimbatore. (*Journ. Bom. Nat. Hist. Soc., xviii, 2, pp. 390—429, 1907, with map.*)

BLATTER, E. . Acta et agenda by the Bombay Botanists. (*Journ. Bom. Nat. Hist Soc., xvii, 3, pp. 562—577, 1907.*)

BLATTER, E. . Cassia renigera Wall. (*Journ. Bom. Nat. His. Soc., xvii, 4, pp. 1036—1037, with plates, 1907.*)

BLATTER, E. . Flowering season and climate. Part II, 1907. (*Journ. Bom. Nat. His. Soc., xvii, 3, pp. 697—708, with plates.*)

BONATI, G. . Sur quelques espèces nouvelles du genre Pedicularis. (*Bull. Soc. Bot. France T. liv, pp. 371—377, June 1907.*)

BURKILL, I. H. . A note on Swertia tongluensis, and on a new variety of Swertia purpurascens. (*Journ. and Proc. Asiat. Soc., Bengal, iii, 1, p. 33, 1907.*)

BURKILL, I. H. . On Gentiana coronata Royle. (*Journ. and Proc. Asiat. Soc., Bengal, iii, 3, p. 149, with plates.*)

BURKILL, I. H., AND FINLOW, R. S. On three varieties of *Corchorus capsularis* Linn., which are eaten (*Journ. and Proc. Asiat. Soc., Bengal, iii, 10, 107, p. 633.*)

BURKILL, I. H. . Note on the Pollination of flowers in India. Note No. 4 on Cotton in Behar. (*Journ. Asiat. Soc., Bengal, iii, 7 July 1907.*)

BURKILL, I. H. . Anguillicarpus—a new genus of the Cruciferæ. (*Journ. and Proc. Asiat. Soc., Bengal, N. S., iii, 8, pp. 559—561, with plates, 1907.*)

BURKILL, I. H. . A variety of Ducrosia anethifolia Boiss, from Baluchistan. (*Journ. and Proc. Asiat. Soc., Bengal, N.S., iii, 8, pp. 563—564, 1907, with plates.*)

CANDOLLE, C. DE . A revision of the Indo-Malayan species of Cedrela. (*Rec. Bot. Surv. Ind., iii, pt. 4, 1908.*)

CLARKE, C. B. . Reductions of the Wallichian Herbarium, iii, Cyperaceæ. (*Kew Bull. 1907, 7, pp. 261—281.*)

COOKE, T. . The Flora of the Bombay Presidency, ii, pt. iv. Euphorbiaceæ to Araceæ, pp. 625—816.

COTTON, A. D. . New or little known marine algæ from the East. (*Kew Bull. 7, 1907, pp. 260—264, with plates.*)

DRUMMOND, J. R. . Literature of Furcræa with Synopsis of the known species. (*St. Louis Rep. Bot Gard., 1907, with plates.*)

ELLIS, E. V. . Cephalostachyum pergracile in flower. (*Indian Forester, xxxiii, 7, pp. 323—324, 1907.*)

ENERS, D. T. . The evergreen forests of the Maunjarabad Forest Range, Mysore State. (*Indian Forester, xxxiii, 7, pp. 324—328, 1907.*)

FISCHER, C. E. C. . Host plants of Loranthaceæ. (*Indian Forester, xxxiii, 8, pp. 353—355, 1907.*)

FISCHER, C. E. C. . Summary of genera and species described in the Flora of British India. (*Indian Forester, xxxiii, 8, pp. 355—362, 1907.*)

FISCHER, C. E. C. . A remarkable tree. (*Journ. Bom. Nat. His. Soc., xvii, 4, pp. 1027, 1907.*)

GAGE, A. T. . A case of lateral Floral Prolification of the inflorescence of the Pine-apple (Ananas sativus

Schult. f.) (*Journ Asiat. Soc., Bengal, Vol. iii, 9, Nov. 1907, p. 593.*)

GAGNEPAIN, F. Quelques Burmannia asiatiques nouveaux de l'Herbier du Museum. (*Bull. Soc. Bot. France liv, pp. 459—465, Juin 1907.*)

GAMMIE, G. A. . The Indian Cottons. (*Memo. Dept. Agri. India Bot. ser. ii, 2, 23, pp. 14, col. pl.*)

GAMMIE, G. A. . The orchids of the Bombay Presidency. (*Journ. Bomb. Nat. Hist. Soc., xviii, 1, Nov. 1907, pp. 88—91, with plates, and also part iv, Journ. Bom. Nat. His. Soc., xvii, 4, pp. 940—942, with plate, 1907.*)

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KING, SIR GEORGE, AND GAMBLE, J. S. Materials for a Flora of the Malayan Peninsula, Nos. 19 and 20. (*Journ and Proc. Asiat. Soc., Bengal, lxxiv, pt. 2, pp. 383—728, 1908.*)

LUSHINGTON, A. W. . Note on some sucker-produced forests of the Krishna District, Madras. (*Indian Forester, xxxiii, 10, pp. 445—451, 1907.*)

PEITZER, E. UND KRANZLIN, F. Orchidaceæ-Monandræ-Cœlogyninæ. (*Das Pflanzenreich. Heft 32, p. 169, with plates. 1907.*)

PRAIN, D. . Diospyros Kaki, Linn. f. and Meconopsis (*Eumeconopsis*) bella, Prain. (*Curtis's Bot. Magazine, 4th ser., iii, 28, April 1907.*)

PRAIN, D. . Codonopsis convolvulacea. (*Bot. Magazine iv, 38, February 1908.*)

RADLKOFER, L. . Sapindaceæ novæ indicæ et malaicæ ex herbario calcuttensi. (*Rec. Bot. Surv. Ind. iii, pt. 3, 1907.*)

RAM, D. . Notes on the flowering, seeding, and cutting of Strobilanthes in Jaunsar Division in 1906. (*Indian Forester, xxxiii, 10, pp. 451-452 1907.*)

TURNER, T. E. C. . Note on Terminalia Chebula and its fruit the Myrabolam of commerce. (*Indian Forester, xxxiii, pp. 362—365, 1907.*)

WILLIS, J. C. . The geographical distribution of the Dilleniaceæ, as illustrating the treatment of this subject on the theory of mutation. (*Ann. Roy. Bot. Gard. Peradeniya, iv, 2, pp. 69—77, 1907.*)

ECONOMIC BOTANY.

BY

ALBERT HOWARD, M.A. (CANTAB.), A.R.C.S. (LOND.), F.C.S., F.L.S.,

Imperial Economic Botanist.

Cotton.—The principal contributions during the year ending June 30th, 1908, to the Economic Botany of India deal with the improvement of cotton. The amount of attention now being bestowed on this crop by botanists offers a good example of the influence of practice on Science. It is perhaps safe to say that but for the recent efforts to develop cotton growing within the Empire none of the investigations indicated below would have been undertaken.

The systematic aspect of the subject has been dealt with by Watt[1] at Kew and by Gammie[2] at Poona. Watt's monograph deals more spe-

[1] *Watt, Sir George.*—The Wild and Cultivated Cotton plants of the World. London, 1907.

[2] *Gammie, G. A.*—The Indian Cottons. Memoirs of the Department of Agriculture in India. Botanical Series, Vol. 2, No. 2, 1907.

cially with the history of cotton and with the description of the various forms met with in cultivation and in the wild state. The information is given in great detail. There is a long bibliography of papers and the work, which obviously represents years of labour, should prove of the greatest value to all interested in the subject and especially to workers in India unable to consult the large libraries of Europe. Gammie has dealt only with the Indian cottons, all the forms of which he refers to one true species, *viz.*, *Gossypium obtusifolium* with its two sub-species *G. arboreum* and *G. herbaceum*.

The growing importance of the study of genetics during recent years has naturally attracted the attention of workers on this crop to this aspect of the subject. In India, Leake [1] has published an important paper on this subject, which however only deals with a small part of the work on cotton-breeding in progress at the Cawnpore Experiment Station. This paper deals with the inheritance of leaf characters and with the occurrence in field of natural cross-fertilisation. The author concludes with regard to this latter subject that "the evidence so far obtained indicates that natural crossing occurs with sufficient frequency to render it impossible to keep types pure when they are grown in the proximity of other types." Fletcher [2] has published a short paper on the inheritance of certain characters of the fibre, seed and flower and he concludes that fineness, length, and colour of the lint are dominant over coarseness, shortness and whiteness. Another investigation on inheritance in Indian Cottons carried out by Fyson at Madras, although completed during the year under review, is still unpublished. A paper of considerable importance to workers in India has recently been published by Balls [3] in which the results of this investigator during the past three years are summed up. Besides the cottons of Egypt several of those grown in India have been studied at Ghizeh. In addition to the Mendelian aspect of the question, this paper is of value to India in that it shows that the Egyptian varieties are by no means pure but that natural crossing has gone on to such an extent that the crop is now simply a mass of hybrids. The introduction of Egyptian cotton into India may therefore easily give rise to diffi-

[1] *Leake, H. M.*—Studies in the experimental breeding of Indian Cottons. Jour. and Procs. Asiatic Soc. of Bengal (New Series), Vol. IV, No. 1, 1908.

[2] *Fletcher, F.*—Mendelian Heredity in Cotton. Journal of Agricultural Science, Vol. 2, Part 3, Dec. 1907.

[3] *Balls, W. L.*—Mendelian studies of Egyptian Cotton. Journal of Agricultural Science, Vol. 2, Part 4, 1908.

culties. Under new conditions, the equilibrium between the various constituents may be upset in India and certain forms may tend to predominate resulting in a change in the quality of the cotton. Natural crossing with the Indian varieties is also probable and this would tend still further to alter the character of the crop.

A number of minor papers on Indian cotton have also appeared during the year. The history of the attempts made in the past to improve the cotton crop in Bombay has been concisely summed up by Gammie.[1] This work is best summed up in the author's own words "The net result from the expenditure of money, skill and experience during nearly 80 years was that the new Orleans cotton was successfully introduced into the Karnatak and that it refused to grow with certainty in other parts of the Presidency. This remains the only exotic cotton now grown as an annual field crop in India. All perennial varieties have been definitely proved to be unreliable as sources of profit."

Clouston[2] has given a brief account of the methods of improving cotton in present use in the Central Provinces and Berar where the various constituents of the local *jari* cotton are being grown and tested separately. The cultivation of Egyptian cotton in Sind has been briefly described by Henderson.[3] It appears that the area sown with this crop in 1907 was 6,335 acres, while in 1905 it was only 1,000 acres. In 1907, about 2,000 acres was sown with Abassi seed obtained from last year's crop, ginned in Sind, while the remaining area was sown with Mit Afifi seed imported from Egypt. A third paper by Gammie,[4] read at the Industrial Conference held at Surat in 1907, deals with the present aspect of cotton-growing in India and the failure of past experiments. The greatly increased yield of cotton due to the application of nitrate of soda to the black cotton soil of Nagpur has been described by Clouston.[5] The soils in this locality appear to be greatly deficient in

[1] *Gammie, G. A.*—Work done towards the Improvement of Cotton in the Bombay Presidency. Agr. Jour. of India, Vol. 3, part 2, 1908.

[2] *Clouston, D.*—Note on the Measures taken for the Improvement of Cotton. Report on the Agricultural Stations in the Central Provinces for the year 1906-07. Nagpur, 1907.

[3] *Henderson, G. S.*—Egyptian Cotton in Sind. Agr. Jour. of India, Vol. 3, part 2, 1908.

[4] *Gammie, G. A.*—Cultivation of Cotton in India. Agr. Jour. of India, Vol. III, part 2, 1908.

[5] *Clouston, D.*—Artificial fertilisers for cotton. Agr. Jou .rof India, Vol. III, part 3 1908.

available nitrogen and the amount of this constituent seems to govern the yield.

Fibres.—The improvement of the fibre industry in India was one of the subjects under discussion at the meeting of the Board of Agriculture [1] held at Pusa in 1908. The report of the sub-committee appointed to deal with this subject has been referred to the Directors of Agriculture of the various Provinces in order that all available information on the subject might be collected. The complete report will be published by the Imperial Department of Agriculture.

An account of the cultivated races of jute in India has been written by Burkill and Finlow and will shortly appear in the *Agricultural Ledger*. These authors[2] have also published a paper on three varieties of *Corchorus capsularis* L. which are used as food. An account of the cultivation of Sunn hemp (*Crotalaria juncea*), Ambari (*Hibistus cannabinus*) and of the various species of Agave in the Central Provinces has been given by Clouston,[3] while two notes ([4], [5]) on the experiments now being undertaken to establish a flax fibre industry in Behar have been published in the *Agricultural Journal of India*. The principal flax experiments in Behar being conducted at Dooriah Factory are on a commercial scale and are being continued as the results so far obtained are considered to be very encouraging. With the Riga flax seed obtained from Europe for these experiments seeds of flax dodder—*Cuscuta Epilinum* Weihe—were introduced into Behar. This parasite, which so far has not been found on the indigenous varieties of linseed in India, forms the subject of a paper by the writer now in the press. Steps have been taken to stamp out the flax dodder in India and to prevent its reintroduction. A paper on the present prospects of sisal hemp cultivation in India has been written by Mann[6] who concludes that there is every prospect of the building up of a flourishing sisal hemp industry in North-East India.

[1] Proceedings of the Board of Agriculture in India held at Pusa in February 1908.

[2] *Burkill, I. H.*, and *Finlow, R. S.*—On three varieties of *Corchorus capsularis* L. which are eaten. Jour. and Proceedings of the Asiatic Society of Bengal (new series), Vol. 3, No. 10, 1907.

[3] *Clouston, D.*—Sunn hemp, Ambari and Agave as Fibre crops in the Central Provinces and Berar.—Agr. Jour. of India, Vol. III, part 2, 1908.

[4] Flax Cultivation in Bengal—Agr. Jour. of India, Vol. 3, part 1, 1908.

[5] Flax as a fibre crop in Behar.—Agr. Jour. of India, Vol. 3, part 2, 1908.

[6] *Mann, H. H.*—The Development of Sisal Hemp Cultivation in India.—Agr. Jour. of India, Vol. II, part IV, 1907.

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[4] *Gammie, G. A.*—Cultivation of Cotton in India. Agr. Jour. of India, Vol. III, part 2, 1908.

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[3] *Clouston, D.*—Sunn hemp, Ambari and Agave as Fibre crops in the Central Provinces and Berar.—Agr. Jour. of India, Vol. III, part 2, 1908.

[4] Flax Cultivation in Bengal—Agr. Jour. of India, Vol. 3, part 1, 1908.

[5] Flax as a fibre crop in Behar.—Agr. Jour. of India, Vol. 3, part 2, 1908.

[6] *Mann, H. H.*—The Development of Sisal Hemp Cultivation in India.—Agr. Jour. of India, Vol. II, part IV, 1907.

Wheat.—Only two papers on this crop have been published during the year. An account of the wheats of Bengal by Mookerji[1] has appeared. To a very large extent the paper is a reprint of an earlier publication by Prain on the same subject. A study of the wheats of the Central Provinces by Evans is announced, while the writer has prepared for publication several papers dealing with the investigations on wheat which have been carried out at Pusa and Lyallpur during the last three years. Only one[2] of these papers has however as yet appeared. A series of representative Indian wheats have been milled and baked in England and a bulletin on this subject has been prepared. One of the Pusa wheats proved to be the best in these tests. An exhaustive study of the wheats of the Punjab which has extended over three years has been completed and a report furnished to the Director of Agriculture of that Province. A memoir on the varietal characters of Indian wheats has been prepared while the monograph on Indian wheats which includes an account of the modern methods of selection and hybridisation has been completed.

Sugarcane.—The lines of future work for the improvement of the sugarcane in India laid down by the Board of Agriculture at Cawnpore in 1907 have been adopted at the Partabgarh Experiment Station and a preliminary paper on the work done by Clarke and Hadi is in the press. A paper by the writer[3] on some of the difficulties underlying sugarcane work which was communicated to and adopted by the Board of Agriculture in 1907 has been published in England.

Fruit.—Continued attention is being paid to fruit investigations in India and an experimental garden has been started by the United Provinces Government at Naini Tal. The fruit experiments at Pusa have been extended during the year and a second report on the results so far obtained is in preparation. It is proposed to start more fruit experiments at Bhagalpur, Dacca, in the Central Provinces and also at Lyallpur in the Punjab.

Miscellaneous.—The investigations of Barber on root parasitism in Southern India which have deservedly attracted considerable attention

[1] *Mookerji, D. N.*—A short wheat survey of Bengal. Departmental Records of the Department of Agriculture, Bengal. No. 2, 1907.

[2] *Howard, A.* and *Howard, G. L. C.*—On Immune wheats.—Journal of Agricultural Science, Vol. II, Part 3, 1907.

[3] *Howard, A.*—Some difficulties in Sugarcane Experiments, Inter. Sugar Jour., 1907.

both from a practical and biological standpoint have been summed up by the author in a recent paper published at Cambridge. Root parasites have been discovered in four genera of the *Olacaceæ* and in ten genera of the *Santalaceæ*. In the paper in question a critical account of the previous literature is to be found.

A note by Gammie on rubber cultivation in Bombay has been published by the Bombay Agricultural Department and two other forthcoming works by this author are announced-- one on the cereals of the genus *Setaria* and another on the field, garden and orchard crops of the Bombay Presidency. A handbook of the commercial products of India by Watt is shortly to appear.

Mann ([2], [3]) has published two papers on rubber in North-East India. He concludes that Para rubber may probably succeed in Cachar and that the methods of tapping *Ficus elastica* in Assam can be considerably improved.

List of papers on Economic Botany in India published during the year ending June 30th, 1908.

1. BALLS, W. L. . Mendelian Studies of Egyptian Cotton. Jour. of Agr. Sc. Vol. II, part 4, 1908.
2. BARBER, C. A. Parasitic trees in Southern India. Proc. of the Camb. Phil. Soc. Vol. XLV, part 3, 1907.
3. BARBER, C. A. . Studies in root parasitism. The haustorium of *Olax Scandens*. Mem. of the Dept. of Agr. in India. Botanical Series. Vol. II, No. 4, 1907.
4. BURKILL, I. H., AND FINLOW, R. S. } On three varieties of *Corchorus Capsularis* L. which are eaten. Jour. and Proc. of the Asiatic Soc. of Bengal (new series). Vol. III, No. 10, 1907.
5. CLOUSTON, D. . Note on the measures taken for the Improvement of Cotton. Report on the Agricultural Stations in the Central Provinces for the year 1906-07. Nagpur, 1907.

[1] *Barber, C. A.*—Parasitic Trees in Southern India—Proceedings of the Cambridge Philosophical Society, Vol. XIV, Part III, 1907.

[2] *Mann, H. H.*—The cultivation of Para rubber in North-East India—Agr. Jour. of India, Vol. II, Part III, 1907.

[3] *Mann, H. H.*—The tapping of Assam rubber (*Ficus elastica*)—Agr. Jour. of India, Vol. II, Part III, 1907.

6. CLOUSTON, D. . Artificial fertilisers for cotton. Agr. Journal of India. Vol. III, part 3, 1908.

7. CLOUSTON, D. . Sunn hemp, Ambari and Agave as Fibre Crops in the Central Provinces and Berar. Agr. Jour. of India. Vol. III, part 2, 1908.

8. FLETCHER, F. . Mendelian heredity in Cotton. Jour. of Agr. Sc., Vol. II, part 3, 1907.

9. FLETCHER, F. . Note on a toxic substance excreted by the roots of plants. Memoirs of the Dept. of Agr. in India, Vol. II, No. 3, 1907.

10. GAMMIE, G. A. . The Indian Cottons. Memoirs of the Dept. of Agr. in India (Botanical Series), Vol. II, No. 2, 1907.

11. GAMMIE, G. A. . Work done towards the Improvement of Cotton in the Bombay Presidency. Agr. Jour. of India, Vol. III, part 2, 1908.

12. GAMMIE, G. A. . Cultivation of Cotton in India. Agr. Jour. of India, Vol. III, part 2, 1908.

13. HENDERSON, G. S. Egyptian Cotton in Sind. Agr. Jour. of India, Vol. III, part 2, 1908.

14. HOWARD, A. . Some difficulties in Sugarcane Experiments. International Sugar Journal, 1907.

15. HOWARD, A. AND HOWARD, G. C. } On immune wheats. Jour. of Agr. Sc., Vol. II, part 3, 1907.

16. LEAKE, H. M. . Studies in the experimental breeding of Indian Cottons. Jour. and Proc. of the Asiatic Soc. of Bengal (new series), Vol. IV, No. 1, 1908.

17. MANN, H. H. . The development of sisal-hemp cultivation in India. Agr. Jour. of India, Vol. II, part 4, 1907.

18. MANN, H. H. . The cultivation of Para rubber in North-East India. Agr. Jour. of India, Vol. II, part 3, 1907.

19. MANN, H. H. . The tapping of Assam rubber (*Ficus elastica*). Agr. Jour. of India, Vol. II, part 3, 1907.

20. MOOKERJI, D. N. . A short Wheat Survey of Bengal. Dept. Records of the Dept. of Agr., Bengal, No. 2, 1907.

21. WATT, SIR GEORGE The wild and cultivated Cotton plants of the world. London, 1907.

22. Flax cultivation in Bengal. Agr. Jour. of India, Vol. III, part 1, 1908.
23. Flax as a fibre crop in Behar. Agr. Jour. of India, Vol. III, part 2, 1908.
24. Proceedings of the Board of Agr. in India, held at Pusa in February 1908. Calcutta, 1908.

MYCOLOGY.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist.

Enquiries into cocoanut and other palm diseases in South India were continued. The Government of Madras provided the grants necessary to carry on the campaign against the Godavari palm disease for a second year. A visit was paid to Travancore to investigate a wide-spread cocoanut disease there and the results published in a report issued in March, 1908.

The general survey of Indian parasitic fungi was carried a step further, the groups dealt with being the rusts, smuts and false mildews in collaboration with Messrs. H. and P. Sydow of Berlin, and the true mildews with Mr. Salmon of Wye College.

A tour was made in Burma in January, 1908, to report on the diseases of crops in that Province and to study orange disease in Amherst District. The cause of the latter has not yet been definitely ascertained.

The study of wilt diseases of various crops, sugarcane diseases, linseed rust and diseases of citrus fruits was continued.

Publications.

BUTLER, E. J. Report on Cocoanut disease in Travancore. *Bulletins of the Agricultural Research Institute, Pusa, No. 9, March 1908.*

SALMON, E. S. Notes on some species of Erysiphaceæ from India. *Annales Mycologici, Vol. V, No. 6, December 1907.*

SYDOW, H. and P. & E. J. BUTLER.—Fungi Indiæ Orientalis, Part II. *Annales Mycologici, Vol. V, No. 6, December 1907.*

FOREST BOTANY.

BY

R. S. HOLE,

Imperial Forest Botanist.

Educational work of Forest Botanist.

1. Much of the time of the Forest Botanist was as usual devoted to the educational work of the Imperial Forest College especially during the months of July, August, September, November, March, and May. The Botanist was engaged on the preparation of a Manual of Botany for the Forest College during the year. The completed manuscript was sent to press on 1st October 1907, but publication was delayed owing to the difficulties experienced in satisfactorily and cheaply reproducing the illustrations that had been prepared. The book will, it is hoped, appear early next year.

Research work of Forest Botanist.

2. The following definite subjects for botanical research were sanctioned by the Inspector General of Forests during the year:—

(*a*) Morphological nature of the coppicing of teak and its effect on the vitality and normal development of the tree.

(*b*) Study of the forms of *Grewia* yielding the most valuable wood for shafts, tool-handles, etc.

So far as circumstances permitted the Botanist was engaged during the year on the collection of data and specimens bearing on these subjects and he was on tour for this purpose from December 4th, 1907, to 5th March 1908 in the Hoshangabad and Jubbulpore Districts of the Central Provinces and from April 30th, 1908, to June 24th, 1908, in the Jaunsar Forest Division.

As regards teak, a quantity of material in the way of observations and specimens was collected in the Central Provinces, special attention being paid to the phenomenon of the dying back of seedlings, the best method of coppicing trees of different ages, the best season for coppicing, the extent to which unsoundness spreads from the old stool to the young stems, the extent to which the coppice shoots become independent of the mother-tree and the structure of seedling and coppice stems. Seed was collected and sown at Dehra Dun for the purpose of studying the

early life-history of the seedling, the fertility of the seed of undoubted coppice shoots, the period during which the seed may remain dormant and other points.

As regards the *Grewias* the satisfactory definition of the important forest species has long been a desideratum. Considerable differences are believed to exist in the quality of the wood of certain forms which are kept distinct as separate species by some botanists and united in one species by others. As the indiscriminate mixing of good and bad timber must seriously interfere with a demand arising for the better kinds, a careful study of the characters of the different forms and of their constancy is a matter of economic importance.

The study of this difficult genus and specially of the remarkable form known as *Grewia sapida* Roxb. also promises to throw light on the question of mutations and the effect of injuries and mutilation, such as occurs in coppicing for example, on the production of new and constant forms.

A careful study of *Grewia tiliæfolia* Vahl and *Grewia vestita* Wall. was made during the Central Provinces tour as regards their mode of occurrence and variations in the forest and the same was done for *Grewia elastica* Royle and *Grewia sapida* Roxb. in Jaunsar. Seeds of the various forms were collected as far as possible and their cultivation commenced at Dehra Dun. All Forest Officers have been asked to contribute series of specimens indicating the range of variation of the different forms.

No publications dealing with research work were attempted during the year partly owing to the fact that the apparatus and appliances necessary for dealing with much of the material collected was only received in April 1908 but it is hoped to issue preliminary notes on both branches of work next year giving the results so far obtained.

Mutations.

3. The fact that coppicing and pollarding frequently result in the appearance of remarkable variations not exhibited by the uninjured plant has long been known to foresters. Thus in the case of *Pyrus Pashia* Ham. the leaves on coppice shoots are often lobed or pinnatifid while the normal leaves are crenate. A fact which is not so generally known however is that in many species such abnormal branches frequently bear flowers and fruit which also exhibit abnormal characters. This naturally suggests the possibility of such abnormal characters becoming hereditary and transmissible to the offspring. The possibility

of the evolution of new forms in this way is, it is hardly necessary to say, a matter of great importance to foresters. The researches now in hand in connection with the *Grewias* will almost certainly throw light on this interesting problem, the observations already made indicating that some of the forms at least exhibit most remarkable variations in response to mutilation.

Considerable attention has recently been paid to this subject in Europe and a very important addition to our knowledge has been contributed by L. Blaringhem in *Mutation et Traumatismes: Etude sur l' Evolution des Formes vegetales* who shows that remarkable hereditary variations may be induced by wounding.

Forest Floras.

4. Mr. H. H. Haines was engaged on his *Flora of Chota Nagpur* during the year and it is now ready for publication. Mr. R. L. Heinig published his *List of Plants of the Chittagong Collectorate and Hill tracts* during the year. Mr. D. O. Witt continued his work of the preparation of a list of species found in the Berar Circle of the Central Provinces and Mr. A. E. Lowrie commenced work on a similar list for the Southern Circle of the Central Provinces.

The preparation of small local floras with brief diagnoses enabling any English-knowing Forest Officer to quickly arrive at the correct name of any woody plant occurring in the area in his charge, together with the establishment of correctly named local herbaria, is a matter of great importance. Under existing conditions it is frequently impossible for a Forest Officer to gain a fair knowledge of the vegetation in his charge until the time arrives for his transfer to another locality, and the collection of data regarding the distribution of species, the probable yield of economic products and other important matters is much hampered by this want of knowledge on the part of local officers.

Systematic efforts have been made by local forest officers in the Bhamo Division of Burma, South Chanda Division of Central Provinces, in Baluchistan and in the Panch Mahals to collect reliable vernacular names of local species.

Herbaria and Collection of Specimens.

5. The Herbarium of the Imperial Forest College, Dehra Dun, remained as usual in charge of the Forest Botanist during the year and a considerable amount of work was done in it. More than 800 sheets were added during the year of which some 300 were very kindly sent by Mr. B. B. Osmaston from the Andamans.

The other principal contributors were Messrs. Lace who sent a most valuable set of chiefly Burmese plants, Haines who sent a large number of specimens from Chota Nagpur, Fischer who contributed a valuable set of Malabar plants, and Witt who sent a representative collection of Berar plants including a fine series of specimens of several species of *Grewia*.

Shortly after the close of the year the Forest Botanist took charge of the Saharanpur Herbarium which was at once removed and suitably housed in Dehra Dun.

Mr. A. Rodger, Deputy Conservator of Forests, has commenced a local forest herbarium in the Ruby Mines Division of Burma and the same has been done in the South Chanda Division of Central Provinces.

A list of the most useful local timbers found in the Tenasserim Circle of Burma was published during the year and a reference collection of hand specimens formed.

A large number of botanical specimens were contributed by Forest Officers during the year to the Reporter on Economic Products, the Gass Forest Museum, Madras, the Central Forest Museum, Poona, the Quetta Museum, Balaghat Training School, and others.

Distribution of Species.

6. Although occupied chiefly with the researches noted in para. 2 above, the Forest Botanist collected several species during his tour in the Central Provinces which were not included in the preliminary list of plants of the Northern Circle published last year. The necessary additions to the list will be issued next year when the collections have been worked up, but a few points of interest may be briefly noted now.

Pongamia glabra Vent. was found undoubtedly wild and almost certainly indigenous in the valley of the Tawa and other tributaries of the Narbada, in the Pachmarhi hills and along the northern slopes of the Satpuras. This species has been stated to be a littoral plant and to be only planted inland.

Berberis asiatica Roxb. was found to be common in the neighbourhood of Pachmarhi, the distribution of which has hitherto been limited to the Himalaya and Parasnath in Behar.

A species of *Rhamnus*, closely allied to and probably identical with *Rhamnus triqueter* Wall. was found common near Pachmarhi which has hitherto been known from the Salt Range, Panjab and the North-Western Himalaya. *Rhus parviflora* Roxb. is another mainly Himalayan species which is very common on the Pachmarhi hills and which

has been previously reported for that locality by both Brandis and Duthie. On the other hand *Clematis triloba* Heyne, a species of Western India and the Deccan is also common at Pachmarhi and the flora of these interesting hills is thus seen to approximate in some respects to that of the Himalaya and in others to that of the Deccan. In questions concerning plant distribution the fact of a plant being wild and reproducing itself freely is settled on sight, but the no less important point as to whether the plant is indigenous or introduced is far more difficult to answer. The existence of a sacred shrine on the Pachmarhi hills which annually attracts pilgrims from remote parts of India may possibly have been responsible for the introduction of non-indigenous species in this locality.

Asexual Reproduction.

7. Reproduction by means of coppice shoots and root-suckers continue to engage the attention of Forest Officers. Mr. Copleston, Divisional Officer, South Kanara, reports that teak seed collected from five-year old coppice germinated and produced strong healthy seedlings.

Mr. A. W. Lushington in his article "Some sucker-produced forests of the Kistna district" in the *Indian Forester*, XXXIII, 445, draws attention to the great utility of root-suckers in rapidly covering ground with a woody growth and forming good soil.

Rotation of Crops.

8. The fact that certain plants, while preparing the way and creating the conditions necessary for the development of others, thereby render their own continued existence in the locality impossible has long been recognized. On the rocky and almost treeless hills of many Indian forests we find such pioneers as *Boswellia serrata* and *Sterculia urens* playing an important part in the formation of new soil which will eventually be able to support a forest growth of different and more valuable species. The shingle banks of the Sub-Himalayan tract are frequently first covered by gregarious forests of *Dalbergia Sissoo* which gradually give place to mixed forests of inferior species and finally in many cases to a pure forest of Sal (*Shorea robusta*). Mr. P. H. Clutterbuck in his Working Plan for the fir forests of Jaunsar has also shown how inferior species such as brambles, willows and poplars prepare the way for the Spruce and Silver Fir. This phenomenon of the natural succession of different types of vegetation is one of the greatest importance for the forester, for his power of insuring the continued reproduction of his valuable species depends upon a due appreciation of the factors at work in such cases as the above.

The results of recent work published by Messrs. Schreiner, Reed and Gardner in America and by Fletcher in India and Egypt concerning the excretion of toxic substances by plants immediately attracted the attention of Indian Forest Officers who found in them a possible explanation of cases of crop-rotation, as indicated by several papers published during the year in the *Indian Forester*. While the actual excretion of a toxic substance has certainly not been proved by the work as yet published the fact does appear to have been established that under certain conditions the continued growth of a particular plant results in the accumulation of a toxic substance in the medium surrounding the plant roots which is capable of inhibiting the further growth of that plant. Whether this substance is formed inside the plant tissues and excreted, or, as seems more probable, outside the plant, by ionisation, by the action of bacteria, or otherwise, is not-known.

The details of the nutrition processes however vary greatly in different species and a vast amount of research dealing with the complex factors affecting the normal nutrition of our forest trees and the relations which exist between them and other living organisms is required before we can hope to adequately explain apparently simple cases of forest crop-rotation.

9. The following are among the more important publications of 1907-08 concerned directly or indirectly with Indian Forest Botany:

C. A. BARBER . *Studies in Root Parasitism* in *Mem. Department of Agriculture in India, Botanical Series*, Vol. II, No. 4.

T. A. SPRAGUE . *Prickly fruited species of Euonymus* in *Kew Bulletin of Miscellaneous Information*, No. 1, 1908, p. 29.

F.H WOOLWARD *Germination of Poplars* in *Journal of Botany*, XLV, p. 417.

T. COOKE . . *Flora of the Presidency of Bombay*, Vol. II, Part IV.

E. BLATTER . *Contributions to the Flora of North Coimbatore* in *Journ. Bo. Nat. Hist. Soc.*, Vol. XVIII, p. 390.

E. BLATTER . *Flora of the Bombay Presidency* in *Journ. Bo. Nat. Hist. Soc.*, Vol. XVIII, 562.

A. W. LUSHINGTON *Is a period of rest and rotation of crops wanted for teak reproduction* in *Indian Forester*, XXXII, p. 409.

A. W. LUSHINGTON *Some sucker-produced forests of the Kistna District* in *Indian Forester*, XXXIII, 445.

A. W. LUSHINGTON *A plea for so-called "Worthless Species"* in *Indian Forester*, XXXIV, p. 530.

B. O. COVENTRY *Alternation of Forest Crops* in *Indian Forester*, XXXIV, p. 327.

T. E. D. INNES . *List of Jungle Products used by the Poor* in *Appendix* to *Indian Forester* for February 1908.

A. B. PUNDE . *Abnormal type of Butea frondosa* in *Indian Forester*, XXXIV, p. 358.

R. S. PEARSON . *Light and Shade* in *Indian Forester*, XXXIV, 200.

M. RAMA RAO . *Sandalwood at Sea Level* in *Indian Forester*, XXXIV, 151.

B. SEN GUPTA . *Macaranga denticulata* in *Indian Forester*, XXXIV, 281.

SYLVICULTURE.

BY

A. M. F. CACCIA, M.V.O., F.Z.S.

Up to the 23rd March 1908, the post of Imperial Sylviculturist was held by the Principal of the Imperial Forest College, and after that date the Imperial Superintendent of Forest Working Plans received charge of the office being most intimately connected with Sylviculture of which Forest Working Plans should be the expression.

Yield Tables.—The collection of statistics relating to the development of the principal timber species forms for many years to come one of the most important duties of the officers in charge of sylviculture and working plans in the Imperial Forest Research Institute. So far a certain number of figures have been locally collected, but on such a varying basis for different provinces, and with so little regard for the uniformity which is essential for collating the statistics, the utilisation of the work done is not always possible. Until a uniform procedure is intro-

duced for the whole of India and experimental work is carried out on identical lines, it will be difficult to compare and to bring together data collected by various investigators working on the same species throughout the Department.

In order to overcome this difficulty a series of experiments have been proposed and the rules governing the same suggested during the year. It is hoped that these experiments and rules, after their details have been discussed by Conservators, will be recognised as a standard in collecting statistical data regarding the development of the principal timber trees in India, and that the registers drawn up will be employed for recording the results.

Once some such principle is recognised as essential to the progress and the development of the Working Plans branch of the Imperial Forest Service, much will have been done towards concentrating the energies of the Department on the elucidation of definite problems in regular order of urgency. For an investigation of the existing experimental areas in India will probably show how little has been hitherto accomplished and how much more extended the operations must be to obtain tangible and reliable results.

Sylvicultural Systems.—An investigation was started during the year into the application of the various sylvicultural systems in Indian forests under systematic management, more particularly with reference to the methods employed in calculating the possibility. A table has been drawn up, classifying the forests for which working plans have been prepared according to the sylvicultural system in force. It will be found that the 'selection' system is the one at present almost universally employed. This system was made the subject of a very comprehensive study, and a note embodying the results of these inquiries has been prepared which will, it is hoped, whilst bringing up to date the information available on the subject, and indicating the line along which further research is required, tend to systematise the various methods at present employed in calculating the possibility.

The inquiry will now be extended to other recognised sylvicultural systems: the method of successive regeneration fellings and the 'group' system being next taken in hand. The former system has so far been practised only in the Darjeeling forests, and in the Pinus longifolia forests of the United Provinces: in both cases with the greatest success. It is now proposed to extend the method to the Monhyin teak forests of Upper Burma, and in the near future it may be found necessary to

apply it to the Terai Sal forests of the Kurseong Division of Bengal. A careful study of the application of this system to India, and of its near ally the 'group' system, is therefore indicated, particularly as regards simplifying and standardising the calculation of the possibility.

Miscellaneous.—In the course of the various investigations undertaken at the Forest Research Institute, the desirability of introducing uniformity in the definitions used in professional forestry literature has made itself felt; and with this object in view a glossary of technical terms for use in Indian forestry was prepared and issued during the year.

List of Indian Publications.

1907-08.

JACKSON, H. . Manual of Sylviculture.

MCINTIRE, A. L. . Notes on Sal in Bengal.

OSMASTON, L. S. . Experimental plantation of Albezzia Lebbek. Indian Forester, XXXIII, 177.

PEARSON, R. S. . On the natural regeneration of Anogeissus latifolia. Indian Forester, XXXIII, 231.

BEADON-BRYANT, F. . Fire-Conservancy in Burma. Indian Forester, XXXIII, 537 and 565.

LUSHINGTON, A. W. . Is a period of rest and rotation of crops wanted for teak reproduction? Indian Forester, XXXIII, 409.

PEARSON, R. S. . Level of subsoil water with regard to forests. Indian Forester, XXXIII, 57.

COVENTRY, E. M. . Note on Sal reproduction, Indian Forester. XXXIII, 174.

TULLOCH, J. C. . Working Plan for the Tehri Garhwal Leased Deodar forests.

COURTHOPE, E. A. . Working Plan for the Berkala, Dholkhand and Ranipur Ranges, Siwalik Division.

MONRO, A. V. . Working Plan for the Dungagali and Tandiani Ranges, Hazara Division.

COVENRTY, E. M. . Working Plan for the Sal forests of the Darrang Division.

DUNBAR BRANDER, A. A. . Working Plan for the forests of the Banjar Valley Reserve.

RORIE, J. J. . Working plan for the East Yoma, Satsuwa and Tindaw reserves.

RORIE, J. J. . Working Plan for the Tonkan Reserve.

COPLESTON, W. F. . Working Plan for Blocks VII-A and XX of the Supa Working Circle.

OSMASTON, L. S. The System of Agriculture combined with forestry in the Deccan of the Bombay Presidency. Indian Forester, XXXIII, 265.

JACKSON, H. . Selection by area. Indian Forester, XXXIII, 145 and 185.

MCINTIRE, A. L. . A Permanent method of treating selection forests without calculating the possibility. Indian Forester, XXXIII, 422.

CACCIA, A. M. F. A Preliminary Note on the development of the Sal in Volume and in Money Value.

CACCIA, A. M. F. . A glossary of technical terms for use in Indian forestry.

FOREST PRODUCTS.

BY

A. J. GIBSON, F.C.H.,

Imperial Forest Economist.

Forest Research Institute.—The Imperial Forest Economist and Imperial Forest Chemist were engaged on investigating a variety of articles of commerce, the raw materials of which are found in Indian Forests.

The chief subjects under investigation were an enquiry into the distribution and occurrence of Indian timbers suitable for cabinet and other fine work, which would meet a demand in the home market; the question of improving the quality and quantity of the raw lac, an industry which is annually becoming of more importance in India; the utilization of inferior Indian timbers for railway and other purposes after suitable chemical treatment to improve their durability; the possibility of making wood pulp from the Himalayan silver fir and spruce; the suitability and utilization of many Indian timbers for matches, tea-boxes, opium chests and lead pencils; and many minor enquiries, frequently started at the instance of some outside enquirer.

Strength Tests of Indian Timbers.—The Sibpur Engineering College has continued testing Indian timbers during the year though the progress made was necessarily slow.

The Products of the resin of *Pinus longifolia*.—The manufacture of oil of turpentine is now established in the Naini Tal and Jaunsar Divisions of the United Provinces and the turpentine has been the subject of analysis by the Imperial Forest Chemist with results that show that the quality of the turpentine could be greatly improved by introducing a system of steam distillation in place of the present system of heat with the addition of water. Professor Dunstan of the Imperial Institute is engaged on investigating the characteristic properties of the *Pinus longifolia* turpentine with a view to the identification of its constituents.

A great deal of colophony and turpentine, valued at some 14 lacs of rupees, is annually imported into India, and as the areas of pine forests in the country are large the local industry, if properly developed, should be capable of meeting a considerable proportion of the local requirements.

Lac.—During the year a publication on the lac insect was published as Part I, Volume I, of the Indian Forest Records. It gives in pamphlet form the state of present knowledge on the subject and the lines on which enquiries should proceed. The Economic branch of the Imperial Forest Research Institute is more concerned with the improvement in quality and quantity of the lac produced and experiments are in train to determine these conditions.

Destructive Distillation of wood.—The destructive distillation of wood, which produces such products as wood-creosote, acetic acid, methyl alcohol, acetone, etc., has been receiving attention and the results of destructively distilling various Indian timbers are now being investigated at the Imperial Forest Research Institute.

The local production of acetone to meet the demands of Indian cordite factories is of considerable importance and under the orders of the Madras Government an experiment on a commercial scale has been made in England with *Casuarina* wood with satisfactory results. The development of the industry depends largely on the possibility of arranging for a trained staff competent to supervise in the forest technical operations involved.

Antiseptic Treatment of woods.—With the ever increasing mileage of railways in India the problem of utilising the many inferior Indian timbers as sleepers gains in importance yearly and the subject is receiving due attention in the Economic branch of the Imperial Forest

Research Institute. A number of Indian timbers are being treated by the Powell process of preserving timber, through the Indian Agents Messrs. Killick, Nixon and Co. of Bombay. There seems little doubt that the process gives immunity from white ants to the timbers treated, but the experiments have not yet proceeded far enough to be able to arrive at any other definite conclusions.

Creosoting of pine sleepers was tried in India by some of the railways many years ago, but the results were not carefully recorded and a repetition of the experiment is desirable to test definitely the applicability of creosoting to Indian conditions. In order to carefully record results a stretch of experimental track to be set aside specially for the purpose, is urgently required.

Wood-Pulp.—During the year Mr. Sindall, the home paper-expert, was able to experimentally manufacture excellent pulp from the wood of the Himalayan silver fir and spruce. The question is receiving attention in the United Provinces and the Punjab and it is hoped that an experimental plant will be erected in one of these provinces to test the commercial prospects of chemical pulp, and possibly mechanical pulp as well, in India.

The Match Industry.—A gratifying amount of interest has been shown by private individuals and firms during the year in regard to the experiments now on foot in the Economic branch of the Imperial Forest Research Institute with the object of testing the suitability of various Indian timbers for making match-splints and match boxes. Thirty-five species of timbers are now being tested in Europe, a complete estimate of profit and loss on a modern equipped factory is available and the industry is likely to take a firm footing in India. The market is a large one, for the imports of matches are valued at nearly 63 lacs of rupees per annum.

Rubber.—The possibility of the profitable cultivation of rubber in India has now been firmly established and the industry can well be allowed to develop by private enterprise. The cultivation of rubber has been receiving attention in Bombay Presidency and elsewhere during the year, with uneven results, largely due to bad quality of seed employed.

Oils and oil-seeds.—The demand for edible oils and oil-seeds is very large and there are many Indian timber trees which produce oily seeds, suitable for extraction of oil and the manufacture of oil-cake. The question has occupied the Imperial Forest Chemist and Imperial Forest Economist during the year, while the Reporter on Economic Products to

the Government of India and the Imperial Institute have also been studying the matter. The scattered distribution of the trees and the want of communications often precludes the possibility of delivering these seeds to consumers at remunerative rates.

Tans and dyes.—Professor Dunstan of the Imperial Institute submitted a report to the Government of India on the relative merits of Borneo Cutch and Rangoon Mangrove extract with the result that the latter was found to have a considerably higher tanning value.

The question of the supply of tanning materials to the large leather-tanning centres in the United Provinces was under investigation during the year and the Cawnpore Chamber of Commerce is of opinion that a good tanning material is obtainable from the bark of *Acacia leucophlæa*, the wood being used for paper pulp. This opinion will probably be tested by making a commercial experiment in Norway with the wood-pulp from this species. Tanning extracts have rapidly come into favour in the home market and it seems more than likely that Indian tanning concerns will have to look in the same direction for a solution of the problem of shortage of local tanning stuffs.

Botanical and other specimens.—In March and April 1908 over 360 forest specimens illustrating the scope and forest products of the Indian Forest Department were despatched by the Imperial Forest Economist, at the instance of the Government of India, to the Franco-British Exhibition, London.

Seeds.—As usual a number of indents for seed of Indian timber trees were received and complied with during the year, many indents being from foreign countries, such as German East Africa, Austria, Chili and the United States of America.

Publications.—Several publications dealing with forest economic products were sent to the press but have not been published up to the time of writing this note.

Of the publications on forest matters the following are the most noteworthy :—

(1) ABBEY-YEATES, R. "Account of an enquiry with regard to the Candle-Nut tree (*Aleurites molucanna*) in India."

(2) CACCIA, A. M. F. "A Glossary of Technical Terms for use in Indian Forestry." (Forest Pamphlet No. 3, W. P, Series No. 1.)

(3) CACCIA, A. M. F. "A Preliminary Note on the Development of the Sâl in Volume and in Money Value." (Indian Forest Records, Volume I, Part II.)

(4) HOOPER, D. . "The Uses and Composition of Tamarind Seed." (Agricultural Ledger No. 2 of 1907.)

(5) HOOPER, D. . "The Fats of Indian Nutmegs" (Agricultural Ledger No. 3 of 1907.)

(6) MR. PURAN SINGH "Note on the Utilisation of Khair Forests in Eastern Bengal and Assam." (Forest Pamphlet No. 1, Chemical Series No. 1.)

(7) TROUP, R. S. . "Indian Woods and their Uses." (*In the press.*)

(8) TROUP, R. S. . "The Present Position and Future Prospect of the Cutch trade in Burma." (*In the press.*)

INDIAN ZOOLOGY.

BY

N. ANNANDALE, B.A., D.Sc.,

Superintendent, Indian Museum, Natural History Section.

The period covered by this Report extends from the end of August 1907 to the end of September 1908. As usual the report deals in the first instance with the zoological research done in the Indian Museum, but also includes a brief account of all work published in India and elsewhere that has a direct and immediate bearing on the study of the fauna of the Indian Empire, whether from the point of view of pure or of applied science. The only zoological subjects not dealt with are Economic Entomology, on which separate supplementary reports are submitted by the Imperial Entomologist and the Imperial Forest Zoologist; Veterinary Zoology, which is included in the report on Veterinary Science, and Zoology in medical education, which the Board of Scientific Advice has decided to be outside its province.

1. Zoological Research in the Indian Museum.

The research done in the Natural History Section of the Museum during the period under review has been of a more varied nature than

has been the case for some years past, mainly owing to the number of scientific workers whose services it has been found possible to enlist as a temporary measure.

Unfortunately, with the exception of myself, none of the workers are permanent officers of the Museum, all being either on special duty, in the temporary employment of the Trustees, or having no official connection with the Museum. The Government of India have expressed their general approval of the scheme for the permanent increase of the zoological staff of the Museum proposed by the Trustees in 1907; but the matter is still under consideration.

Survey of the fauna of stagnant water.—A collection of the aquatic animals of the Tibetan provinces of Tsung and U was made in 1907 by Captain F. H. Stewart, I.M.S., who generously presented it to the Indian Museum on condition that arrangements were made for the description of its component parts by specialists in the various groups represented. It has been found possible to fulfil this condition by distributing the collection widely, and Captain Stewart has added to our obligations not only by working out the Rotifers and Gastrotricha himself, but also by contributing an introduction to the report on his collection, which will be published shortly by the Trustees. Professor E. von Daday of Buda-Pest has written an account of the Entromostracous Crustacea and of the only water-mite obtained; Colonel H. H. Godwin-Austen, F.R.S., has described a new slug of aquatic habits but closely allied to a common European species, and M. Germaine of the Paris Museum, a new *Planorbis*: Dr. J. G. deMan in Holland and Professor L. Camerano at Turin have supplied notes on the Nematomorph worms, as I have done on a species of Hydra and on the larva of *Rana pleskii*, the only frog obtained. Captain R. E. Lloyd, I.M.S., has described the fishes, of which several are new to science, and Major J. Stephenson of Lahore, the Oligochæte worms; the leeches have been submitted to Professor Blanchard of Paris, the majority of the molluscs have been named and described by Mr. H. B. Preston in London, while Prof. von Graf of the University of Graz in Austria has kindly arranged to have the Turbellarians worked out in his laboratory. The completion of the work on this collection will add considerably to our knowledge not only of the zoology of Tibet but also of the aquatic fauna of high altitudes generally, the specimens having been obtained at above 13,000 feet. I have described in detail how the collection has been distributed to illustrate the manner in which it is necessary now-a-days to sort out even a homogeneous

collection of the kind, in order that the different groups represented in it may receive attention from their proper specialists.

The fauna of stagnant water in Indian territory has continued to occupy a great part of my own attention. Experiments are in progress as regards the biology and evolution of the sea anemone (*Metridium schillerianum*) of the brackish ponds at Port Canning, and I have described several Hydroids and Polyzoa from the same ponds, including a remarkable new genus of Entoprocta. Papers on the crustacea of the ponds based on my collections have been written by Dr. J. G. de Man, the Rev. T. R. R. Stebbing, F.R.S., and Mr. W. M. Tattersall of the Irish Fishery Board, while Dr. A. Willey, F.R.S., Director of the Colombo Museum, has recently sent to the "Records" a description of a new Polychæte and Major J. Stephenson, I.M.S., has described an aberrant Oligochæte worm.

A visit to the Western Ghats in the Bombay Presidency last November enabled me to obtain material for the study of several interesting sponges and Polyzoa, while a tour in Burma in February and March increased the opportunity of investigating the distribution of these groups, resulting in the discovery of new species of *Tubella* and *Pectinatella*, genera poorly represented in the East and not hitherto recorded from India.

At the beginning of the "rains" I made a hurried trip to the Darjeeling hills in order to obtain the eggs and larvæ of *Tylototriton*, the only Indian newt. A considerable amount of material as regards this species was obtained and other aquatic collections were made.

The whole of the Museum collection of Telphusidæ (freshwater crabs) has recently been sent to Lieutenant-Colonel A. W. Alcock, F.R.S., the late Superintendent, in order that he may prepare a descriptive catalogue of the Indian species. As this collection is perhaps the most complete of any in existence so far as Eastern Asia is concerned, Colonel Alcock's account of it cannot fail to be of the greatest importance in the study of the distribution of the aquatic fauna of the East.

Terrestrial Zoology.—I mentioned in my last report to the Board that the Trustees of the Indian Museum contemplated appointing a temporary assistant with a specialist's knowledge of the Mammalia, in order that he might work out the rats sent to the Museum as a result of the circulation of Dr. Hossack's pamphlet on the common Indian species. The honorarium that the Trustees were able to offer did not prove sufficient to attract any zoologist whose experience entitled him to be

considered a specialist; but the gentleman appointed, Mr. T. Bentham of Queen's College, Oxford, has done valuable work in re-arranging the old collection of mammals, which had of necessity been somewhat neglected in recent years. The fact that a specialist was not found to deal with the rats has proved fortunate in the end, for there can be little doubt that an expert mammalologist would have been justified in devoting his attention mainly, in the short period of time at his disposal in India, to a study of taxonomic minutiæ. Owing to the fact that a specialist was not found, moreover, Captain R. E. Lloyd, I.M.S, was put on special duty in the Museum for a period of six months—afterwards extended to a year, in order that he might study the distribution of the different Indian rats in connection with the distribution of plague. Interesting as taxonomic minutiæ may be, there can be no doubt that the work Captain Lloyd has done is of more importance both to pure and to sanitary science. The generous response that has been made to our appeal for rats measured in the flesh and properly preserved has made it possible for him not only to study the distribution of the typical forms but also to investigate their variation biologically, and at the same time to give detailed and accurate descriptions of the species or races occurring in or characteristic of a large number of localities. He has been able, further, to supply definite information correlating the absence of one common rat with the absence of plague in one of the great Indian ports. His work, it may be said, is that of a zoologist in the larger sense, acquainted with local conditions and able to make enquiries on the spot regarding points on which information was not forthcoming. The fact that he has been able to refrain from describing a single new species, although he has clearly indicated that certain species are peculiarly liable to the production of sports that may be either perpetuated or die out at once, is important. It is no exaggeration to say that in some cases he has had at his disposal hundreds of specimens for every ten that exist in European museums. The results of the work done during his year of special duty will be published shortly in a special number of the "Records of the Indian Museum," but it is to be hoped that his return to medical duty, if the medical authorities so decide, will not put a stop to the important work inaugurated by Dr. Hossack and so widely extended by himself.

Mr. Bentham, temporary assistant in the Museum, has studied the skulls, skins and skeletons of the Takin (*Budorcas*) belonging to the Museum or on permanent loan from the Asiatic Society of Bengal and has

demonstrated that the nasal chamber is very much more highly developed in the race which inhabits the Mishmi Hills on the northern frontier of Assam than in that found in Eastern Tibet. Possibly this difference may be correlated with a difference in habit, the Mishmi race living in dense jungle and therefore being obliged to trust to its sense of smell to detect the approach of enemies. Mr. Bentham has also prepared an illustrated catalogue of the collection of Asiatic horns and antlers (with measurements of all the specimens) which will be published shortly.

The earthworms of India have hitherto received comparatively little attention from zoologists, although it is recognized that no group provides better evidence in the study of zoogeography; nor was the Museum collection until recently by any means a large one. Two years ago, however, tubes of spirit were circulated all over India to those likely to assist us, with an appeal that the common earthworms of the locality to which the tubes were sent might be collected. The appeal met with generous support and a collection representative of most parts of India was obtained. The collection was submitted to Dr. W. Michaelsen, of the Hamburg Natural History Museum, who has written an exhaustive monograph on the Indian Oligochæte worms as a result of its study. The monograph will shortly be published in the "Memoirs of the Indian Museum," together with an account of the anatomy of some aquatic species of the same order by Major J. Stephenson, I.M.S., Professor of Biology at the Government College, Lahore.

It is now some years since the Museum was relieved of the burden of economic entomology by the appointment of a special officer under the Agricultural Department of the Government of India to deal with this branch of the subject. The wisdom of the separation, considering the small staff of the Museum, is now becoming apparent in the increased attention it has become possible for us to devote to taxonomic work as regards insects. The only original work that has been done recently in this direction in the Museum is Mr. E. Brunetti's revision of certain families of Diptera. During the year he has finished his account of the Bombylidæ, Leptidæ and Psychodidæ—the last family in conjunction with Dr. Annandale and Mr. Lefroy, and has made considerable progress in his study of the Tipulidæ and Sepsinæ, thus greatly extending our knowledge of the Oriental species of the order.

Scarcely less important, however, from the point of view of the study of entomology in India, is the humbler task of arranging the collections that have already been named by specialists in Europe, and of sorting

out into their families the new specimens that have recently been received, in order that they too may be sent to specialists. The progress that has been made in these directions has been great, for it is now possible to say that a large proportion of the entomological collection can be consulted with ease by the serious student, who is able to see at a glance from the labels on the specimens who is responsible for the names given them — a matter of some moment. During the last year a large proportion of the beetles have been carefully re-arranged, keeping this point in view; the whole of the Cicindelidæ have been examined and named by Dr. Walter Horn in Berlin and the Cleridæ by Dr. Schenkling in the same city, while some of the Cerambycidæ, Cetonidæ and Curculionidæ sent to the British Museum last year in connection with the preparation of volumes in the "Fauna of British India," have been returned. A valuable collection of beetles of different families sent for determination to France twenty years ago and long lost sight of, owing to the death of the specialist to whom they were sent, has also, through the kind offices of Professor E. L. Bouvier, of the Paris Museum, been sent back to India, a large proportion of the specimens named by good authorities. Similar work has been done as regards the mosquitoes, Aculeate Hymenoptera, Rhynchota and Microlepidoptera, with the invaluable assistance given us in England by Mr. F. Theobald, Lieutenant-Colonel C. T. Bingham, Mr. W. L. Distant and the Rev. E. Meyrick, F.R.S.

Marine Zoology. —One of the chief drawbacks to the scientific study of zoology in the tropics has hitherto been the belief that it is impossible to cut serial sections with a microtome at high atmospheric temperatures. It is therefore satisfactory to report that this difficulty has been proved to be rather imaginary than real. Work has recently been done in the Museum, during the rains and the latter part of the hot weather, by Captain F. H. Stewart, I.M.S., D.Sc., Surgeon-Naturalist, Indian Marine Survey, on a remarkable deep-sea worm which he considers to represent a new order of Gephyrea. The discovery of a hitherto unknown order in any group is an event of zoological importance, but the excellence of Captain Stewart's serial sections and other preparations is perhaps even more important to Indian zoology, in that it removes the only argument left to those who assert that biological research should not be attempted in Calcutta. Captain Stewart's paper will be published in the "Memoirs of the Indian Museum".

Captain R. E. Lloyd, I.M.S., D.Sc., has obtained his doctorate in

science from the University of London on a thesis consisting of the results of his investigations on marine zoology recently undertaken in the Museum. These include an account of the anatomy of the largest of known Isopod Crustaceans (*Bathynomus giganteus*) and of a peculiar Hydroid (*Nudiclava*) parasitic on a pelagic fish and differing from all other known forms in certain strongly marked characters. Captain Lloyd has also nearly ready for the press an account of the deep-sea fish dredged by the "Investigator" since Colonel Alcock's monograph on the collection was published.

I have myself commenced the preparation of an account of the Indian stalked barnacles, for the study of which the Museum collection affords unique opportunities not only owing to the "type" specimens it includes but more specially to the large number of individuals by which many of the least known species are represented.

During the past year the Museum has come into definite relations with Bengal fisheries owing to the purchase by the Local Government of a steam trawler and the generous manner in which our request for specimens of the fishes and other animals captured has been met. It is understood that a Fishery Board is about to be constituted of which the Superintendent of the Natural History Section will be a member *ex-officio*, and that a zoological expert has already been appointed to advise the Commissioner of Fisheries on technical matters. In the meanwhile progress has been made in the study of the valuable collection of large rays and other fishes presented to the Museum by the Commissioner of Fisheries. The rays are particularly valuable from a scientific point of view, because, owing to their large size, they have been little studied in the flesh by ichthyologists and are mostly known from dried skins and other imperfectly preserved specimens. Arrangements have therefore been made to obtain photographs, water colour sketches and casts of the more interesting species while the specimens are still fresh, in addition to preserving the skins and skulls. For several months Mr. B. L. Chaudhuri, B.Sc., Assistant to the Commissioner of Fisheries, has devoted such time as he has been able to spare to systematic work on ichthyology in the Museum, and has, with the aid of Day's and the "Investigator" collections, been able to name the great majority of the fish taken by the trawler. Some of these appear to be new to science, although evidently not uncommon in the Bay of Bengal, while others hitherto not obtained in Indian seas or considered rare have been taken in considerable numbers.

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Museum Conference in Calcutta.—A conference of delegates from various Local Governments and Native States was summoned to meet in Calcutta in December last by the Government of India. As its deliberations may have an important result as regards the study of zoology in India it may be mentioned here. Perhaps the most noticeable fact apparent in the discussions, so far as zoology was concerned, was the readiness both to give and ask for assistance from the Central Museum (Indian Museum) evinced by the curators of local museums. A full report on the Conference, which was held in the Indian Museum under the Chairmanship of Mr. (now Sir Thomas) Holland, F.R.S., Chairman of the Trustees, has been issued by the Government of India and copies have been sent to the members of the Board.

II. Work on Indian Zoology outside the Museum.

Research undertaken in India.—The investigations undertaken by Major Stephenson in the Government College, Lahore, on aquatic Oligochætes have considerable importance, while a paper on the spiny lobster of Bombay, published in the "Journal of the Bombay Natural History Society" by Dr. Arthur Powell of the Grant Medical College, is perhaps of even greater importance in that it helps to supply one of the wants felt by the student of zoology in India, namely, the lack of clear and detailed descriptions of the anatomy of the zoological types which he must examine. It is often forgotten that even the earthworms which the Indian student has to dissect belong to different families from those described in the ordinary text-books, and that the differences even between species in some orders are of a kind that puzzle a trained zoologist, unless he chances to have made a special study of the group to which the specimens whose structure he must demonstrate belong. Little progress can therefore be expected in the teaching of practical zoology until descriptions like that of Dr. Powell are available to students and teachers. Without a sound practical training, zoological research is much better left alone.

In this connection it is interesting to note the difference in the incidence of zoological research in this country and in Great Britain, in which scientific zoology is cultivated in the colleges and universities rather than in the museums. In the latter if any zoological research is

done at all, it is almost solely taxonomic; if it is otherwise, it ranks as the private work of the men who do it and not as part of their official duties. In India, on the other hand, the greater part of the pure zoological research in all branches that has been and is being done has been undertaken in connection with institutions not connected with teaching.

As regards the zoological work of private societies in India, the numerous and valuable papers published in the "Journal" of the Bombay Natural History Society are the best proof of its vitality, while the fact that a branch society and a museum have recently been established in Quetta proves that interest is taken in some branches of zoology in Baluchistan. So far as papers are concerned, the Asiatic Society of Bengal has perhaps suffered by the institution of a regular series of publications on the part of the Indian Museum; but the Museum was originally founded by the Society and still maintains its connection therewith through the Trustees appointed by the Council of the Society.

Work done in Europe and America.—I have already referred to some of the European specialists to whom collections have been distributed for identification from the Indian Museum during the year; a complete list will be found in my annual report to the Trustees for the financial year 1907-1908. The work done on the material thus sent out and on other material already in Europe, whatever the source of the specimens may be, is and must be mainly taxonomic. Few representatives of the Indian fauna diverge in structure so far from the normal as to be of special interest to students of morphology, while it is obvious that the biological aspects of Indian zoology can only be studied in India, as many interesting observations can only be made in the case of living animals.

As regards taxonomy, it is interesting to observe, as can be done by consulting the bibliography appended, that work on Indian specimens is by no means the monopoly of any one museum. Except in Calcutta, the largest Indian collections are probably in London; but the amount of Indian material on the Continent is by no means small, while the number of Continental specialists engaged in work on groups well represented in India is very large. It is therefore possible in many cases to get specimens promptly named in Berlin, Paris, Buda-Pest or Vienna which in London would be relegated to store cabinets for months or years until some specialist arose who could or had time to name them. Hence the necessity for distributing zoological collections so widely.

List of the Papers and Books having a special reference to Indian Zoology recently published.

In the *Annals and Magazine of Natural History*. A Contribution to the knowledge of the Hymenoptera of the Oriental Zoological Region. By P. Cameron. Series 7, Vol. XX, 1907, pp. 10, 81.

On the Generic Position of Benson's *Helix hyba* and the similarity of its Anatomy to that of *Khasiella vidua*, W. T. Blanford. By H. H. Godwin-Austen. *Ibid.*, p. 55.

New and little known Eastern Moths. By C. Swinhoe. *Ibid.*, p. 75.

A Subdivision of the old Genus *Nesokia* with Descriptions of three new members of the Group, and of a *Mus* from the Andamans. By Oldfield Thomas. *Ibid.*, p. 202.

New Species of African and Indo-Malayan Hesperiidæ. By C. Swinhoe. *Ibid.*, p. 430.

New Eastern Lepidoptera. By C. Swinhoe. Series 8, Vol. I, 1908, p. 60.

Notes on the Coleopterous Genus Oniticellus and Descriptions of new species from India. By G. J. Arrow. *Ibid.*, p. 178.

On the generic names of the Rupicaprine Ruminants known as Serows and Gorals. By R. I. Pocock. *Ibid.*, p. 183.

Additions to the Hymenopterous Genera *Myzine* and *Plesia*. By R. E. Turner. *Ibid.*, p. 497.

A case of Abnormal Dentition in a Dhole, or Indian Red Dog (*Cuon dukhunensis*). By R. I. Pocock. Series 8, Vol. II, 1908, p. 196.

Notes on the Coleopterous Genera *Horia*, Fab., and *Cissites*, Latr., and a list of the described species. By C. J. Gahan. *Ibid.*, p. 199.

On a new species of Histeridæ and notices of others. By G. Lewis. *Ibid.*, p. 137.

On some new species and sub-species of Birds from Upper Burma. By H. H. Harington. *Ibid.*, p. 244.

In the *Journal of the Linnean Society of London*. Some New Alcyonaria from the Indian and Pacific Oceans. Preliminary Notice. By Ruth M. Harrison, Lady Margaret Hall. Vol. XXX (Zoology), 1908, p. 185.

In the *Proceedings of the Malacological Society of London*. A Revision of the species of Cyclostreniatidæ and Liotiidæ occurring in the Persian Gulf and North Arabian Sea. By J. C. Melvill. March 1906, p. 20.

On a species of the land Molluscan Genus *Dyakia* from Siam. By H. H. Godwin Austen. June 1906, p. 93.

Notes on Indian and Ceylonese species of *Glessula*. By R. H. Beddome. September 1906, p. 160.

On *Glessula parabilis*, Benson. By R. H. Beddome. March 1907, p. 204.

In the *Annals of Tropical Medicine and Parasitology*. Two new Human Cestodes and a new Linguatulid. By J. W. W. Stephens. Series T. M. Vol. I, No. 4, 1908, p. 549.

What is "*Schistosomum mansoni*" Sambon 1907?. By A. Looss. Series T. M. Vol. II, No. 3, 1908, p. 153.

The Life History of *Trypanosoma lewisi*. By J. E. Salvin Moore, Anton Breinl and E. Hindle. *Ibid.*; p. 197.

Contributions to the Morphology and Life History of *Piroplasma canis*. By Anton Breinl and E. Hindle. *Ibid.*, p. 233.

In the *Transactions of the Entomological Society of London*. Notes on the Indo-Australian Papilionidæ. By P. I. Lathy. 1907, p. 1.

A Preliminary Revision of the Forficulidæ (*sensu stricto*) and of the Chelisochidæ, families of the Dermatoptera. By Malcolm Burr. *Ibid.*, p. 91.

On a remarkable undescribed form of Moth belonging to the family Tineidæ. By C. T. Bingham. *Ibid.*, p. 177.

Odonata collected by Lt.-Col. Nurse, chiefly in North-Western India. By K. J. Morton. *Ibid.*, p. 303.

On a large series of Nycteribiidæ, parasitic Diptera, from Ceylon. By H. Scott. *Ibid.*, p. 421.

Notes and Descriptions of Pterophoridæ and Orneodidæ. By E. Meyrick. *Ibid.*, p. 471.

On the species of Hesperidæ from the Indo-Malayan and African Regions, described by Herr Plotz, with descriptions of some new species. By C. Swinhoe. 1908, p. 1.

Metamorphoses of two Hemiptera-Heteroptera from Southern China. By J. C. W. Kershaw and G. W. Kirkaldy. *Ibid.*, p. 59.

In the *Proceedings of the Zoological Society of London*. Contribution to the knowledge of the Anatomy of the Batrachian Family Pelobatidæ. By F. E. Beddard. 1907, p. 871.

On the Hæmogregarine from the Blood of a Himalayan Lizard (*Agama tuberculata*). By E. A. Minchin. *Ibid.*, p. 1098.

Notes upon an abnormally marked Leopard-skin from the Deccan. By R. Lydekker. 1908, p. 1.

Notes on some Species and Geographical Races of Serows (*Capricornis*) and Gorals (*Næmorhedus*), based upon specimens exhibited in the Society's Gardens. By R. I. Pocock. *Ibid.*, p. 173.

A Revision of the Sharks of the Family *Orectolobidæ*. By C. Tate Regan. *Ibid.*, p. 347.

A Revision of the Oriental Pelobatid Batrachians (Genus *Megalophrys*). By G. A. Boulenger. *Ibid.*, p. 407.

In the *Proceedings of the Royal Society*. The Life History of *Trypanosoma equiperdum*. By J. E. Salvin Moore. Series B, Vol. LXXX, 1908, p. 288.

In the *Proceedings of the Cambridge Philosophical Society*. The histology of the early placenta of *Macacus nemestrinus*. By W. L. H. Duckworth. Vol. XIV, 1908, p. 299.

On a new genus of Ixodoidea together with a description of eleven new species of ticks. By G. H. F. Nuttall and C. Warburton. *Ibid.*, p. 392.

On some new and obscure species of the genus *Hæmaphysalis* of the Ixodidæ. By C. Warburton. *Ibid.*, p. 508.

The Geographical Distribution of the Acarine Family Oribatidæ. By C. Warburton. *Ibid.*, p. 532.

In *Parasitology*. The Structure and Biology of *Hæmaphysalis punctata*, Canestrini and Fanzago. I. By G. H. F. Nuttall, W. F. Cooper and L. E. Robinson. Vol. i, 1908, p. 152.

In the *Journal of Hygiene*. Reports on plague investigations in India. Issued by the Advisory Committee appointed by the Secretary of State for India, the Royal Society, and the Lister Institute. Tom. vii, 1907, p. 324.

In *Novitates Zoologicæ*. Two new Indian Sphingidæ in the British Museum. By Sir George Hampson. Vol. xiv, 1907, p. 327.

In the *Canadian Entomologist*. On a few Oriental Geocoridæ (Hemiptera). By G. W. Kirkaldy. Vol. xxxix, 1907, p. 331.

A note on the species of *Micronecta* occurring in India and Ceylon. By G. W. Kirkaldy. Vol. xl, 1908, p. 209.

In the *Bulletin of the Museum of Comparative Zoology, Cambridge, U. S. A.* Notes on Chiroptera. By G. M. Allen. Vol. lii, No. 3, 1908, p. 25.

In the *Journal of the Bombay Natural History Society*. A Popular Treatise on the Common Indian Snakes. By F. Wall. Vol. xviii, 1908, pp. 1, 227, 525.

On the Birds of the Chindwin, Upper Burma. By A. Mears and E. W. Oates. *Ibid.*, p. 78.

Some Indian Freshwater shells. By G. Dalgliesh. *Ibid.*, p. 92.

Notes on Snakes collected in Fyzabad. By F. Wall. *Ibid.*, p. 101.

On a new Genus and some new species of Aculeate Hymenoptera collected by Lieut.-Colonel. Nurse in Baluchistan. By P. Cameron. *Ibid.*, p. 130.

Descriptions of Indian Micro-Lepidoptera. By E. Meyrick. *Ibid.*, pp. 134, 437, 613.

On the Generic position of the Groups of Squirrels typified by *Sciurus berdmorei* and *pernyi*, respectively, with descriptions of some new Oriental species. By Oldfield Thomas. *Ibid.*, p. 244.

The Drinking Habits of Wild Animals. By R. G. Burton. *Ibid.*, p. 250.

Two new snakes from Assam. By F. Wall., *Ibid.*, p. 272.

On some Indian forms of the Genus *Micromys*. By R. C. Wroughton. *Ibid.*, p. 280.

Notes on the Birds of Thandiani. By H. A. F. Magrath. *Ibid.*, p. 284.

A Contribution to the Aculeate Hymenoptera of the Bombay Presidency. By P. Cameron. *Ibid.*, pp. 300, 649.

Notes on a collection of Snakes from Khasi Hills, Assam. By F. Wall. *Ibid.*, p. 312.

Palinurus or the "Spiny-Lobster" of Bombay. By A. Powell. *Ibid.*, p. 360.

A Further List of the Birds from the Chindwin, Upper Burma. By C. Hopwood. *Ibid.*, p. 432.

Breeding habits of some snakes and lizards. By F. Dreckmann. *Ibid.*, p. 434.

Further Notes on birds of the provinces of Kashmir and Jammu and adjacent districts. By A. E. Ward. *Ibid.*, p. 461.

A new long-eared Bat from Northern India. By G. E. H. Barrett-Hamilton. *Ibid.*, p. 468.

Biological Notes on Oriental Hemiptera, No. 1. By J. C. Kershaw and G. W. Kirkaldy. *Ibid.*, p. 596.

In the *Journal of the Asiatic Society of Bengal*. Note on the

Blue or Common Heron (*Ardea cinerea*). By D. C. Phillott. Vol. iii, 1907, p. 553.

Hindustani-English Vocabulary of Indian Birds. By D. C. Phillott and G. L. Bonnerjee. Vol. iv, 1908, p. 55.

Note on the Peregrine Falcon. By D. C. Phillott. *Ibid.*, p. 259.

In the *Memoirs of the Indian Museum.* The Anatomy of *Bathynomus giganteus.* By R. E. Lloyd. Vol. i, No. 2, 1908, p. 81.

In the *Records of the Indian Museum. Nudiclava monocanthi*, the type of a new genus of Hydroids parasitic on Fish. By R. E. Lloyd. Vol. i, 1907, p. 281.

Preliminary descriptions of three new Nycteribiidæ from India. By P. Speiser. *Ibid.*, p. 295.

Annotated Catalogue of Oriental Culicidæ. By E. Brunetti. *Ibid.*, p. 297.

Notes on Oriental Diptera, No. iv. By E. Brunetti. *Ibid.*, p. 381.

Notes on Freshwater Sponges. By N. Annandale. *Ibid.*, p. 387, and Vol. ii, pp. 25, 157.

Description of a new Cyprinid Fish of the genus *Danio* from Upper Burma. By C. Tate Regan. Vol. i, 1907, p. 395.

The Fauna of Brackish Ponds at Port Canning, Lower Bengal. By N. Annandale, J. Stephenson, T. R. R. Stebbing, J. G. de Man, and W. M. Tattersall. Vol. ii, 1908, pp. 11, 39, 119, 211, 233.

Description of a new species of *Danio* from Lower Burma. By B. L. Chaudhuri. *Ibid.*, p. 125.

Rhynchota Malayana, Part i. By W. L. Distant. *Ibid.*, p. 127.

Cimex rotundatus, Signoret. By W. S. Patton. *Ibid.*, p. 153.

Fruit Bats of the genus *Pteropus* inhabiting the Andaman and Nicobar Archipelagos. By G. E. Mason. *Ibid.*, p. 159.

A new species of Sun-Bird obtained near Darjeeling. By T. Bentham. *Ibid.*, p. 167.

Three Indian Phylactomæmata. By N. Annandale. *Ibid.*, p. 169.

On two new species of Eagle-Rays (Myliobatidæ). By R. E. Lloyd. *Ibid.*, p. 175.

Description of a new species of the genus *Sesarma*, Say., from the Andamans. By J. G. de Man. *Ibid.*, p. 181.

Descriptions of new species of land, marine and freshwater shells from the Andaman Islands. By H. B. Preston. *Ibid.*, p. 187.

Description of a new Dictyonine Sponge from the Indian Ocean. By R. Kirkpatrick. *Ibid.*, p. 21.

Remarkable cases of Variation. No. 1. By R. E. Lloyd. *Ibid.*, p. 29.

Description of a new species of Lizard of the Genus *Salea* from Assam. By N. Annandale. *Ibid.*, p. 37.

Description of a new Cavernicolous Phasgonurid from Lower Siam. By W. F. Kirby. *Ibid.*, p. 43.

Description of new species of Marine and Freshwater Shells in the collection of the Indian Museum. By H. B. Preston. *Ibid.*, p. 45.

Notes on Oriental Syrphidæ. Part I. By E. Brunetti. *Ibid.*, p. 49.

Description of a new variety of *Spongilla loricata*. By R. Kirkpatrick. *Ibid.*, p. 97.

Notes on Oriental Diptera. By N. Annandale. *Ibid.*, p. 101.

On some Oriental Solifugæ with descriptions of new forms. By A. S. Hirst. *Ibid.*, p. 241.

The difference between the Takin (*Budorcas*) from the Mishmi Hills and that from Tibet, with notes on variation displayed by the former. By T. Bentham. *Ibid.*, p. 249.

On *Caridina nilotica* (Roux) and its varieties. By J. G. de Man. *Ibid.*, p. 255.

Description of a new species of *Charaxes* from the Bhutan Frontier. By G. de Rhé-Philipe. *Ibid.*, p. 285.

First Report on the Collection of Culicidæ and Corethridæ in the Indian Museum, with descriptions of new genera and species. By F. V. Theobald. *Ibid.*, p. 287.

Occasional Publications of the Indian Museum. Echinoderma of the Indian Museum: Shallow-water Holothurioidea collected by the R. I. M. S. Investigator. By R. Koehler and C. Vaney.

In the *Bulletin de la Société Entomologique de France.* Diagnoses de deux *Ancyrona* nouvelles de l'Inde (Col.), par A. Léveillé. 1907, p. 87.

Contribution à la faune indo-chinoise (Col.). Tennochilides recueillis au Tonkin par le capitaine de frégate L. Blaise, par A. Léveillé. *Ibid.*, p. 163.

Note sur les *Papilio* asiatiques du groupe d'*Alcinous* (Lep. Rhop.), par Ch. Oberthur. *Ibid.*, p. 136.

Description de Silphides et Liodides nouveaux (Col.) par G. Portevin. *Ibid.*, p. 251.

Description de deux formes nouvelles de Tennochilides (Col.), et note rectificate, par A. Léveillé. 1908, p. 212.

Descriptions de deux nouveaux *Stomoxys* du Bengale, par F. Picard. *Ibid.*, p. 20.

In the *Deutsche Entomologische Zeitschrift.* Liste des Mutillides recueillis à Ceylan par M. le Dr. Walther Horn et Description des espèces nouvelles (Hym.), par E. André. 1907, p. 251.

Berytiden und Myodochiden von Ceylon aus der sammelausbeute von Dr. W. Horn (Rhynch. het.), von G. Breddin. *Ibid.*, p. 34.

Die Arten der Gattung *Læna* Latr. (Tenebrionidæ) au dem westlichen Himalaya, gesammelt auf seinen Reisen von Herrn Karl Rost (Col.), von Edm. Reitter. 1908, p. 275.

Die Cleriden des Deutschen Entomol. National-Museums (Col.) Nachtrag ii, von Sigm. Schenkling. *Ibid.*, p. 477.

Neue indische Hemiptera, von E. Bergroth. *Ibid.*, p. 589.

Neue Erotyliden, von P. Kuhnt. *Ibid.*, p. 626.

Beitrage zur Staphylinidenfauna Ostindiens (West-Himalaya), von K. Schubert. *Ibid.*, p. 609.

In the *Zeitschrift fur systematische Hymenopterologie und Dipterologie.* Description of two new genera and four species of Indian Parasitic Hymenoptera. By P. Cameron. Vol. vii, 1907, p. 462.

On some new genera and species of Ichneumonidæ from the Himalayas. By P. Cameron. *Ibid.*, p. 466.

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In the *Zoologisches Anzeiger.* On the systematic position of *Eunephthya maldivensis* Hickson. By S. J. Hickson. Bd. xxxiii, 1908, p. 173.

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In the *Stettiner Entomologische Zeitung.* Neue indomalayische Russelkafer, vorwiegend aus Madras und Borneo. Von K. M. Heller. 69 Jahrgang, 1908, p. 122.

Coleopteren aus Ostindien. Von J. Weise. *Ibid.*, p. 213.

Versuch einer monographischen Revision der Indo-Australischen Neptiden. Von H. Fruhstorfer. *Ibid.*, p. 240.

In the *Annales de la Société Entomologique de Belgique.* Pselaphides nouveaux des Indes, par A. Raffray. Vol. lii, 1908, p. 205.

In *Notes from the Leyden Museum.* Systematic Monograph of the Atlantidæ (Heteropoda) with enumeration of the species in the Leyden Museum. By J. J. Tesch. Vol. xxx, 1908, p. 1.

In the *Annales Musei Nationalis Hungarici.* Die Dipteren-Gruppe Milichinæ. Von Th. Becker. Vol. v, 1907, p. 507.

Some new Exotic Phoridæ. By C. T. Brues. *Ibid.*, p. 400.

Coleoptera nova in Museo Nationali Hungarico, descripsit E. Csiki. *Ibid.*, p. 574.

Formicides du Musée National Hongrois, par A. Forel. *Ibid.*, p. 1.

Vier Neue *Pipunculus*-Arten. Von K. Kertész. *Ibid.*, p. 579

Nouveaux Genres et espèces du Groupe des Geocorinæ. Par A. L. Montandon. *Ibid.*, p. 89.

Monographie der Carabiden-Tribus Cychrini. Von H. Roeschke. *Ibid.*, p. 99.

Nachtrag zur Monographie der Cychrini. Von H. Roeschke. *Ibid.*, p. 569.

Nouvelles Espèces d'hemiptères aquatiques, par A. L. Montandon. Vol. vi, 1908, p. 299.

Vorarbeiten zu einer Monographie der Notacanthen, von K. Kertész. *Ibid.*, p. 321.

The Fauna of British India, including Ceylon and Burma.

Mollusca (Testacellidæ and Zonitidæ). By the late W. T. Blanford and H. H. Godwin Austen.

Butterflies, vol. ii. By C. T. Bingham.

Rhynchota (Homoptera), vol. iv, pt. 1 By W. L. Distant.

Coleoptera (Chrysomelidæ), vol. ii. By Martin Jacoby.

Other Publications.

Essays on Evolution. By E. B. Poulton.

Land and Freshwater Mollusca of India, Pt. x, vol. ii, 1907. By H. H. Godwin Austen.

The Elephant's Head: Studies in Comparative Anatomy of the organs of the Head of the Indian Elephant and other mammals. Pt. I. By J. E. V. Boas and Simon Paulli.

Beitrage zur Kenntnis von *Branchiocerianthus imperator* (Allman). By E. Stechow.

Besides the papers mentioned in the above list many shorter notes, descriptions of single species, etc., have been published in the Journal of the Bombay Natural History Society and the Records of the Indian Museum.

AGRICULTURAL ENTOMOLOGY.

BY

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Imperial Entomologist.

The study of the insect pests of crops was continued by the Imperial Entomologist, his staff and the assistants in Provincial Agricultural Departments. The detailed study of the more important insect pests was continued in the insectory and in the experimental farm at Pusa, as well as in the field, and part of a series of coloured plates, illustrating life histories of injurious insects, were circulated for use in the Agricultural Department. The reintroduction of the bollworm parasite to Sind has helped to restore normal conditions and the prevalence of bollworm in the Punjab was normal. Further investigations were made into the potato-moth and methods of storage of seed-potatoes tried at Pusa. Further trials of methods against the groundnut leaf-miner were made in Madras and the rice stem borers investigated. The problem of controlling surface grasshoppers, of checking mango hoppers and of eradicating the big cricket were specially investigated; field trials of insecticides non-poisonous to cattle were continued. New insecticides were tried and tests of patent insecticides were made at the request of agents for their sale in India. Special attention has been paid to the influence of climate upon the prevalence of insect pests and their seasonal occurrence.

The number of inquiries received and replied to has been large and the subjects covered a wide range. Insects attacking bristles, stored mohwa and cheroots have been investigated at the request of firms.

The cultivation of eri silk was continued at Pusa and in the Tapti valley, the latter by the Baroda State with assistance from Pusa. It was shown that a peculiar disease attacks the worms and this was investi-

gated by the Imperial Mycologist. The results obtained tend to show that the best direction for future work lies in encouraging the use of the silk for local use and not as an article of export, the price offered in England not being sufficiently remunerative, while the silk can be very easily employed by ryots in India without any special appliances or new processes. The cultivation of lac was continued mainly as a demonstration to students, also on indigo factories in Behar where there is a field for lac cultivation on a large scale. The food of birds has been the subject of inquiry by Mr. C. W. Mason, Supernumerary Entomologist, as also the fumigation of plant imports, grain and merchandise.

The commencement of an advanced course of teaching at Pusa has necessitated the abandonment of some lines of research formerly proposed. The work on "biting flies" mentioned in last year's report was taken over by the Second Imperial Entomologist, Mr. F. M. Howlett, who arrived in December, 1907. Since much is known of mosquitoes in India from the work of medical officers, the study of the less well-known groups was taken up including *Tabanidæ*, *Psychodidæ Chironomidæ*, and *Muscidæ*. The study of Indian Diptera has also been specially undertaken by him, the very important question of fruit-flies having been commenced during this year. Mr. C. B. Antram, Entomologist to the Indian Tea Association, has continued his work on insects injurious to tea. The treatment of mosquito blight by spraying with soap has been tried on a large scale with good results and an exhaustive enquiry into the pest has occupied the whole year.

The text of the volume on the Insects of India was completed by the Imperial Entomologist, the portion on Diptera by the 2nd Imperial Entomologist, and arrangements made for its publication. The Pusa collections of insects have now been transferred to their permanent place and completely arranged. A large part has been sent to England for the use of prospective authors of the Fauna of India volumes and much has been received back; the Orthoptera, Neuroptera, Ichneumonidæ, Braconidæ, Cetoniidæ, Chrysomelidæ, Curculionidæ, Microlepidoptera and Rhynchota Homoptera are the more important collections thus being dealt with. Collections of insects have been identified for workers in India and an exhibit collection arranged for the Madras Museum. Enquiries have been received for permission to translate Indian Insect Pests into several vernaculars and revisions in two have been undertaken by members of the Imperial Entomologist's staff. A list of the publications in agricultural Entomology is appended.

List of Publications.

Memoirs.

VOL. I, NO. 6 .	. The Mustard Sawfly.
VOL. II, NO. 1 .	. The Rice Bug.
VOL. II, NO. 3 .	. The Red Cotton Bug.
VOL. II, NO. 4 .	. The Castor Semi-looper.
VOL. II, NO .5 .	. The Tobacco Catterpillar.
VOL. II, NO. 6 .	. The Cotton Leaf-roller.

Bulletin.

BULL. NO. 7 .	. Preliminary Account of Biting Flies.
BULL. NO. 10 .	. Treatment and Observation of Crop Pests on the Pusa Farm.

Journal articles.

VOL. II, PART 3	. "Locusts in India" and "the Pests of introduced Cottons."
VOL. II, PART 4	. Practical Remedies for "Insect Pests" and "The Tse Tse Fly in India."
VOL. III, PART 1	. "The Tobacco Stem Borer."
VOL. III, PART 2	. "The Sugarcane Borers of Behar and Insect Pests of Mangel Wurzel."
VOL. III, PART 3	. "Imported Insect Pests."

The Bulletins of the Indian Tea Association published in 1907.

NO. 5. C. B. Antram.	"The Bark-Eating Borers of Tea."

FOREST ZOOLOGY.

BY

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Imperial Forest Zoologist.

General.

The chief economic and scientific investigations of the year resulted from visits paid by the Imperial Forest Zoologist to the Simla Catchment Area Forests, to the Terai Sal belt of the United Provinces, and to the Kumaun *Pinus longifolia* Forests. The object of

the visit paid in April to the forests of the Simla Catchment Area, from which the water supply of Simla is drawn, was to study an attack of bark-boring beetles which had made its appearance in these forests and to prescribe the steps to be taken to counteract the attack and endeavour to stamp out the beetles.

The tour in the Terai Sal belt of the United Provinces was carried out in April-May when a study was made of the Sal bark-borer, *Sphærotrypes*, and the Sal bark and wood-borer *Æolesthes holosericea*. Other previously unreported Lepidopterous pests including a Noctuid leaf defoliator, an *Arbela* bark-eater, a Pyralid shoot tunneller and several heterocerous seed tunnellers were also studied, the results attained being of considerable economic importance.

Portions of May and June were spent in the Kumaun Oak and *Pinus longifolia* forests. Here investigations were made into the life histories of two previously undescribed species of *Scolytidæ* (*Dryocetes Hewetti*, n. sp. Steb. and *Sphærotrypes querci*, n. sp. Steb.), species of Buprestid (Amorphosoma?) and Cerambycid (*Xylotrechus*) bast and wood-borers, all infesting the oaks (*Quercus incana* and *dilatata*). In addition to studying in a sufficiently complete manner the spring and early summer stages in the life history of the *Cryptorrhynchid* weevil alluded to in last year's report as infesting the *Pinus longifolia*, the Imperial Forest Zoologist was able to make investigations into other serious pests of this tree amongst which may be mentioned a bad Noctuid bark and bast eating caterpillar and species of buprestid and cerambycid (*Stromatium*) bark and wood-borers. The bark-boring beetle (*Scolytidæ*) pests of this tree, amongst the most important of which are *Tomicus longifolia* Steb. and *Polygraphus longifolia*, Steb. and the wood-borer *Platypus?* sp., were also studied.

THE CHIEF ECONOMIC RESULTS OF THE YEAR.

(*a*) By the Imperial Forest Zoologist.

The Simla Catchment Area Bark-boring beetle Attack.

The bark-boring beetles (*Scolytus major* and *Scolytus minor*, Steb. and *Polygraphus major*, Steb.) :—

A bark-boring beetle attack in the coniferous forests of the Simla Catchment Area is of considerable importance since it is on the main-

tenance of forest on this area that the Simla water supply at present depends. The present attack was first noticed in February 1908. An examination of young infested dying deodar trees showed that the beetles present included two deodar bark-borers, species of *Scolytus*, and a species of *Polygraphus*, a beetle which generally confines itself to the Blue pine. In addition it was discovered that many trees were infested by the grubs of a species of buprestid, *Amorphosoma*? sp., the life history of which is at present unknown. Subsequent investigations brought to light that a longicorn grub also infests the trees. The attack and the measures taken to combat it were still in progress at the close of the year.

The Terai Sal Belt Pests.

Æolesthes holosericea (The Terai Sal borer).—This longicorn may be said to take the place of the *Hoplocerambyx spinicornis* beetle which infests the sal of the Central Provinces and Assam Sal belts.

The damage it does to the trees is very similar, the larvæ living and feeding in the bast layer till full grown, subsequently boring down into the heart wood to pupate. Several doubtful points in the life history were solved and it was definitely ascertained that the insect passes through one life cycle in the year.

Sphærotrypes siwalikensis, Steb. (The Sal-bark borer).—A few additional points in the life history of this insect were investigated.

Boarmia selenaria (The Geometrid Sal Defoliator).—Considerable areas of Sal forest in the Garhwal and Kumaun Divisions were defoliated by this pest in April. As it is known that this generation of larvæ pupate in the soil at the foot of the trees, experiments were carried out with the object of ascertaining whether the pest could be got rid of by burning the dead leaves which thickly cover the forest floor.

Arbela sp.—Whilst investigating the pests of the Assam Sal belt in 1906 it was discovered that the Sal trees in parts of Goalpara were infested by a ark band wood-boring species of caterpillar belonging to the family *Arbelidæ*. An examination of the U. P. Terai Sal belt has shown that young Sal seedlings and saplings are attacked in a similar manner by a minute species of *Arbela*, the caterpillar destroying the bast layer of the tree.

Other Terai Sal pests.—A second defoliator, a species of *Noctua* ? which entirely confines itself to the young spring leaves, was found to defoliate the tree. Investigations were also carried out into the various

species of insects which destroy the seed. It has become apparent that these insects differ entirely from those infesting the tree in Assam.

The Oak Pests.

The new Scolytid Bark-borers.—Two previously undescribed bark-boring beetles were discovered infesting the *Quercus dilatata* in Naini Tal. These I have described in the Indian Forest Memoirs under the names of *Dryocetes Hewetti* and *Sphærotrypes querci*. Investigations into their life histories were carried out.

The Buprestid and Longicorn Pests.—Investigations were also made on the life histories of a buprestid bast and wood-eater previously unrecorded and tentatively placed as an *Amorphosoma* and into those of three species of longicorn beetles: *Xylotrechus smei* and *Xylotrechus Stebbingi*, Gahan, the latter first recorded from Kilba, Bashahr, and into the large species of Cerambyx (probably *Lophosternus hugelii*) which is responsible for the large tunnels so often found in the heart of Hill Oak timber. It was discovered that the grub of this latter insect feeds entirely in the cambium and sap wood, not living in a winding tunnel as is the general rule of longicorn grubs, but eating out a large irregular shallow patch of bast and wood, subsequently, when nearly full grown, tunnelling into the heart of the tree.

Other Oak Beetle Pests.—Notes were also made on the life histories of the Scolytid and Platypid wood-borers, *Chramesus* (*Chramesus globulus* n. sp. Steb.) and *Diapus impressus*.

The Oak Scale Pest, Kermes himalayensis, Green in litt.—Probably one of the most interesting of the scientific investigations made in the oak belt was the discovery of a species of the scale insect *Kermes* seriously infesting old *Quercus incana* trees in the neighbourhood of Bhim Tal in the Kumaun Hills.

This is the first report of this genus being known to exist in India. With the exception of one Australian species on Acacia the genus has only previously been reported from Europe and North America where it invariably infests oaks.

The *Pinus Longifolia* Pests.

Cryptorrhynchus and Scolytid bark and wood-borers.—Allusion was made in last year's report to the weevil and bark beetle attacks to which the *Pinus longifolia* is subject. Considerable progress was made in the investigation of these attacks.

Scolytid and Platypodid Wood-borers.—Species of *Rhyncholus* and *Hylastes* tunnel into the wood of the tree in addition to the *Platypus* mentioned in the last year's report.

Noctuid Caterpillar Pest.—A serious pest of young growth was discovered in the Kalimath Plantations near Almora where a Noctuid caterpillar of considerable size was discovered feeding in the bast layer of the trees, the tunnel made usually girdling the young tree and killing it.

Buprestid and Longicorn Bark and Wood-borers.—Investigations have shown that the tree is subject to attack by two species of buprestid, a *Capnodis* and *Chrysobothris* and by a species of longicorn (*Stromatium* sp.). The larvæ of these insects feed in the bast layer only tunnelling into the sap wood to pupate.

Predaceous and Parasitic Insects.—The Histerid beetle *Niponius canalicollis*, as also species of *Platysoma* and *Paromalus* and the Clerid larvæ of *Thanasimus himalayensis*, Steb., were found to prey upon the bark and wood-boring beetles (*Tomicus*, *Polygraphus*, *Rhyncholus*, *Hylastes*, etc.) infesting the *Pinus longifolia*. A hymenopterous fly (*Ichneumon ?* sp.) grub is parasitic upon the Cryptorrhynchid weevils.

(*b*) By other Departmental Observers.

Polygraphus major, Steb. in Kulu.—The Assistant Conservator of Forests reported that this bark-boring pest was killing off saplings and poles of blue pine in the Kulu forests.

Scolytus and Polygraphus bark-borers in the Simla Catchment Area.—The attack was first reported by the Divisional Officer, Mr. A. V. Monro, I.F.S. It has been already alluded to above.

Beetle borers in Prosopis spicigera.—Considerable uneasiness has been aroused in Quetta by the discovery that the firewood imported into the station from Sind (Sukkur) contains Cerambycid grubs resembling the grubs of the Quetta borer (*Æolesthes sartus*). Both the Divisional Forest Officer at Sukkur and the Extra Assistant Conservator of Forests at Quetta are endeavouring to procure the beetle in order to settle the question as to its identity with the Quetta borer. The only insects as yet sent from Sukkur have been species of the Bostrychid wood-borers *Sinoxylon crassum* and *S. anale*, Lesne, neither of which have any connection with the larva in question.

Teak Galls from Surat.—Specimens of galls made upon the branches of Teak trees by a species of *Cicidomyiidæ* were received from Surat and also, by request, were sent from Mysore. Endeavours are being made to obtain the fly.

Rats and Hares attacking Acacia arabica in Berar.—The Divisional Officer, Buldana, and the Conservator of Forests, Mr. G. Rogers, reported serious damage from the rat (*Gerbillus indicus*) and hares to young plants of *Acacia arabica* in plantations. The stems were gnawed all round and the plants killed.

Coelosterna scabrata in Acacia arabica in Berar.—The grubs of this longicorn beetle tunnel into the roots of young plants of *Acacia arabica* and kill the trees. The damage done is considerable and the pest a serious one. The beetles strip the bark from young seedlings, thus killing them. They are assisted in this work by the buprestid *Psiloptera fastuosa*.

Balaghat Sal defoliator.—The caterpillars of the moth *Lymantria semicincta* were again reported by the Divisional Officer as defoliating Sal trees in April and again in July.

Caryoborus sp. in Cane seed at Nellore.—The Divisional Officer of Nellore reported that cane seed imported from Upper Burma was seriously infested by insects. These latter turned out to be a species of *Caryoborus*, a genus common as a seed eater throughout India.

The Mango Borer in Ganjam (Batocera sp.).—Allusion was made last year to the longicorn beetle *Acanthophorus serraticornis* as infesting mango in Ganjam. Subsequent investigations and correspondence have disclosed the fact that the true mango borer is a species of *Batocera*. So far as is at present known *A. serraticornis* does not infest mango.

Acacia arabica defoliators in Guntur, Madras.—The larvæ of the Lymantriid moths *Euproctis lunata* and *E. rhoda* were reported as very severely defoliating *Acacia arabica* trees, both leaves, twigs and pods being devoured in February-March. The moths appeared in April-May.

The 'Bee-hole' borer of Teak in Tounghoo.—This insect was reported by the Deputy Conservator of Forests as fairly common throughout the teak forests of Tounghoo.

Monophlebus tectonæ? in the Upper Chindwin.—This scale insect was reported for the first time from the Chindwin forests. Its identity with the *M. tectonæ* has not yet been satisfactorily settled owing to the specimens sent being immature.

Teredo marine-borer in Bamboos.—Experiments made in Tennasserim with bundles of various species of bamboo anchored in tidal waters have shown that all are subject to the attacks of the Teredo borer.

Andamans Padouk Weevil and Scolytid Wood-Borer.—Mr. B. B. Osmaston reported that Padouk seedlings are ringed and killed by a tiny weevil (*Baridius* sp.) in the Andamans. The life history of this insect is at present unknown. The same officer also reported that Padouk timber when stacked on land was subject to the attacks of a minute Scolytid insect which has been identified as a species of *Xyleborus* or closely allied genus.

(*c*) By other Observers.

Scarabæidæ in Grass Lawns at Quetta.—The Agent to the Governor General in Baluchistan reported that grass lawns in Quetta were seriously infested by the grubs of beetles which turned out to be specimens of *Melolonthidæ* or cockchafers.

A Longicorn borer in the Zhob Forests.—The Political Agent, Zhob, Captain E. H. James, reported that the Chilgoza (*Pinus Gerardiana*) trees in the North Zhob forests were infested by a species of longicorn beetle which proved to be *Stromatium barbatum* or a closely allied species.

Some notes on the life history of this insect were submitted by the Political Agent.

The Pinus gerardiana bark beetles of Zhob.—The Political Agent, Zhob, submitted a report showing the steps taken to continue the attack against the bark beetle infestation in the *P. Gerardiana* forests.

Chief Scientific Results of the year.

Foremost in the scientific results of the year may be placed the discovery that the genus *Kermes* (Family *Coccidæ*) is present in India, this being apparently the first record of its existence in the region.

The discovery and description of undescribed species of *Dryocetes* and *Sphærotrypes* is of scientific interest.

Species of *Hymenoptera* parasitic upon the *Chrysobothris* buprestid beetle infesting the deodar and upon the larvæ of *Scolytus major*, also infesting the deodar, have been bred out and the flies obtained.

The identification of these insects should prove of high interest and value.

List of Publications.

STEBBING, E. P. . *Lecanium capreæ* as a pest to Almond trees. Indian Forester, XXXIII, 168.

STEBBING, E. P. . *Icerya Ægyptiaca*, on Teak in Burma. Indian Forester, XXXIII, 222.

STEBBING, E. P. . The Shot-Borers of Bamboo and Wood-Borers of *Pinus longifolia*. Journal, Bombay Natural History Society, XVIII, 18.

STEBBING, E. P. . On Some Assam Sal (*Shorea robusta*) Insect Pests: with notes upon some Insects predaceous and parasitic upon them. Forest Bulletin No. 11.

STEBBING, E. P. . A Note on the Lac Insect (*Tachardia lacca*), its life history, propagation and collection. Indian Forest Records I, 1.

STEBBING, E. P. . A Manual of Forest Zoology for India (Illustr.) Government of India Press, Calcutta. (1908.)

STEBBING, E. P. . The Bark-boring beetle Attack in the Coniferous Forests of the Simla Catchment Area. Forest Pamphlet No. 2, Zoology Series, No. 1.

STEBBING, E. P. . The Terai Sal bark-borer (*Sphærotrypes siwalikensis*). Leaflet No. 1, Zoology Series.

STEBBING, E. P. . The Teak leaf defoliator (*Hyblæa puera*). Leaflet No. 2, Forest Zoology Series.

STEBBING, E. P. . The Teak leaf Skeletonizer (*Pyrausta machæralis*), Leaflet No. 3, Forest Zoology Series.

VETERINARY SCIENCE.

BY

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In the Imperial Bacteriological Laboratory at Muktesar the output and issue of the various products prepared were considerable and occupied the major portion of the time of the staff.

The following table shows the preparation and issue of these during the year :—

Name of sera.	Quantity prepared.	Quantity issued.	Increased or decreased manufacture as compared with last year.	Remarks.
	Doses.	Doses.	Doses.	
Anti-rinderpest .	482,833	440,585	+14,840	
Anti-anthrax .	16,091	38,772	+811	
Hæmorrhagic Septicæmia.	188,796	112,713	+99,921	
Charbon Symptomatique.	300	2,100*	—17,569	*Balance in hand during the past year being sufficient to meet requirements.
Mallein . .	3,753	7,926	—7,523	Ditto.
Tuberculin . .	34	75†	...	†Enhanced issue from the stock of previous years.

Rinderpest.—The preparation of anti-rinderpest serum for use by the serum alone method—the only means at present possible for dealing with rinderpest in India—has been continued and an increase in output is noticeable. Several improvements connected with the routine method of preparation have been effected.

Anthrax.—The question of the success of the serum alone method of protecting animals against this disease in the field has been studied. The conclusions which have so far been arrived at are that although it is not altogether a satisfactory method for the reason that the passive immunity which it gives is of short duration and that no rigorous hygienic measures can be adopted in this country, still, it is the only one which we can at present make use of. It is, in some cases, useful and may be continued in certain special circumstances. We have been recommended to adopt some of the known methods of giving protection against the disease in India. This is, in the great majority of instances, quite impossible. As a matter of fact we know very little indeed regard-

ing the prevalence and importance of the disease in India and, with the staff at present available, cannot hope to greatly increase our knowledge for many years to come. We require better organisation and a more highly trained staff before it will be possible to make much progress in mapping out the zones in which anthrax is enzootic and in determining where we shall be justified in attempting to apply any of the recognised protective methods. A preliminary step has been made in this direction by asking the Provincial Superintendents to gradually map out the areas where the disease is detected and especially those in which the diagnosis has been confirmed by microscopical or biological tests.

In order to obtain some useful knowledge regarding the disease as it occurs amongst animals in this country, the following questions have been studied in the Imperial Laboratory :—

(i) The susceptibility of the horse, ox and sheep of India to experimental inoculation.

(ii) The practical value of the use of anti-serum alone.

(iii) Various methods of preparing a serum of high protective power.

(iv) The immunizing properties of dead bacilli and other products of anthrax culture.

(v) The value of the practical application of the simultaneous injection of serum and virus.

The latter appears to us to be the method most suitable for use in India when we are in a position to use one at all. The results so far obtained in cattle are very promising but more work is necessary before any definite opinion can be formed. The investigation is proceeding.

Hæmorrhagic Septicæmia.—The question of dealing with this troublesome disease in the field has also received attention. On a careful consideration of the nature of the disease and the protective power of the serum in use, it did not appear to be likely that much good could possibly result from its use in the field and it has consequently been stopped.

The results of the work in the laboratory show (*a*) that a serum capable of conferring immediate immunity for about a month's duration can be prepared, (*b*) that dead vaccines can be used for immediate protection of somewhat longer duration.

Enquiry is being made into the practicability of (*a*) serum and virus and (*b*) dead vaccine and virus. This will be continued.

Charbon Symptomatique—The single vaccine prepared in pillule form by Messrs. Parke Davis & Co. has proved exceedingly suitable to the

conditions at present prevailing in the country and has met with the approval of Superintendents who have had occasion to deal with this disease. After numerous experiments, Captain Holmes has succeeded in preparing a single vaccine in pillule form for use in the districts. The laboratory tests of this vaccine have been very satisfactory, no casualties occurring after its use and an active immunity being established in from two to three weeks. A full report of this research will be published in the Journal of Tropical Veterinary Science.

Experimental treatment of Surra.—A few experiments were made regarding the value of Atoxyl alone, Atoxyl with Perchloride of Mercury and Tartar Emetic. A report of this investigation was published in the Journal of Tropical Veterinary Science. A further series of experiments on the treatment and prophylaxis of Surra by means of the combined use of Atoxyl and Orpiment are being conducted and the results so far obtained are hopeful.

Cattle Lymphangitis.—An investigation into a form of lymphangitis occurring amongst cattle in Calcutta and locally known as "Calcutta sores" was made by Captain Holmes. The details of the work done on this subject are published in the Journal of Tropical Veterinary Science, No. 3, Vol. III, page 289.

Ratin.—The practical value of this virus was tested by Captain Holmes at Muktesar and more thoroughly by Mr. Gaiger at the Panjab Veterinary College laboratory and in the field. The reports have not been published but the experiments proved that the virus is of no value in this country.

Camel diseases.—Investigations into the diseases of the camel have been commenced, a definite scheme of enquiry having been adopted. The most important points which have so far suggested themselves are as follows:—

In the first place, Surra appears at present to be the most prevalent and fatal disease affecting these animals. From investigations I have made extending over four years, it appears that camels which are the subject of it may live for that time carrying the parasite in their blood, but that even when kept in the most favourable conditions, *i.e.*, when well fed and not worked, very few of them recover after long periods of illness and that those which do recover are of little use.

No cure has yet been found.

Ever since surra was discovered by Evans the cause of spread has been considered to be a biting fly which acts as a mechanical transmitter of the disease. Steps are being taken to confirm this by experiment,

and Mr. Leese will form a temporary laboratory in a surra zone during the ensuing surra season for the purpose.

The flies, ordinarily, in Northern India at any rate, are seasonal, appearing in the summer and disappearing in the autumn. This appears to be the cause of what is known as the "Surra season." That is to say that when they are present the disease assumes an epizootic form and when they disappear it ceases to spread. Moreover, the flies ordinarily live in zones having the same physical character, *i.e.*, jungle land, subject to inundation and marshy. Thus, they are very plentiful along the banks of rivers covered with undergrowth, on marshes, etc. It is in such zones that surra is most prevalent.

For the spread of surra, three things appear necessary:—

(i) A reservoir of the virus, *i.e.*, an animal carrying the parasite in its blood. The camel itself, owing to the length of time which it may remain alive when diseased, and to the fact that at short intervals the parasites are numerous in the peripheral circulation, forms an ideal reservoir of the virus. Other animals, especially cattle and buffaloes, have also been proved to carry it without showing symptoms of the disease.

(ii) A means of transmitting the parasite from the diseased animals' blood to that of a susceptible animal. This, from experiments already made and from the analogy furnished by other forms of trypanosomiasis as well as from observations made with surra in Malaya, exists in the form of biting flies—such as Tabanus, Hæmatopota and Stomoxys. Collections of such flies are being made and their transmitting power tested.

(iii) The presence of susceptible animals. These are healthy camels and other animals. If the above statements be proved to be correct, it is easy to understand that a camel suffering from surra is a source of great danger to others in its vicinity at the time when biting flies are prevalent.

With these facts before us, the first step in our investigation is to ascertain the death rates in different localities and the seasonal and geographical prevalence of the disease. Mr. Leese has since his appointment been devoting attention to this point and Provincial Superintendents have been asked to collect whatever information they can in regard to it. We may thus hope, in the course of time, to obtain a reliable record of dangerous zones which may be of use to us in avoiding them during the season when flies are prevalent. We

must get rid of all camels which are dangerous to others by forming a reservoir of the virus, and careful examinations of the blood are being conducted as often as possible so as to prevent the diseased going to work and graze with healthy animals in dangerous localities when biting flies are prevalent. It is obviously necessary to provide camels with suitable surra free grazing grounds which is the chief means of keeping them free from surra.

These then are roughly the lines on which the enquiries into Surra amongst camels are proceeding and a good deal of information has already been collected in connection with the incidence of surra in the various Camel Corps and the probable causes of it. The importance of early diagnosis of the disease so as to secure the early removal of diseased camels from amongst the healthy ones, the necessity for avoiding dangerous zones in the fly season have been illustrated by the mortality which annually resulted amongst the camels of the Lahore Corps as the result of their passage through the surra zones in the Gurdaspur district during the fly season. The danger of marching surra camels with other susceptible transport animals was also forcibly brought to notice on that route, mules becoming infected from the camels. These points have already been brought to the notice of Government.

The necessity of employing another specially qualified officer for camel work has already been brought to notice, but sanction cannot be obtained for the appointment at present. Other epidemic diseases of the camel have been noticed. Tuberculosis ; Wail, apparently due to a Stomach Strongyle ; Camel Pox : Jhoolak ; Gal Sujha ; and Filariasis, which will be investigated when time and opportunity can be found.

The preliminary report on work done by Mr. Leese is being published.

College laboratories.—Those at the Panjab and Bengal Veterinary Colleges have been working during the year, but owing to there being no whole time Pathologist available, the officers have been unable to do much beyond diagnosis and teaching work in them.

A list of publications contributed during 1907-08 from the Imperial Bacteriological Laboratory.

HOLMES, J. D. E. . Investigation of an outbreak of Horse Surra with result of treatment with Atoxyl, Tartar Emetic, Mercury and other drugs. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 157.

HOLMES, J. D. E. . A peculiar form of Streptotrichosis among cattle. Journal of Tropical Veterinary Science, Vol. III, No. 3, page 289.

A list of papers published during 1907-08 bearing on such diseases.

ANTONIO PRICOLO Contribution to the study of Epizootic Lymphangitis. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 217.

ASCOLI, A. . . Experimental Researches into the Accidents consecutive to Anti-anthrax inoculation. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 71.

BALDREY, F. S. H. Hæmorrhagic Septicæmia of cattle, and its relation to Preventive Vaccination. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 287.

BALDREY, F. S. H. Aggressins in Barbone and their application as an Immunising Agent. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 351.

CAZALBOU, L. . A Note on "Baleri." Journal of Tropical Veterinary Science, Vol. III, No. 1, page 85.

EVANS, G. H. . On the care of Elephants. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 356.

EVANS, G. H. & T. RENNIE. Notes on some Parasites in Burma. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 13.

FRANCISQUE JANIN Researches into the Sarcosporidia of the sheep. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 36.

GAIGER, S. H. . Cœnurus serialis found in two goats in India. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 316.

GAIGER, S. H. . Demodex ovis. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 173.

GARIBALDO LISI . Fibrous Nodules of the Liver of a Horse. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 333.

GIOVANNI MAZZINI	Experiments regarding the Diagnosis of Anthrax. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 207.
HARRIS, NORMAN MACL.	A Method of Preparing the Romanowsky Stain. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 92.
HUTCHEON, D.	Biliary Fever in Dogs. Malignant Jaundice or Canine Piroplasmosis. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 402.
LAVERAN, M. A.	The Trypanosomiases of the Upper Niger. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 364.
LUIGI-COMINOTTI	Ulcerative rhinitis in a horse simulating Glanders. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 228.
MARCONÉ, D. G.	Saccharomycosis of the Nasal Fossæ of the horse simulating Glanders. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 80.
MONTGOMERY, R. E.	On a Spirochæte occurring in the blood of Chickens in Northern India. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 1.
MORAX, V.	Ocular manifestations in the course of Trypanosomiasis. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 322.
PEASE, H. T.	Susceptibility of the Indian Dog to Dourine. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 310.
PEASE, H. T. & W. D. GUNN.	A résumé of our knowledge of Canine Pyroplasmosis with an outbreak amongst the Hounds of the Madras Hunt. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 175.
REMLINGER, P.	Spontaneous recovery of experimental Rabies in the Dog and the Persistence of the Rabic Virus in the Saliva of recovered animals. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 393.
SCHBIN, H.	Contribution to the Study of Surra in Indo-China. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 191.

SCHEIN, H. . Hæmatozoa of Bovidæ in Indo-China. Journal of Tropical Veterinary Science, Vol. III, No. 2, page 202.

THEILER, A. . Experiments with serum against East Coast Fever. Journal of Tropical Veterinary Science, Vol. II, No. 3, page 249.

THEILER, A. . On the correlation of various Diseases in Stock in South Africa. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 33.

THIROUX, M. . Animal Trypanosomiasis in Senegal. Journal of Tropical Veterinary Science, Vol. II, No. 4, page 417.

WALKER, G. K. . A practical method of determining the dose of serum required to protect contact animals in outbreaks of Rinderpest. Journal of Tropical Veterinary Science, Vol. III, No. 1, page 28.

PROGRAMMES OF WORK FOR 1908-09.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1908-09, AS APPROVED BY THE BOARD ON THE 11th MAY 1908.

1.—The Imperial Institute, London, and the Department of Economic Products, Calcutta.

Programme enumerating the chief enquiries to be undertaken by the Reporter on Economic Products and (Part 2) at the Imperial Institute. Enquiries in the hands of the Reporter on Economic Products are enumerated in the report and programme of his department for 1907.

1. Investigations of myrrh, frankincense, byssabol, habaghadi and allied products will be continued.

2. Investigation regarding the use of *Baccaurea sapida* as a dye stuff or dyeing auxiliary will be continued.

3. The investigation of the following indigenous drugs will be continued:—*Adhatoda Vasica, Alstonia scholaris, Calotropis procera, Cæsalpinia Bonducella, Embelia Ribes, Ipomæa hederacea, Picrorhiza Kurrooa, Podophyllum Emodi.*

4 and 5. An attempt will be made to complete the Reports on Juar (*Sorghum vulgare*) and Yams (*Dioscorea spp.*) mentioned in previous programme.

6. The enquiry on the origin of native pens will be concluded.

7. The study already in hand of the nature of Indian lemon oil grasses —a continuation of Dr. Stapf's work—will be prosecuted.

8. Material for the study of *Colchicum luteum* as a poison will be supplied to the Pharmacological Laboratory, Cambridge.

9. *Rices.*—Analyses will be made of the chief commercial rices of the Central Provinces, Nepal and Madras in continuation of the enquiry into the composition of Indian rice grains.

10. *Fixed oils.*—Examinations are being made of the minor fixed oils of the country, such as those obtained from the seeds of cucurbitaceous plants, the Terminalia nuts, and a few others about which very little is known.

11. *Lac.*—An investigation will be continued into the composition of crude lac collected under varied conditions; and an endeavour will be made to solve certain questions connected with the manufacture of shellac.

(PART 2).—*Chief investigations in hand at the Imperial Institute.*

Indian Aconites.—The investigation of the alkaloids present in the roots of the following species of Indian aconites will be continued during the year. *Aconitum palmatum, Aconitum heteropylloides, Aconitum soongaricum, Aconitum spicatum, Aconitum laciniatum* and the hybrid *Aconitum laciniatum x spicatum.* It is hoped that it will be possible to complete the chemical examination of the alkaloids present in these species.

Solanaceous Drugs.—Eighteen Solanaceous drugs, including *Datura Stramonium, Datura fastuosa* and *Hyoscyamus reticulatus* have been received, and the amount and nature of the several crystalline alkaloids present in a selection of these drugs are being determined.

Indian Turpentine.—The oleo-resin, derived from *Pinus longifolia* is under investigation. The constituents of the turpentine oil are being determined and a comparison of the constituents of the colophony with those of French and American colophony of commerce is being made. In extension of this investigation about 28 pounds of the oleo-resins obtainable from other Indian pines such as *Pinus Gerardiana, Pinus Khasya* and *Pinus Merkussii,* are to be collected for the purposes of comparative examination.

The following minor enquiries will be conducted :—

Cyanogenetic glucosides.—Further investigations will be conducted, especially with reference to the varieties of Rangoon beans (*Phaseolus lunatus*) which furnish considerable quantities of prussic acid.

Oilsand Oil Seeds.—The oil obtained from the seeds of *Amoora Rohituka* and the fats prepared from the seeds of *Bassia butyracea, B. longifolia* and *B. latifolia* will be investigated. The seed and fruits of the Bassias will be examined. A supply of the seeds of *Schleichera trijuga* has been asked for, so that their constituents, other than oil, may be investigated.

Fibres and Cotton.—During 1907-08 a large collection of reference samples of cotton and of botanical specimens of cotton plants was received from the Economic Botanist at the Ganesh Khind Botanic Gardens, Poona, and it is desirable that the transmission of such samples to the Imperial Institute should be continued so that they can be added to the permanent reference collection of cottons now maintained in the public exhibition galleries of the Imperial Institute. A sample of the fibre of *Dregea volubilis* is under investigation.

Rubbers.—*Ficus elastica* and *Ceara* rubbers, the former from Mukkie Malabar, and the latter from South Arcot, will be examined.

Resins.—The resin of *Canarium bengalense* will be examined and its commercial value ascertained.

Drugs.—In addition to the Aconites and Solanaceous drugs referred to above, the constituents of the seeds of *Strychnos potatorum* and of the roots of *Thalictrum foliolosum* will be examined.

Minerals.—The enquiries conducted on behalf of the Geological Survey with reference to pottery clays and laterites will be completed.

2.—Meteorological Department.

Astronomy.—It is proposed to do the following work at Kodaikanal :—

1. Daily photographs of the sun with photoheliograph.
2. Ditto ditto spectroheliograph (both disc and limb).
3. Observations of prominences (visual).
4. Study of sunspot spectra (visual and photographic).
5. Photographic study of prominence spectra.
6. Measurement of rotation speed of higher gases of the chromosphere.
7. Study of flocculi in relation to sunspots.
8. Distribution of the various types of prominences.
9. Distribution of dark linear markings on flocculi plates.
10. Study of long-enduring prominences in high latitudes.
11. Photograhhic comparison of the light of the moon and Jupiter with first magnitude stars, with a view to the detection of possible periodic variations in the solar radiation.
12. Study of solar radiation with Angström's Pyrheliometer.

Meteorology.—*Registering balloons.*—It is proposed to make special endeavour this year to secure meteorograph records of temperature and humidity up to great heights by means of small balloons. At four nearly equidistant periods between April and December batches of registering balloons will be liberated at some place in the west of the Punjab and organised efforts will be made to recover as many as possible on descent. Each batch will comprise perhaps ten complete units, the adjustment and liberation of which will take between a week and ten days It is hoped to reach heights of 25,000 feet in the earlier experiments, and later in

the year when experience has been gained to increase the heights at which the balloons are caused to descend until 50,000 feet has been reached. It is important to reach this height in order to see whether the isothermal zone which has been almost invariably found at or near that level by sounding balloons in Europe is to be encountered over India.

Kites.—It is doubtful whether in the absence on leave of the head of the department the programme proposed for balloon ascents will allow of kite work this year, but it is hoped that even if a visit to Belgaum for the purpose prove to be impracticable, some kite work may be done in Simla at special periods. If so, records will be obtained by means of apparatus which was partly developed last year during kite flights in the plains, and now promises well. It consists of a very light meteorograph (weight about 2½ oz.) which is attached to a sailing traveller arranged to run up the kite wire before the wind, and on nearing the kite to throw away its sail and descend to the operator at the kite engine.

This apparatus which was successfully used up to a height of nearly a mile over the middle of the Arabian Sea last year secures very nearly simultaneous records of temperature and humidity throughout the layers traversed, a result which has not before been attained outside of India.

Atmospheric Electricity.—An endeavour will be made to get complete records of the three following elements of atmospheric electricity:—

(1) The potential gradient by means of a Benndorf self-registering electrometer and a radium collector:

(2) The conductivity of the air by means of a specially designed apparatus which will photographically record in a continuous manner the changes in atmospheric conductivity for both positive and negative electricity:

(3) The quantity of electricity brought down by rain during thunderstorms, with the special object of determining if more negative than positive electricity is carried down.

Laboratory experiments are also being undertaken for the purpose of throwing some light on the production of electricity in thunderstorms.

Seasonal variations of climate.—It is proposed to continue the attempt to obtain light on the changes in the strength of the monsoon currents and in the quantity of cold weather precipitation. For this purpose statistical methods will be employed as well as recent information from ships and observatories.

Seismography.—Movements of the earth are at present recorded by Omori seismographs at Simla and Bombay, and by Milne seismographs at Alipore, Kodaikanal and Bombay.—A second Omori instrument will shortly be installed at Simla.

TERRESTRIAL MAGNETISM.—The routine measurements by means of absolute and variation instruments at Alibag will be continued. The preparation of the sixty years' record at Colaba for publication is not yet completed owing to the need of examining the temperature coefficients and the causes of discrepancies in the earlier portion of the period: these investigations appear to have been successful and it is hoped that printing will begin in June next.

Appendix to the Programme of the Meteorological Department.

Report on the recommendations contained in paragraphs 4 and 5 of a letter dated 14th November 1907, from the Royal Society, London, to the Under-Secretary of State, India Office.

1. The view of the Observatories Committee that every effort should be made to secure observations by means of small balloons up to a height of 50,000 feet involves a material extension of the suggestions which our programme was intended to convey. We have already made preparations for sending up small unmanned sounding balloons in fairly calm weather to a height of 10,000 feet, and expect that on their descent, which is automatically secured by the instruments carried, they would usually alight not further than six miles away from the starting point: there would thus be a good chance of their being followed up by coolies employed by us and found with the self-registering instruments still attached to them. I fear, however, that a balloon which would rise to 50,000 feet would have to remain in the air for at least four hours; it would then probably alight at some place between 40 and 200 miles from the starting point, for winds of 100 miles an hour are frequently met with at great elevations in India.

2. Balloons rising to such heights are now employed in practically all civilised countries, and a large proportion of those sent up are sooner or later found and returned. In India, however, the chances of recovery are much smaller than in other countries where such work is done and it was for that reason that our programme was arranged on a less extensive scale than that now proposed.

3. Some preliminary experiments on a small scale were made during February in Lahore, and as a result of them I am now able to propose the following scheme, in order to carry out the recommendation of the Observatories Committee. The main ideas in my proposal have been adopted with success in other countries, but the details have been modified to suit Indian conditions—

(*a*) A visit would be made in May to some place in the Punjab where the surrounding country is flat, free from forest land, well populated and at some distance from native territory; about 10 balloon outfits would be liberated from there. At this stage of the work it would appear advisable to be satisfied with heights not exceeding 25,000 feet because at that altitude the winds of very high velocity are seldom reached, and the point of alighting would be near enough to the starting point to afford a good chance of the recovery of the instruments within a few days.

(*b*) In the light of the experience gained in May three further series of ascents would be made, in July, September and December. These would be similar in general character to the May ascents, but would be greatly extended as regards height to be reached in order to meet the recommendation of the Observatories Committee.

(*c*) The self-recording apparatus to be used would be somewhat similar to Mr. Dines' instrument as used in Europe for sounding balloons and would be made in the Simla workshop at a cost of about R12 for each outfit.

It would be attached to two balloons of which one would be arranged to collapse or detach itself at the maximum height required. When this occurred the second balloon would be pulled down by the weight of the apparatus, and on the latter reaching the ground would, except in strong winds, remain in the air above it at the end of a long cord and mark its position. The self-recording apparatus would register variations of pressure, temperature and humidity continuously during the ascent and descent.

4. If the scheme is approved it will be necessary to secure the co-operation of the Deputy Commissioners of the districts in which balloons are likely to descend in advertising our intentions among headmen of villages. In the case of the experiments in May such districts would be those lying round and within 25 miles of the starting point, in all

directions, but for the work in July, September and December the area where descent is likely would extend for 200 miles and be confined to the quadrant between north-east and south-east of the starting point.

5. Varnished labels attached to the instruments would explain in several languages what was to be done with the balloons, and inform the finder that a reward of R5 would be paid to him by the department provided that he followed the instructions. The finder would inform the nearest Revenue or Police officer and through him a telegram would be sent to us at the starting point, when our own messenger would be sent to bring back the balloons and pay the reward. My estimate of the additional expenditure to be met from my funds for the whole work proposed for 1908 would be R1,500.

6. With regard to the matter raised in paragraph 5 of the Committee's note the solar observations now in progress in different countries fall into three classes:—(*a*) eye observations and photographs of the sun's surface, for the study of spots and other abnormalities, (*b*) spectroscopic observations (by eye and spectro-heliograph) showing the distribution and behaviour of the heated gases, and (*c*) examination of heat given out by the sun. The last two have been developed to a far greater extent in America than elsewhere: in fact the only complete apparatus for (*c*) in the world is there. At Kodaikanal we carry out (*a*) and (*b*), but disregarding entirely untrustworthy instruments, there are no regular measurements at present possible in India of the heat given out by the sun except some of a limited kind by means of the Angström pyrheliometers at Simla and Kodaikanal.

7. It is well established that the winds on the earth's surface as well as evaporation and the formation of cloud are directly due to the heat of the sun; and as we know that the solar activity (as evinced by sunspots) changes considerably from year to year it seems probable that the heat given out should exhibit corresponding variations and there should be consequent changes in the amount of rainfall and the strength of such currents as the monsoon. Recent investigations indicate that the black-bulb thermometers formerly used in India for the measurement of radiation are inadequate and that our present equipment for solar work in India is therefore somewhat ill balanced in that we keep up a really good observatory for examining the sun from certain standpoints, but have no apparatus which I should call first class in place of black-bulb thermometers for examining those solar changes which have most to do with the monsoon and the general well-being of the country.

8. When I was in America I incidentally saw Professor Langley and his bolometer which was by far the best instrument of its kind in existence; I had not time however to acquire more than general ideas on the subject. At the earliest opportunity I started in India the use of the Angström pyrheliometers, probably the best instruments apart from the American ones; but these give only a small part of the information obtainable by the latter, and being liable to change, require from time to time comparison with a standard instrument, a somewhat difficult task for which we have no equipment. The complete outfit in accordance with American methods, which have been improved by Langley's successor Mr. C. G. Abbot, would probably cost £2,000 to £3,000; but correspondence with Mr. Abbot has shown that an instrument suitable for our purpose and giving much more information than the Angström pyrheliometers could be made for a comparatively small sum and I should not expect to find it necessary to recommend spending more than £150 upon it.

9. When Mr. Field went on leave six months ago, I endeavoured to arrange that he, who is exceptionally clever in devising and making apparatus and is keenly interested in solar radiation, should be sent to America to learn their methods and discuss with Mr. Abbott an instrument to be set up at Kodaikanal. The knowledge of means of standardising which he would have acquired would have been invaluable in enabling us to compare our present Angström pyrheliometers with a standard instrument, and so to correct for the changes which would from time to time occur in them. My effort was unsuccessful, and the Observatories Committee are now urging the department to a large increase of activity in this direction.

10. It would appear that the variations in the amount of solar radiation which we are to study can only be investigated by means of observations extending over a series of years; and it may perhaps be inferred that the Committee in recommending continuous observations at a high altitude for twelve months intended that information should thereby be gained as to the best method of carrying on the observations on a reduced scale in future years. To this proposal it must unhappily be replied that it would be quite impossible without crippling the work of the department to spare Mr. Field or either of the other two gazetted assistants to remain for the whole of a year in a place at a high altitude where he would be unable to take part in the ordinary work at headquarters. Further we have not the equipment for the purpose.

11. It does not seem advisable to ask for an additional appointment of a gazetted officer for measuring solar radiation and it seems inevitable that the work should be undertaken at Kodaikanal by the present staff who are accustomed to dealing with optical problems and have many instrumental facilities.

12. With regard to the equipment an Angström pyrheliometer has recently been provided at Kodaikanal and Dr. Schuster suggested the use in conjunction with it of such a coloured screen as has been recommended by Angström for cutting out those portions of the radiation which are mostly affected by terrestrial absorption. It was also proposed by Mr. Evershed to eliminate the disturbing effects of absorption by the earth's atmosphere by making a series of comparisons of the brightness of the moon or of Jupiter with that of Sirius or some other bright star, the bodies being compared on the same night and at the same altitude. Variations of the solar radiation would affect the light of the moon and of Jupiter and if the variations were found to be the same whichever star was chosen for reference they might be assumed to be real.

13. It would appear desirable to supplement this work by a spectro-bolometric examination of the sun's radiation in order to ascertain which parts of the spectrum are chiefly affected by the atmosphere and to trace the variations of those parts which are least affected. In the absence of information gained by a personal visit we shall have to rely upon correspondence and many of the details will have to be worked out afresh with a considerable expenditure of valuable time. From the scientific standpoint, however, there is some compensating advantage in this duplication in that a largely independent investigation will be secured.

It must be admitted that the atmospheric conditions at Kodaikanal at 7,700 feet are probably not so good as at some less accessible station at a much greater altitude in the Himalayas, but the facilities available at our existing observatory make up for this, and it is the only place at which the experimental difficulties could without great outlay be overcome by our present departmental staff.

3.—Survey of India (Scientific Research Work).

Gravimetric Survey.—Pendulum observations will be taken on the Aravalli and Vindhya mountains. Observations of the plumb-line will be taken south of the Nepal Himalaya.

Magnetic Survey.—Colaba Observatory under the Meteorological Reporter and the four observatories under the Surveyor-General will continue to work. Observations will be taken at 24 Repeat stations and the preliminary survey will be completed.

Solar Photography.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M. at Dehra-Dun, as has been done since 1879 in conjunction with Greenwich.

Himalayan Geography and Geology.—In conjunction with the Geological Survey, the Survey of India will publish a paper summarising the present position of Himalayan Geography and Geology. (Unforeseen delays have occurred in the publication of this paper.)

Standard of length.—A new standard of length will be procured for the Survey of India. The old standard has been sent to Breteuil for comparison against the international metre.

4. Geological Survey.

PART A.—*Subjects undertaken during 1907-08 to be continued.*

(1) Mapping of unsurveyed areas in the Shan States.
(2) Continued survey of the tin deposits in South Burma, with general geological survey of the areas in which they occur.
(3) Survey of the oil-bearing regions in the Irrawaddy valley and in the Arakan districts.
(4) Survey of the volcano of Popa in the Myingyan district of Upper Burma.
(5) Examination of the material collected from the copper-bearing belt in Singhbhum, and associated Dharwarian and gneissose rocks.
(6) Annual inspection of manganese mines in the Central Provinces.
(7) Extension of the geological map over unsurveyed areas in the Chanda, Raipur and Drug districts.
(8) Extension of geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana.
(9) Chemical work on brines and salt samples from Rajputana.
(10) Palæontology of (*a*) the Liassic rocks of Baluchistan, (*b*) the Lower Tertiary marine beds of Baluchistan, and (*c*) the Cambrian, Ordovician and Silurian rocks of Spiti.

PART B.—*New Questions.*

(11) Mapping of previously unsurveyed areas in the Amherst district of Lower Burma.

(12) Revision of the geological map of the Raniganj coalfield in conjunction with a Committee appointed by the Mining and Geological Institute of India.

(13) Survey of the ossiferous deposits of the Siwaliks and the Salt Range.

(14) Examination of copper-ore and associated sulphide-ore deposits in Sikkim.

(15) Survey of certain glaciers in Sikkim.

(16) Palæontology of (*a*) Cretaceous rocks of Tibet, (*b*) Fossil fishes of the East Coast Gondwanas.

5. Botanical Survey.

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta :—

(*a*) **Bengal.**—An endeavour will be made to make a representative collection of the plants found in one or more of the districts of Bengal to be utilized, it is hoped, ultimately in the preparation of District lists.

(*b*) **Assam and Burma.**—The same policy will be pursued as far as possible within Assam and Burma.

II.—Survey of Bombay. No programme has been submitted.

III.—Survey of Southern India. The Government Botanist, Madras, proposes during the year 1908-09 to explore the flora of the Nilgiris and the Anamalais from April to June and the Enamalais and Nallamalais during July—September.

IV.—Survey of Northern India. No programme has been submitted.

6. Agricultural Departments.

I.—GENERAL.

The Inspector-General of Agriculture has promised from his grant for Agricultural Experiments substantial assistance (*a*) for enquiries regard-

ing Reh in Sind, (*b*) for a threshing machine trial in the Punjab, (*c*) for the flax fibre industry which in parts of India is likely to succeed, (*d*) for the distribution of selected seed of various important crops, (*e*) for the testing of certain agricultural methods, implements and manures which are likely to be economically introduced in some districts, (*f*) for improving the scope of poultry breeding, (*g*) for testing bee-keeping as a minor agricultural industry.

2. In addition to the general field work at Pusa which is now very varied, lac has been there introduced as there is a large field for lac culture on existing trees in Behar.

3. The cultivation of eri silk is being tested as likely to be a useful minor agricultural industry in some districts where the castor oil plant is commonly grown. At Pusa it will be determined, amongst other questions, whether the worms will survive the dry hot weather or can be acclimatized to it.

4. A big enquiry has been started which will deal with the natural fodder plants of India, their distribution and feeding value.

5. The Research Institute will be ready for occupation at latest in June 1908. The apparatus and records of each section will be transferred before that date from the temporary laboratories to the new buildings. Distinguished graduates of the Provincial Agricultural Colleges, or distinguished science students from Indian Universities, will be admitted for a two years' course. Each will specialize in a particular branch of Agricultural Research. The majority of these students will be helped by fairly liberal scholarships. The facilities at Pusa for the post-graduate teaching of Indian agricultural students will, when the Institute is opened, be of the very highest standard.

II.—Agricultural Chemistry.

1. *Available plant food in soils.*—This subject has been referred to in previous programmes. The work during the past year has been on the lines already indicated, but in addition to work at Pusa field experiments on the value of superphosphate are being conducted at a number of centres in Behar, that is, the laboratory results are being tested in the field. Whilst this work is yielding useful information, it must be fully recognised how empirical are our methods, and the laboratory work at Pusa is now being directed to a more thorough

examination of the precise state of the compounds in the soil, the phosphates forming the first main objective. The more exact relationship of the carbonic acid gas in the soil to plant foods forms another part of the same subject.

2. *Water in soils.*—This subject divides itself under two heads, namely, drainage and evaporation. The four gauges at Pusa are providing interesting data regarding the former, which are supplemented by those at Cawnpore. In addition to the gross amount of water passing away, data are being collected regarding the rate of percolation and the nature and amount of dissolved substances which are carried with the drainage water.

The records of evaporation which are being maintained have so far led to two important conclusions, the one being that dry weather water rises in the soil from a limited depth only, the other that the rate of loss depends (among other things) on the amount of water present. There is some hope, too, that the true relation between the physical properties of a soil and its power to retain water may be rendered clearer than it is at the present day. An account of the first year's work is in the press.

A knowledge of the amount of water in a soil is, however, only one factor of a larger subject, for it is equally important to know how much water crops require. Tentative experiments are in progress on this part of the subject. The data which have been published in Europe and America are not only divergent among themselves, but would not, without verification, be applicable to Indian conditions. It is obvious that a more exact knowledge of the movement of water in soil will at the same time yield information as to the movements of dissolved substances, whether these are valuable plant foods or deleterious salts; at present this subject is chiefly characterised by its nebulous state.

3. The chemical investigations connected with the permanent field experiments at Pusa will be commenced.

4. *Cyanogenetic glucosides.*—It was explained in the last programme that the work on this subject is restricted at Pusa to the ascertainment of the conditions under which these compounds are formed in large quantity in the plant. At present it can only be said that the work is in progress. Some positive results were obtained last year with jowar (*Andropogon Sorghum*), but it would be premature to publish them at present. This investigation will rank as of second importance.

III.—Economic Botany.

1. *Plant breeding and plant improvement.*—During 1908 wheat, tobacco, cotton and barley will be especially studied, but attention will be given to other important crops grown in Behar. The determination of the varieties of Indian wheat, tobacco and barley will be continued.

2. *Fibre plants.*—The collection and investigation of fibre-yielding plants will be continued.

3. *Fruit experiments.*—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

4. *Minor investigations.*—The study of Cassava as a famine food stuff. The economic importance of the male plants in Ganja cultivation.

5. *Publications.*—The monograph on Indian wheat will be completed.

IV.—Mycology.

1. *Training.*—The training of probationers for posts of Mycological Assistants in the provinces will be continued.

2. *Research and experimental work.*—The amount of pathological work of pressing importance which has arisen during the past year has led to the temporary abandonment of the work on soil *Fungi*, referred to in the last programme.

3. The following will be the chief lines of investigation :—

(*a*) *Diseases of indigo.*—The introduction of the Java Natal variety of this plant has led to severe outbreaks of disease. Its successful cultivation at the present moment centres on the checking of these diseases. They have not, however, been previously studied, and much investigational work is needed before even their causes can be determined.

(*b*) *Wilt diseases of cotton, gram and pigeon pea.*—The prolonged investigation into the wilt diseases of cotton, gram and pigeon pea which has not yet determined successful treatment will be continued. The investigation of other wilt diseases which are known now to affect Indian crops has been taken up.

(*c*) *Diseases of Citrus fruits.*—A number of these have been recently reported and are under study. The results will probably be ready for publication during the year.

(*d*) *Palm diseases.*—The biologic study of the parasite of bud rot is practically completed. Assistance will continue to be given in the operations to check this disease in the Godavari delta.

(*e*) *Sugarcane diseases.*—Field experiments with red-rot and smut will be continued.

(*f*) The identification and study of other crop diseases will continue as usual.

4. *Systematic work.*—The identification and recording of the species *of Fungi* collected in India will be continued with assistance from abroad. Three of the main groups have been finished up to date from the Pusa collections. The largest, however, remain.

5. A commencement has been made in preparing a text-book of Indian crop diseases, and it is hoped to complete this.

V.—Entomology; Part I.

1. Special attention will be paid to insects injurious to indigo, to the problem of controlling surface grasshoppers and to pests of rice.

2. Assistance will be given in directing the work of Provincial Assistants and in coping with any large outbreaks of pests that may occur. The extent to which Provincial Departments of Agriculture will require assistance cannot be estimated at present.

3. The enquiries into insecticides non-poisonous to cattle and regarding the experimental cultivation of lac and of eri and other wild silks will be continued.

4. The transfer and arrangement of collections and records to the main laboratory will occupy considerable time.

5. The teaching of Entomology to advanced students will entail the preparation of a syllabus.

6. Simple leaflets to explain coloured plates illustrating the life history of common injurious insects will be prepared, if necessary, for any province. Economic work in dealing with such insects will be developed as far as possible, and, if necessary, other work will be dropped to give time for this.

7. The study of insect-eating birds will be continued by the Supernumerary Entomologist.

8. Further enquiry will be made into fumigation methods for treating grain and plants.

9. Methods of checking white ants will be further studied.

10. A month's course of elementary Entomology will be given at Nagpur by the First Assistant.

PART II.

1. The investigation of the biting flies of India will be extended. The distribution and breeding habits of the various species will be especially studied, as being most likely to afford information of value in connection with the spread of disease.

2. Dipterous pests of crops will be studied.

3. The sorting and arrangement of collection of Diptera will be undertaken, and the species identified, wherever possible.

4. The care and maintenance of the general collection will be taken over by the Second Entomologist.

5. The Second Entomologist will help in the preparation of the text and illustrations of the book of Indian insects.

VI.—AGRICULTURAL BACTERIOLOGY.

One or more of the following problems will be attacked :—

I.—The chief bacteria characteristic of Indian soils, particularly those taking part in—

(*a*) The fixation of nitrogen.

(*b*) The rotting of organic material.

(*c*) Nitrification.

II.—The characteristic organisms growing in association with leguminous crops in India, with particular regard to the inoculation of the soils growing them.

III.—The bacteria taking part in the rotting of stored organic material under Indian conditions and the bearing of the knowledge gained on the conservation of cattle manure in India.

IV.—The fermentation processes taking place accompanying the manufacture of silage in India.

V.—The fermentation processes taking place during the manufacture of tobacco.

VI.—The fermentation processes taking place during the manufacture of indigo.

VII.—Any bacterial diseases of important Indian crops.

VII.—AGRICULTURE.

1. *Permanent manurial experiments.*—These are described in detail in Series I below.

2. *Permanent rotation experiments.*—These are described in detail in Series II below.

3. *Permanent pasture experiments.*—These will be continued according to the scheme appended. These experiments are not considered of the first order.

4. *Sugarcane.*—Work on sugarcane will include (i) trials of varieties, (ii) methods of planting, (iii) methods of manuring, (iv) selection of superior sorts or other selection. The sugarcane work is not considered of the first order.

5. *Flax and other fibre crops.*—The possibility of establishing a flax industry in this country will be further investigated. Experiments on the cultivation and preparation of flax will be conducted on a larger scale than hitherto. In view of opinions given by the flax expert, the crop will not occupy at Pusa the same land oftener than once in four years and will be grown in rotation with indigo and other important Behar crops. The work will include plant selection in the crops which are dealt with. Sunn-Hemp (*Crotalaria juncea*), *Sida rhombifolia*, *Hibiscus cannabinus*, *Hibiscus panduriformis* and *Malachra capitata* will be tested on a field scale.

6. *Tobacco.*—A fairly large area of selected indigenous and exotic varieties will be grown, and experimental work in curing will be done in the curing house.

7. *Varieties.*—Varieties tested will include those of wheat, rice, maize, opium and castor. Plant to plant selection will be carried out wherever possible.

8. *Threshing trials.*—These will be continued on the same lines as last year with special reference to wheat.

9. *Breeding.*—The breeding of bulls for the province of Bengal will be continued. A Dumbha ram has been purchased and will be used with selected ewes. Poultry breeding will be carried on with selected imported and indigenous breeds. In connection with the cross-breeding of sheep and poultry, Mendel's Laws will come under study.

10. The general improvement of the estate will be continued.

Note by the Imperial Agriculturist on the permanent experiments at Pusa.

The problem of agriculture is to secure from the soil the maximum production possible under the existing conditions and with the resources at the command of the cultivator. Next to climate, the most important factor in production is the degree of fertility of the soil; fertility is conditioned by circumstances which are still far from being properly understood. While in a large measure it is a quality inherent in the soil it may be profoundly modified by agricultural practice with respect to cultivation, manuring and rotation of crops. The proposed permanent experiments detailed below have been arranged with a view to study the conditions which determine soil fertility in a sub-tropical climate, and in particular the manner in which soil fertility is affected by the application of the more important manures, including green manure, by rotation of crops (with special reference to the part played by legumes in a rotation) and by tillage.

Permanent Pasture Experiments.

Manurial Scheme for Pasture Experiment.

No.	Details.	Remarks.
1	No manure.	To be applied once; thereafter at the end of three years or other date to be subsequently fixed to be followed by 10 tons farm yard manure repeated every fifth year.
2	Superphosphate=150 lbs. Phosphoric acid per acre.	
3	Basic slag=150 lbs. Phosphoric acid per acre.	
4	Superphosphate=100 lbs. Phosphoric acid per acre.	
5	Superphosphate=100 lbs. Phosphoric acid per acre. + Sulphate of potash=50 lbs. Potash per acre.	

No.	Details.	Remarks.
6	Rape Cake=100 lbs. Nitrogen.	To be applied every fifth year.
7	Castor Cake=100 lbs. Nitrogen.	
8	Ammonium sulphate=20 lbs. Nitrogen per acre.	
9	Nitrate of Soda=20 lbs. Nitrogen per acre.	
10	Superphosphate=25 lbs. Phosphoric acid per acre.	
11	Superphosphate=25 lbs. Phosphoric acid per acre. Sulphate of potash=20 lbs. of Potash per acre.	
12	Superphosphate=25 lbs. of Phosphoric acid per acre. Ammonium Sulphate=20 lbs. of Nitrogen per acre.	To be applied every year.
13	Superphosphate=25 lbs. of Phosphoric acid per acre. Ammonium Sulphate=20 lbs. Nitrogen per acre. Sulphate of Potash=20 lbs. Potash per acre.	
14	Farm-yard manure 3 tons per acre.	

The extent of even land available in the pasture land at Pusa is limited and the proposed experimental plots are therefore smaller than is desirable. The area in one block will be divided into 14 plots each of one acre. One-fourth of each plot will be fenced off and cut annually as hay, the remaining three-fourths will be grazed by cattle and simply kept under observation.

A detailed botanical examination of the character of the herbage of each plot will be undertaken.

SERIES I.

Permanent Manurial Experiments.

The object of this series is to determine the specific effect on soil fertility of the more important organic and chemical manures applied alone and in various combinations to a two years' four-course rotation.

Kharif.	Rabi.	Kharif.	Rabi.	Manures applied per acre.
1. Maize	Rahar.	Maize	Oats .	No manure.
2. Maize	Rahar	Maize	Oats .	Farm-yard manure to supply 10 lbs. Nitrogen.
3. Maize	Rahar	Maize.	Oats .	Farm-yard manure to supply 20 lbs. Nitrogen.
4. Maize	Rahar	Maize.	Oats .	Farm-yard manure to supply 30 lbs. Nitrogen.
5. Maize	Rahar.	Maize	Oats .	Rape cake to supply 20 lbs. Nitrogen.
6. Maize	Rahar.	Maize.	Oats .	Sulphate of Ammonia to supply 20 lbs. Nitrogen.
7. Maize	Rahar.	Maize.	Oats .	Sulphate of Potash to supply Potash as in Farm-yard manure No. 3.
8. Maize	Rahar.	Maize.	Oats .	Superphosphate to supply Phosphoric acid as in Farm-yard manure No. 3.
9. Maize	Rahar.	Maize	Oats .	Sulphate of Potash to supply Potash. / Superphosphate to supply Phosphoric acid. } As in Farm-yard manure No. 3.
10. Maize	Rahar.	Maize.	Oats .	Sulphate of Ammonia to supply Nitrogen. / Sulphate of Potash to supply Potash. / Superphosphate to supply Phosphoric acid. } As in Farm-yard manure No. 3.

Plots to be ¼ acre duplicated, and all the crops of each rotation to be grown in the same year. Manures to go on every year on the Maize.

SERIES II.

Permanent Rotation Experiments.

This series is designed to determine how far soil fertility is affected by growing in a rotation leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures. It is complementary to Series I, inasmuch as the results obtained will give an indication of how far legumes can replace manures in a rotation.

Kharif.	Rabi.	Kharif.	Rabi.	Manures applied per acre.
Maize .	Barley	Maize.	Oats .	No manure.
Maize .	Barley	Sunn .	Oats .	Green manure on cereal rotation.
Maize	Rahar.	Maize.	Oats .	Residual value of deep-rooted pulse.
Maize .	Rahar .	Maize .	Oats and peas.	Residual values of two legumes one deep and one shallow rooted.
Maize .	Rahar.	Sunn Hemp	Oats	Residual value of a pulse crop plus a green manure.

Plots to be ¼ acre duplicated, all the crops of each rotation to be grown in the same year.

Provincial Departments of Agriculture.—The programmes for next year generally follow those described in last year's programme placed before the Board of Scientific Advice. The following are, however, important additions:—

Bengal.—An area of 210 acres has been acquired for a Government Farm at Chinsura in the Hooghly district. The land is representative of the deltaic tracts of the province.

Experimental work will be commenced on the newly opened farms at Bankipur and Sabaur. Well boring experiments will be undertaken. Proposals have been made for the improvement of sericulture.

United Provinces.—At Cawnpore several new investigations will be taken up. They include the trial of cotton refuse as manure, the methods of preserving potatoes and fruits, and the renewal of seed stocks of potatoes in the hills. Preliminary experiments with a view to

study of losses in sugar manufacture will be undertaken by the Agricultural Chemist. Mr. Hadi, the Assistant Director, has been deputed on special duty to organise sugar manufactories according to his methods of manufacture. Information concerning the agaves of the provinces will be collected by the Economic Botanist.

Punjab.—The equipment of the Lyallpur College and the framing of the curriculum and prospectus will be undertaken. A second experimental farm will be opened for preliminary investigations with regard to diseases of gram, the question of fodder scarcity, improvement of tillage, study of crop rotations and other experiments. Preliminary observations on the effect of light and heavy waterings and surface cultivation on different crops and soils will be made with a view to restarting irrigation experiments. Other experiments include the trials of machinery and the inoculation of land newly sown with leguminous crops. The Agricultural Chemist, when his chemical laboratory is ready, will start on investigations regarding the Punjab alkali lands, the water of salt wells in the Southern Punjab and the improvement of sugar manufacture. The Economic Botanist will undertake a survey of the indigenous cottons of the Punjab and the North-West Frontier Province.

Bombay.—Experiments will be initiated in the manuring of the pasture lands. At Daulatpur in Sind, experiments will be made to reclaim the worse kind or alkali or kalar lands.

Madras.—Paddy experiments will be carried out at the Samalkota, Palur and Coimbatore stations with numerous objects in view. Cotton experiments will be conducted on a larger scale than last year. Indigo will be tried as a rotation crop with cotton. An enquiry will be made into the fodder plants of the chief grazing districts of the Presidency. The Agricultural Chemist will start an investigation regarding the agricultural value of the tank and river silts of the Presidency.

Burma.—Experimental work will be commenced on the newly formed farms at Mandalay and Hmawbi. Cotton, paddy, groundnut, jute, sugarcane and other crops will be tried on these farms. Rotation and manurial experiments will also be undertaken. Attempts will be made to introduce better implements. A survey of the agricultural conditions of the province will be started. The Agricultural Chemist will take up the examination of the soils of the experimental farms and of some saline lands.

Eastern Bengal and Assam.—A considerable number of new crops will be tried including American potatoes and groundnut. Improved

poultry breeding will be attempted. Sericulture will be promoted by supplementing pure seed stations with the large rearing stations.

7. Forest Department.

The following are some of the various investigations which will be made with the assistance of other officers of the Department :—

I.—Working-Plans.

1. The compilation from selected Working-Plans of data regarding the rate of growth of different species (ring countings, sample plots) and generally the tabulating, in convenient form, of statistics and information regarding different species, methods of working, etc., now scattered throughout the plans. A statement showing sanctioned Working-Plans, with area of forest, period of plan, method of treatment and principal species has already been compiled as a basis of this and other investigations.

2. With regard to normal stock, selected areas containing what appears to be a full stock of I, II, III and other classes will be counted out, and the average of each class taken as an approximate normal, as a preliminary to the more accurate investigation of this subject. The following species will be first taken in hand—Sâl, Teak, Deodar, *Pinus longifolia*, *Pinus excelsa*, and as soon as possible other species now being worked under Working-Plans.

3. A careful study of the selection system will be made. The following points merit attention in this regard in order to discover the best means of working by compartments so as most nearly to approach the ideal method of working over the entire area annually for the removal of mature trees, *e.g.*,—

(*i*) By making the annual coupes as large as possible so that the area may be worked over at as frequent intervals as possible.

(*ii*) By fixing such an exploitable girth that the loss of interest due to leaving mature trees standing for an excessive period is reduced.

(*iii*) By allotting gradually decreasing areas for the annual coupes.

4. The examination of control of forms in order to ascertain the average outturn by different methods of working in force, and generally to collect and collate the statistics of the results of forest management

study of losses in sugar manufacture will be undertaken by the Agricultural Chemist. Mr. Hadi, the Assistant Director, has been deputed on special duty to organise sugar manufactories according to his methods of manufacture. Information concerning the agaves of the provinces will be collected by the Economic Botanist.

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2. With regard to normal stock, selected areas containing what appears to be a full stock of I, II, III and other classes will be counted out, and the average of each class taken as an approximate normal, as a preliminary to the more accurate investigation of this subject. The following species will be first taken in hand—Sâl, Teak, Deodar, *Pinus longifolia*, *Pinus excelsa*, and as soon as possible other species now being worked under Working-Plans.

3. A careful study of the selection system will be made. The following points merit attention in this regard in order to discover the best means of working by compartments so as most nearly to approach the ideal method of working over the entire area annually for the removal of mature trees, *e.g.*,—

(*i*) By making the annual coupes as large as possible so that the area may be worked over at as frequent intervals as possible.

(*ii*) By fixing such an exploitable girth that the loss of interest due to leaving mature trees standing for an excessive period is reduced.

(*iii*) By allotting gradually decreasing areas for the annual coupes.

4. The examination of control of forms in order to ascertain the average outturn by different methods of working in force, and generally to collect and collate the statistics of the results of forest management

throughout India which are included in past control forms will be continued.

5. The compilation of a list of terms to be used in all Working-Plans, the meanings of the terms used being given and the list officially circulated and prescribed for future use will be completed.

6. Preparation for teak of a paper setting forth all that is known regarding habits, methods of treatment, etc., such as has already been prepared for the sâl.

II.—Sylviculture.

7. A practical examination will be made into the effects of fire on grazing areas in order to ascertain—

(*i*) Whether the grass on areas burned over annually decreases in quantity and quality;

(*ii*) Whether this result or the reverse happens in the case of areas protected from fire, and especially whether protection from fire encourages the growth of coarser grasses, or leads to the replacement of coarse grasses by others more suitable for fodder.

8. The effects of fire conservancy of different species in various conditions of climate and growth, more especially on sâl and teak will be studied.

9. An examination into the conditions favourable to the replacement of the selection method by the regular method will be commenced.

10. The effects of soil composition and underlying rock on the distribution and growth of different species will be investigated.

11. The effects of the continuance of a given species (*e.g.*, sâl, teak) as regards the soil fertility for that species will be enquired into.

III.—Forest Zoology.

12. Investigation in the United Provinces into the distribution and life histories of the *Monophlebus* scale insect, *Sphærotrypes Siwalikensis*, and the sâi defoliators in the submontane sâl areas of the Ganges, Garhwal, Kumaun and Naini Tal Divisions, and into the *Pinus longifolia*, *Cryptorrhynchid* weevil, *Tomicus* and *Polygraphus* bark-borers and

Platypus wood-borer in the Chir areas of Garhwal, Kumaun and Naini Tal Divisions will be continued.

13. Investigation in the Punjab into the distribution and life histories of the following insects in the hill coniferous forests of the Kangra Division :—

The *Scolytus* pests of the deodar and the *Polygraphus Pityepenes*, *Platypodæ* and cone-borers and defoliators of the *Pinus excelsa*, Spruce and Silver Fir: also the defoliating and wood-boring pests of the hill oaks and pests of *Pinus longifolia* will be carried on.

IV.—Forest Economy.

14. The enquiry into the utilization of the less valuable kinds of timber as railway sleepers will be continued and a practical experiment will be made with sleepers obtained from *Dipterocarpus* sp. from Burma and the Andamans.

15. Seeds of the more important indigenous species will be collected and sent for experimental cultivation to various British colonies and Foreign countries.

16. Enquiry will continue into the subject of—

(*a*) Woods suitable for the manufacture of matches.
(*b*) Cultivation of lac.
(*c*) Antiseptic treatment of timber, particularly for railway sleepers.
(*d*) Utilization of various oil seeds from forest trees.
(*e*) Timbers at present little known which it is desired to bring to notice.
(*f*) Utilization of *Xylia dolabriformis* waste for paving blocks.
(*g*) Woods for lead pencils.
(*h*) Woods for cricket bats.
(*i*) Yew wood for archery.
(*j*) Woods for tea boxes.
(*k*) Camphor from *Blumea balsamifera*.
(*l*) Cultivation of *Podophyllum*.
(*m*) Cutch.
(*n*) Destructive distillation of wood.
(*o*) Walnut "Burrs."
(*p*) Rubber cultivation.

throughout India which are included in past control forms will be continued.

5. The compilation of a list of terms to be used in all Working-Plans, the meanings of the terms used being given and the list officially circulated and prescribed for future use will be completed.

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(*e*) Timbers at present little known which it is desired to bring to notice.
(*f*) Utilization of *Xylia dolabriformis* waste for paving blocks.
(*g*) Woods for lead pencils.
(*h*) Woods for cricket bats.
(*i*) Yew wood for archery.
(*j*) Woods for tea boxes.
(*k*) Camphor from *Blumea balsamifera*.
(*l*) Cultivation of *Podophyllum*.
(*m*) Cutch.
(*n*) Destructive distillation of wood.
(*o*) Walnut "Burrs."
(*p*) Rubber cultivation.

V.—Forest Botany.

17. The following subjects will receive attention :—

(*a*) Study of the coppicing of teak, its effect on the normal health and development of the tree.

(*b*) The grasses of Savannah tracts in Bengal will be examined with special reference to their difference in burnt and unburnt areas.

(*c*) A study will be made of the timber of different species of Tun and *Grewia*, to ascertain which yield the most valuable wood.

(*d*) Investigation (in the Madras Presidency) into the subject of the rising of marks on tree stems, used to indicate fixed levels of measurement in sample trees or plots.

VI.—Forest Chemistry.

18. Further examination of tannin extracts will be made.

19. The collection and analysis of the latices of rubber-producing species will be continued.

20. The following subjects will be worked at—

(*a*) The analysis of oil seeds for their oil values and oil oaks utilization.

(*b*) The analysis of resin and lac.

(*c*) Experiments with the newly designed camphor still and the distillation of camphor from *Blumea balsamifera* of Burma.

(*d*) Investigation in Burma into the various species of Compositæ as to their suitability for the production of camphor or any other valuable essential oil.

(*e*) Investigations into the active principles of the Nim tree (*Melia indica*).

(*f*) Investigation into Catechu with a view to prepare Catechin-free Cutch on a commercial scale will be continued.

(*g*) Investigation into the manurial value of the various leaves, twigs and shrubs indigenous in the Madras Presidency, in order to ascertain the proportion of nitrogen and phosphoric acid, etc., which they contain.

VII.—General.

21. Pamphlets, circulars, as well as the Memoirs and Records of the Forest Department, setting forth the results of investigations into various

subjects affecting the progress of Indian Forestry, will be published from time to time.

8. Natural History Section, Indian Museum.

The Superintendent, with the aid of specialists in Europe, will continue his work on the fauna of fresh and brackish water in India and on the distribution of the reptiles and insects of the Himalayas. Captain R. E. Lloyd, I.M.S., will continue the survey of the house rats of India commenced in the Museum since last year's programme was submitted, while the special temporary assistant will arrange the old collection of mammals and work at new material representing groups other than Muridæ. Captain F. H. Stewart, I.M.S., Surgeon-Naturalist on the "Investigator," will, while in Calcutta, work at the Museum collection of Polychætes, while Captain Lloyd investigates in his spare time the unidentified deep-sea fish. The late Superintendent, Lieutenant-Colonel A. W. Alcock, will continue his "Catalogue of the Decapod Crustacea," collections being sent him to Europe, while other specialists in Europe and America will work at the collections of other groups which have already been or will shortly be despatched from Calcutta. Special attention will be devoted in the Entomological laboratory to the Diptera of India, at which Mr. E. Brunetti will continue to work, and to the insects of Calcutta and the neighbourhood, regarding which it is proposed to commence the compilation of a local "fauna" during the year.

9. Civil Veterinary Department.

By the Laboratory Staff:—

(1) **Anthrax.**—An investigation into the methods and practical value of immunization by means of bacterial products in order to obtain a single and efficient vaccine suitable to the conditions of the country.

(2) **Hæmorrhagic Septicæmia.**—Investigations into methods of immunization against the disease.

(3) **Trypanosomiasis.**—To continue investigations on the lines laid down in the programme of previous year.

By the Officer investigating camel diseases:—

The Officer investigating camel diseases will continue the investigations into Surra in the field. He will establish temporary

head-quarters for the purpose during the summer and rains and endeavour to ascertain the causal agents of transmission and the natural history of the disease.

By the provincial staff :—

Collection of information and the mapping out, as opportunity occurs, of the incidence of Surra, Piroplasmosis, Hæmorrhagic Septicæmia and Anthrax.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED FOR INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDED THE 30th SEPTEMBER 1908.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

The following are the principal investigations relating to the composition and economic value of Indian products dealt with in the Scientific and Technical Department of the Imperial Institute during the year.

DRUGS.

Aconites.—The investigation of the various Indian aconites has been continued with the new material supplied by the Officiating Reporter on Economic Products, but the work has been delayed somewhat in order that special attention might be given to expediting the work on solanaceous plants referred to below.

Solanaceous Plants.—Estimations of the total alkaloids present in the Datura and Hyoscyamus plants received have now been made and the work of determining the amount and nature of each of the various alkaloids present is in a fairly advanced stage.

Strychnos species.—The seeds of *Strychnos potatorum* are under investigation in connection with this enquiry.

Opium.—The working plant for the extraction of alkaloids from opium by the new process devised at the Imperial Institute, referred to in last year's report as under construction for the Opium Factory at Ghazipur, has now been despatched.

Thalictrum foliolosum.—The roots of this plant are being investigated at the suggestion of the Imperial Institute by Professor W. H. Perkin, F.R.S.

RUBBER.

Four samples of rubber were reported on during the year, three being specimens of *Ficus elastica* rubber and the fourth Ceara rubber.

Two of the Ficus rubbers came from Mukkie in the Kanoth range, North Malabar, and were in the form of 'Scrap' and 'biscuits' respectively. The former contained 28·1 per cent. of resin and was valued at 2*s.* 11*d.* per lb.; the biscuits, although containing less resin (23·6 per cent.) than the scrap were very dark coloured and were consequently valued at only 2*s.* 5*d.* per lb. The third specimen of Ficus rubber was collected by natives in Northern Arakan during 1904-05. It was highly impure and was not suitable for analysis or valuation.

The Ceara rubber was from South Arcot, Madras. It was of very fair quality and was valued at 2*s.* 5*d.* per lb. At the time of all the above valuations fine hard Para rubber was quoted at 3*s.* 5½*d.* per lb.

A collection of Para, Ceara and Castilloa rubbers from the Nilgiri Hills, forwarded by the Agri-Horticultural Society at Teynampett, was under investigation at the end of the year.

FIBRES.

Cotton.—Five samples of cotton, grown in the Myingyan district, Burma, were examined. These consisted of American Upland cottons, and although of very promising quality on the whole, they were somewhat inferior to similar cotton grown in the United States, since they were stained and partly immature. It was suggested that greater care should be exercised in cultivation, and that measures should be taken to prevent damage by insect pests. The samples were valued at 6*d.*-6½*d.* with "middling" American at 6·63*d.* per lb.

A sample of "kidney" tree-cotton, grown at Sambalpur, was of good quality, and would probably find a market as a rough, long-stapled cotton of Peruvian character. It was valued at 9*d.* per lb. with "good fair" moderately rough Peruvian at 9¼*d.* per lb.

A boll of a wild cotton plant from Tenasserim, Burma, was examined. The lint was of excellent quality, resembling that of short-stapled Indian cotton, and was regarded as worth about 5½*d.*-6*d.* per lb., with "fine" machine-ginned broach at 5 $\frac{5}{16}$*d.* per lb.

Information was supplied to a London firm with reference to the yield of lint obtainable from Caravonica seed cotton.

Agave and Furcræa Fibres.—Three samples of fibre grown at the Hindupur Fibre Firm in the Anantapur district of the Madras Presidency were examined. The fibre of *Agave rigida* was of excellent quality and worth £36 to £38 per ton with Mexican sisal at £34 per ton. The

specimen of *Agave Americana* fibre was rather short and of uneven quality, part of it being white, lustrous and fairly well cleaned, while the remainder was gummy and had a small quantity of greenish leaf pulp adhering to it. The fibre of *Furcræa* sp. was rather short, somewhat uneven in colour and not very carefully prepared. It was considered to be worth £25 to £27 per ton, with Mauritius hemp at £24 to £30 per ton.

Two samples of Agave fibre from Assam were of good strength, but not well cleaned. If properly prepared and not less than four feet long, the fibre would have been worth about £30 per ton.

Sida rhombifolia.—A specimen of *Sida rhombifolia* fibre from Bengal was fine, silky, well-prepared, of fair strength and compared favourably in chemical composition and behaviour with "extra fine" Indian jute. It was stated that it could probably be used for mixing with silk, and that for the finest purposes to which jute is applied it would sell very readily in large quantities at £25 to £30 per ton, with "good" to "fine" jute at £16 to £25 per ton. It was recommended that the cultivation of this plant should be encouraged.

Dregea volubilis.—A specimen of the fibre from this plant, submitted with reference to its suitability for the manufacture of explosives, was badly cleaned and contained adherent woody tissue. The fibre is non-lignified and, if carefully prepared, could probably be used for the purpose mentioned.

Marsdenia tenacissima.—A specimen of the stems and young shoots of *Marsdenia tenacissima*, grown in Rajmahal, was received from the Director of Agriculture, Bengal. It was suggested that for information with regard to the properties and value of the fibre reference should be made to the "Bulletin of the Imperial Institute," 1903, 1, 121.

Wool.—Samples of wool yarn and patti from the Central Jail, Coimbatore, were examined. One specimen of wool was of a fixed and irregular type and worth about 10*d.* to 1*s.* per lb.; the other was valued at only 6*d.* to 8*d.* per lb. on account of its brown colour. Recommendations were made with reference to breeding. The yarn and patti were unsuitable for export to the United Kingdom.

Flax dodder.—In reply to a request from a firm of planters for information with regard to *Cuscuta Epilinum*, the flax dodder, which was said to be attacking flax plants in India, a memorandum was supplied giving the particulars required.

Calotropis gigantea.—In reply to an enquiry from a commercial

firm with reference to the quality and value of the bast fibre of *Calotropis gigantea*, it was pointed out that this fibre is unlikely to assume commercial importance owing to the difficulties of preparation, the lowness of yield, and the shortness of the ultimate fibre. The attention of the enquirer was directed to the seed-floss of this plant as being of some value.

Masulipatam carpet.—An enquiry, accompanied by a sample, was received from a technical institute in Humburg asking for information with respect to the materials of which Masulipatam carpet is composed. The sample was examined and the required particulars supplied.

OILS AND OIL-SEEDS.

A sample of the oil of *Amoora Rohituka* was examined and the results were compared with those yielded by previous samples. The oil appears to be of a somewhat variable character, but could probably be used for soap-making.

A specimen of oil-seeds was received from a firm of merchants with a request for information with reference to its identity and the properties and uses of the seed and oil. The seeds were recognised as the product of *Melia Azadirachta* ("Margosa" or "Neem" fruits) and the required particulars were supplied.

Samples of the fruits, seeds and fats of *Bassia longifolia*, *B. latifolia* and *B. butyracea* have been received and are being examined with reference to the yield and properties of the fats.

TANNING MATERIALS AND DYES.

Symplocos spicata.—A preliminary report on the leaves of this plant has been forwarded to India, showing that it contains a mere trace of a glucoside and appears to be of little or no value as a dye.

Mangrove Cutch.—In continuation of the enquiry on the commercial value of extracts made from the bark of *Rhizophora mucronata* at the tanning extract factory at Rangoon, comparative analyses of this material and of mangrove cutch as exported from Borneo were made, and it was found that the Indian material, though slightly richer in tannin, was far darker in colour and yielded a harsher leather than the Borneo product.

Cæsalpinia digyna pods.—Some correspondence with reference to this product has taken place during the year, mainly with a view to ascertaining whether the husks of the pods can be put on the market in this country, and a number of samples have been received. So far, however, it has proved impossible to obtain the pods in large enough quantity and at a low enough price to interest likely consumers in this country.

TURPENTINE OIL.

Considerable progress has been made with this enquiry, and an interim report on the composition of the oil is now in preparation.

RESINS.

Large samples of the colophony and turpentine of *Pinus longifolia* and *P. excelsa* have been received; their preliminary examination has now been completed and an interim report on this work is being prepared. The chemical examination of the constituents of the resin in comparison with the colophony of commerce is also being continued.

A sample of black dammar resin was tried as a substitute for shellac in crepe finishing, but proved to be not quite suitable for this purpose.

CYANOGENESIS IN PLANTS.

This investigation has been continued, on the lines indicated in last year's report, in consultation with the Board of Agriculture. The results of analyses of a number of samples of Burma beans as sold in this country were given in a paper by Professor Dunstan and Dr. Henry, published in the "Journal of the Board of Agriculture" (1908, XIV, 722). These show that the amount of prussic acid obtainable even from white Burma beans may vary within somewhat wide limits. It was suggested that feeding trials with Burma beans and other products capable of yielding prussic acid should be instituted in order to ascertain whether the continued use as feeding-stuffs of products yielding small quantities of prussic acid exercises any injurious action on cattle. This investigation has acquired further interest recently owing to the occurrence in this country of several poisoning cases among cattle alleged to be due to the use of linseed cake.

TIMBERS.

At the suggestion of a firm of match-makers, samples of woods likely to be suitable for match-making were obtained from India, and were submitted to the firm for trial. They reported that none of the samples supplied was suitable for this purpose.

Samples of boxwood forwarded for valuation were submitted to experts, who valued them at £3 10*s.* to £5 per ton, but stated that the timber would probably be difficult to sell in this country and that the price it would bring would probably not be remunerative to exporters.

TOBACCOS.

Samples of tobaccos sent by the Director of Agriculture, Bombay, are under investigation.

MINERALS.

Pottery Clays.—A report giving the results of firing tests with a large number of Indian clays and analyses of a selected few of these has been sent to the Officiating Reporter on Economic Products. In addition requests for information as to the occurrence of various minerals in India have been received and samples of a number of minerals from India have been submitted by commercial firms for identification and valuation. The most interesting of these were samples of plumbago, mica and samarskite.

MISCELLANEOUS.

Cow-dung Cakes.—A sample of this material was forwarded by the Director of Agriculture, Bombay, with the request that its manurial and calorific values might be determined. The results of the analysis showed that the product contained much mineral matter and was of very low manurial value.

The following rep orts have been forwarded to India during the year :—

Report on Cotton from Burma.

" Agave and Furcræa Fibres from Hindupur, Anantapur, Madras.

" *Ficus elastica* rubber from Mukkie.

" Agave fibre from Assam.

Report on Pottery Clays.
" Indian timbers for the manufacture of matches.
" Black Dammar resin, *Canarium bengalense*.
" Colouring properties of leaves of *Symplocos spicata*.
" *Ficus elastica* rubber from North Arakan.
" *Amoora Rohituka* oil.
" Cow-dung cakes.
" *Manihot Glaziovii* rubber from South Arcot, Madras.
" Fibre from the stem of *Dregea volubilis*.
" Development of Trade in Indian Medicinal Opium.
" Boxwood.
" *Marsdenia tenacissima* fibre from Rajmahal.
" *Sida rhombifolia* fibre from Bengal.
" Three-cotton and seed from Sambalpur.
" Comparative tanning values of Rangoon mangrove extract and Borneo Cutch.
" Wool, yarn and patti from the Central Jail, Coimbatore.
" *Cæsalpinia digyna* pods.
" Inga fruit from Baroda.
" Wild cotton from Tenasserim River, Mergui.

The following articles dealing with subjects of special interest to India have been printed in the "Bulletin of the Imperial Institute" during the year:—

Tanning Materials from India, the Colonies, and other sources . . . . . 1907, V, 343.
Para rubber from Mergui, Burma . . . 1907, V, 371.
Cryptostegia grandiflora rubber from India . 1907, V, 371.
Jute substitutes from the Nyasaland Protectorate . 1907, V, 374.
Teas from Natal . . . . . 1908, VI, 1.
Cottons from India . . . . . 1908, VI, 11.
Rubber of *Ficus elastica* from India . . . 1908, VI, 22.
Uses, properties, and production of gums . . 1908, VI, 29.
Weight as a factor in Seed Selection, with special reference to Cotton . . . . 1908, VI, 74.
Use of dried Cow-dung as fuel in India . . 1908, VI, 88.
Jute and Jute substitutes from West Africa . . 1908, VI, 126.
Production and utilisation of Wattle Bark . . 1908, VI, 157.
Fibre of *Sida rhombifolia* from India . . . 1908, VI, 211.
Mineral Production of India . . . . 1908, VI, 215.

Cultivation and Marketing of Maize . .	. 1908, VI, 261.
International Rubber Exhibition in London .	. 1908, VI, 277.
Experiments in Jute Cultivation in Bengal .	. 1908, VI, 292.
Export of Tanned Skins from India . .	. 1908, VI, 319.

Summaries of the contents of the principal Indian publications relating to economic products are now being published regularly in the Bulletin, as they appear, see "Bulletin of the Imperial Institute", 1908, VI, Nos. 2 and 3.

The above statement of the work conducted on Indian materials refers to the samples of those which have been received from India, and does not include enquiries which have been dealt with at the request of the India Office or of the India Store Depot.

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(2) Commercial Circulars printed for circulation but not on sale.
(3) Annual Report of the Industrial Section, Indian Museum.

II.—Meteorological Department.

Government of India Office.

(1) The India Daily Weather Report and Chart.
(2) The Weekly rainfall summary.
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(6) Indian Meteorological Memoirs.

Bengal Office.

(1) Bengal Daily Weather Report and Chart.
(2) Monthly rainfall tables and summaries of the chief features of the weather of the month over Bengal.

Bombay Office.

(1) Bombay Daily Weather Report and Chart.
(2) Monthly abstracts of the Bombay observations (Bombay Gazette).

Madras Office.

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(2) Monthly rainfall tables (Madras Gazette).

Allahabad Office.

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III.—Geological Survey.

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Palæontologia Indica arranged in series, and sold in parts which are priced at 4 annas (6 pence) per plate.

Memoirs, Vols. I—XXXVI, including the larger papers on geological subjects.

Records, Vols. I—XXXII, including the shorter papers and Annual Reports from 1868 to 1904 sold in parts, price one rupee each.

Manuals, Guides and Maps.

A complete list of the contents of these publications can be obtained by application to the Registrar, Geological Survey of India, 27, Chowringhi Road, Calcutta. Indexes to the Genera and Species described in the Palæontologia Indica up to 1891, to the Memoirs, Vols. I—XX, and to the Records, Vols. I—XXX, have been printed for sale.

IV.—Survey of India.

(1) Annual General Report.
(2) Professional Papers.

V.—Botanical Survey and Royal Botanic Garden, Calcutta.

(1) Annual Report of the Botanical Survey of India.
(2) Records of the Botanical Survey, Vols. I—III, and Vol. IV, Nos. 1—3.
(3) Annual Report of the Royal Botanic Garden, Calcutta.
(4) Annals of the Royal Botanic Garden, Calcutta, Vols. I - X.

VI.—Department of Agriculture.

(1) *Annual Report.*—An account of the year's work of the Imperial Department, including the separate reports of the scientific officers of each branch (Agricultural Chemistry, Botany, Mycology, Entomology and the like).

(2) *The Agricultural Journal of India.*—A quarterly journal containing articles on agricultural matters intended for the educated agriculturist and the general reader interested in Agriculture.

(3) *Scientific Memoirs of the Department of Agriculture.*—An occasional publication for papers of a scientific or technical nature divided into series such as Chemical, Botanical, Entomological, and the like.

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(5) *Leaflets.*—Short notes of practical instruction in agricultural matters, dealing mainly with entomological subjects.

VII.—Forest Department.

(1) *Review of Forest Administration in British India* by the Inspector-General of Forests (issued annually).

(2) *Annual Progress Report of Forest Administration in each Province.* Issued by the Local Governments annually.

(3) *The Indian Forester.*—A monthly Journal of Forestry, Agriculture, Shikar and Travel. This is a Departmental Journal published monthly.

(4) Bulletins are published from time to time.

VIII.—Zoological Department.

(1) Annual Report.

(2) Monographs, appearing at irregular intervals.

IX.—Civil Veterinary Department.

(1) Annual Report.

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ANNUAL REPORT FOR 1908-09.

ANNUAL REPORT

OF THE

BOARD OF SCIENTIFIC ADVICE FOR INDIA

FOR

1908-09.

SUMMARY OF PROCEEDINGS.

Fifteenth Meeting held at Simla on the 10th May 1909.

The Board had under consideration a reference from Government on the question of the disposal of surplus copies of the volumes of the "Fauna of British India." It was resolved to adopt the report of the Sub-Committee to whom the question had been referred and forward it to Government. In the Sub-Committee's report it was recommended that sets of the "Fauna" should be distributed to Provincial Governments for their Agricultural Departments and to deserving Natural History Societies and Museums that require the work but did not possess it; that of the copies remaining after this distribution a certain number ought to be reserved by Government, while the residue should be transferred to one or more of the Agents in India for the sale of Government Publications.

The report of the Sub-Committee on the establishment of scientific libraries in India was then discussed. The attention of the Board had been drawn to the fact that the rapid increase in the number of Scientific Institutions throughout the world was rendering it more difficult to obtain back numbers of the more important scientific periodicals and that unless efforts were made now to secure complete sets of some

of those for India it would be impossible at a later date to establish efficient libraries for the requirements of scientific research in India. The Sub-Committee had issued a circular to all Institutions that seemed likely to include scientific libraries, explaining the object of the enquiry and inviting information regarding the libraries at present existing at the principal centres. After full consideration of the replies received the Sub-Committee submitted a comprehensive report to the Board in which they stated that they were of opinion that it was unnecessary to deal with the question of maintaining College Libraries—in view of the reforms that were in progress in the Indian Universities—or with the Libraries attached to the Scientific Departments of Government. Accordingly the Sub-Committee restricted their recommendations to the maintenance of general reference libraries in each Province of India. They were of opinion that a "first-class" general reference library should be maintained in each of the following Provinces: Bengal, Bombay, Burma, Madras, the Punjab, and the United Provinces. The Sub-Committee gave a list of scientific periodicals that in their opinion should be maintained in all "first-class" libraries. In addition to the "first-class" libraries the Sub-Committee recommended that "second-class" libraries should be maintained in large towns like Ajmere, Cawnpore, Dacca, Jubbulpore, Mandalay, Nagpur, Ootacamund, Quetta, Shillong, Simla, etc. Such libraries would not be sufficient for the requirements of research students but would be of great value to many students who leave the Universities and who otherwise have no opportunities of keeping up their interests in the subjects studied in the Universities. The Sub-Committee gave a list of the scientific periodicals that might be maintained in such "second-class" libraries. A list was also given of the more important scientific journals with prices of complete and short sets and the amounts of annual subscriptions to assist Local Governments and the governing bodies of local institutions in drawing up their estimates of cost. The Sub-Committee drew attention to the imperfect care bestowed on valuable books and explained the importance of preserving sets of reference works complete and in good condition. The Board resolved to adopt the report of the Sub-Committee and forward it to Government with the recommendation that steps should be taken to establish libraries on the lines suggested or to subsidise existing libraries in order that as regards scientific periodicals they might be brought up to the standard suggested in the Sub-Committee's report.

The appendix to the Annual Report of the Board for 1907-08 giving an account of the work performed at the Imperial Institute of London on behalf of the Government of India was considered. The Board were of opinion that the general practice of mentioning the names of investigators and the authors of reports referred should be adopted in future reports on the work done at the Imperial Institute on behalf of the Government of India.

The Programmes of the various Scientific Departments of Government were discussed and approved with the exception of the Programmes of the Reporter on Economic Products to the Government of India, of the Forest Department, and of the Agricultural Department which were referred to Sub-Committees for revision and re-submission. It was suggested as an addition to the Programme of the Survey Department that arrangements should be made to run a series of levels in suitable places across the foot hills of the Himalayas; that bench-marks should be carefully constructed and preserved in order to determine at some future date the amount of any rise in progress due to earth movements. The Board were of opinion that the exact lines of levels might be settled by consultation between the Surveyor-General and the Director of the Geological Survey, but the Board suggested the following lines might be taken up as soon as convenient :—

(1) Siliguri to Tindharia; (2) Bareilly to Naini Tal Brewery; (3) Najibabad to Lansdowne; (4) Umballa to Solon; (5) Pathankot to Dharmkot.

The remarks of the Advisory Committee of the Royal Society of London on the work of the various Scientific Departments were referred to appropriate Sub-Committees and the Heads of Departments concerned for consideration and submission of reports to the Board.

Sixteenth Meeting held at Simla on the 17th May 1909.

The Board at this meeting read the Report of the Director of the Geological Survey on the criticisms of the Advisory Committee of the Royal Society regarding the work of his Department. On consideration of the report the Board were satisfied that the main energies of the Geological Survey Department were devoted to the preparation of the general geological map of India, that satisfactory progress had been made in recent years, and that it was premature to call for a progress report of the kind recommended by the Advisory Committee.

The Programmes of work for 1909-10 of the Reporter on Economic Products to the Government of India and of the Forest Department, which had been referred to a Sub-Committee at the previous meeting for revision, were resubmitted with alterations and thereupon accepted by the Board.

The Report of the Sub-Committee appointed to consider the criticisms of the Advisory Committee of the Royal Society on the work of the Civil Veterinary Department was also accepted as a satisfactory reply to the remarks of the Advisory Committee on the work of that Department.

Seventeenth Meeting held at Calcutta on 7th January 1910.

The Board read and recorded a letter from the Government of India on the reorganisation of the Botanical Survey and of the Department of Economic Products in which the postponement for the present of the proposals submitted by the Board with regard to those two Departments was explained.

The revised report of Sub-Committee C. on the remarks of the Advisory Committee of the Royal Society concerning the work of the Agricultural Department and the programme of the same department for 1909-10 was considered. The questions discussed in the Sub-Committee's report comprised the work of the Mycologist and the Entomologist; permanent agricultural experiments at Pusa; the manurial requirements of soils; the availability of plant food in soils; the investigation of gases in soils and of the value of Calcium Cyanamide and Nitrates as manures; the investigation of fibre-yielding plants and the co-ordination of the work of the Provincial Agricultural Departments with that of the Central Research Institute at Pusa. It was proposed to omit certain of the subjects for investigation in view of the remarks of the Royal Society's Advisory Committee, but the Sub-Committee of the Board upheld the views of the Agricultural Department with regard to the desirability of experiments with farm-yard manure instead of artificial manure; of pasture experiments and continued investigation of fibre plants, of study of plant nutrition and of the scheme of work of the Mycologist and the Entomologist. The Board resolved to accept the report of the Sub-Committee and to accept the programme of the Agricultural Department as submitted.

The Board again considered the question of whether the names of investigators and the authors of reports referred to should be given in reports on the work done at the Imperial Institute on behalf of the Government of India and while it was held that the names of those who had taken part in enquiries were not required for publication, it was considered important that in scientific and commercial enquiries the departments interested should be acquainted with the names of the experts consulted.

The Draft Annual Report of the Board for 1908-09 was discussed, and after several emendations of and additions to certain of the sections of the report was accepted for submission to Government in due course.

INDUSTRIAL AND AGRICULTURAL CHEMISTRY.

BY

I. H. BURKILL, M.A., F.L.S.,

AND

H. E. ANNETT, B.Sc., M.S.E.A.C.

This report is a review of a year's chemical work done in connection with industries and agriculture in India or on Indian material. We shall endeavour to indicate in it the relation of that work to India's commercial progress. It will be found to record a considerable amount of analytical work: but only a little work on improvement of processes. India's industries are mainly in the copying stage; and the work to hand is therefore the search for material for manufactures to work on. For the purpose of the report the following classification has been adopted :—

i. Analytical methods.
ii. Fuel.
iii. Industries based on mineral production.
iv. Chemistry and physics of soils and water; manuring.
v. Analysis of organic raw products and manufacturing processes connected with them—
    1. Gums, resins and rubber.
    2. Oils.
    3. Dyes and dyeing, paints and pigments.
    4. Tans and tanning, glue, size, etc.
    5. Fibres, cordage and fabrics.
    6. Paper and pasteboard.
    7. Building materials.
    8. Flours, sugars, starch, etc.
    9. Accessories to human food.
    10. Spirits.
    11. Drugs.
    12. Cattle foods.
    13. Organic manures.

A bibliography will be found on pp. 30-35. We have been favoured by notes from several chemists in India, and have particularly to thank Dr. R. L. Jenks for the information given under Section v, sub-head 10.

There are but few chemists privately entertained in India: these are attached to sugar works, oil mills, paint works and chemical works. No publications by any of them have come to our notice: what has been done has emanated almost entirely from the official laboratories of the Geological Survey, Imperial Agricultural Department and some of the Provincial Agricultural Departments, Imperial Forest Research Institute, Industrial Section of the Indian Museum, the Cinchona Department Sikkim, and also from the subsidised laboratories of the Behar Planters Association and Indian Tea Association: lastly a small amount of the work done by the Chemical Examiners to the various Provincial Governments and by the Municipal and Customs Analysts is industrial, but is meagrely reported. Enquiry leads to the conclusion that the Chemical Examiners would give useful information on the industrial work were it not that the limit fixed to their annual reports does not allow them to set out more than their administration and their medico-legal results. It seems a pity that these officers and also the Municipal Chemists should not have space to report on the commercial analyses that they perform.

§ i. **Analytical methods.**—Every chemist well knows how rarely it happens in India that a laboratory attains a temperature in any degree approximate to that of laboratories in Europe. Instruments in Europe are calibrated for a temperature of 15° or 20° C and tables are constructed giving the percentage composition of sulphuric acid, etc., of different specific gravities for various temperatures but specially worked out for 15° or 20° C. These temperatures are much below the mean temperature in Indian laboratories and Professor Brühl proposes the adoption as a standard of a temperature of 30° for India. The Asiatic Society of Bengal, before which he laid his proposals, has appointed a committee to collect evidence and opinions, with Mr. D. Hooper as its Secretary. If the laboratories of India agree on a suitable temperature, tables can be forthwith prepared.

Work on analytical methods in regard to Indigo and Ganja will be reported further on.

§ ii. **Fuel.**—Professor E. R. Watson has contributed to the Indian Trade Journal, x, supplement, pp. 2-8, a paper on the "*Calorific and manurial values of Indian cowdung commercially considered.*" He does not concern himself with the value of fuel for factories, but for ordinary cooking as done through India. "No fuel," he finds, "can successfully compete with cowdung cake as a cheap fuel for cooking purposes on a small scale. But whereas the market value of cowdung cake as fuel is

only 4½ annas per maund, this same material is worth 11½ annas per maund as manure, and it would most undoubtedly pay the ryot to reserve his cowdung as manure and buy a slightly more expensive material as fuel. Even taking into consideration the manurial value of the ashes of the cowdung, which may be taken as something less than 3½ annas per maund of dung, it would still amply pay the ryot to use cowdung as manure and buy other materials, say, firewood, coal, coke or kerosine oil as fuel." The value of the cowdung as manure in the above statement was calculated by Mr. B. Coventry.

In the course of his work Professor Watson ascertained the heating power of various other fuels, *e.g.*, firewood from *Ceriops Roxburghiana* (the common Calcutta firewood), kerosine oil of various brands, Bengal coal and coke made from it; and his paper is full of statistics of the prices of these in different parts of India.

Professor Dunstan had reported previously on a sample of Indian cowdung fuel (Bulletin, Imperial Institute, 1908, p. 88). He gives an analysis, and—more important—his estimate of the calorific value is confirmatory of Professor Watson's.

§ **iii. Industries based on mineral production.**—Analyses of minerals from various parts of India, have been made by the Geological Survey of India and will be found reported on in the Geological Section below (p. 60). It is not necessary, therefore, to give details here. Further at the Imperial Institute at the request of the Geological Survey examinations of Bauxite have been made. The production of sulphuric acid in India has increased slightly, but no changes in the chemical processes are recorded. No work has been done on the saltpetre industries.

Salt.

Table salt produced round the coasts of India is frequently analysed for the salt department, but the analyses are not generally published.

The position of the glass-making industry in India is improving somewhat: and in connection with it two papers are of interest, one, Mr. Murray Stuart's report on the suitability of sand in the Raj Mahal hills for glass-making and the other, Mr. Plymen's report on the salt deposit of the Lonar lake. A local soap-making industry is worked with the salts of the Lonar Lake, but the local glass-making and dyeing industries have waned.

§ **iv. Chemistry and physics of soil and water; manuring.**—Most of the work on this subject has emanated from the laboratory of the Imperial Agricultural Chemist.

Soils.

Analyses of soils have been made by Mr. A. A. Meggitt in Bombay and by Dr. Leather of good wheat-producing soils at Raipur, Central Provinces. A large number of alkali soils from the United Provinces have been examined by Dr. Leather and some from the Bombay Presidency by Mr. Meggitt. It is understood that a memoir is in course of preparation on "The alkali lands of the Nira valley" by Dr. H. H. Mann of the Bombay Department of Agriculture.

Soil moisture.

Dr. Leather made numerous determinations of water in the soil at Pusa throughout the dry season, down to a depth of 7 feet. He holds that his figures shew that water moves upwards in the soil from a limited depth only. In any case, the upward movement of water in soils must take place at a much slower rate than has hitherto been taught. Dr. Russell in criticising Leather's conclusions, however, has stated that the results are equally well explained on the supposition that the upward movement takes place at all depths, since the amount of water present in a particular layer depends on the respective rates at which water is gained from below and lost to the upper layers.

Dr. Leather has replied that he adheres to his original conclusion and adds that if the total decrease of water which occurs during a dry period throughout the strata is ascertained, this will be precisely that quantity of water which has evaporated from the surface of the land. Dr. Russell in a further criticism says that he also does not agree with this later statement. Further experiments in the field made during the last cold weather at Pusa strongly support Dr. Leather's conclusions.

Water requirements of crops in India.

A memoir of the Department of Agriculture gives information regarding the amount of water transpired by some of the commonly cultivated crops, when grown in Behar soil. Although some data have been obtained in other countries, there is need for information of this sort in India, as pointed out in the Indian Irrigation Commission Report for 1901-03. In chapter xi the remark appears, "in the course of our investigations we have been struck with the small amount of attention which appears to have been given by the Departments of Agricuiture and Public Works to matters connected with the application of water to cultivated crops." The data presented in the memoir should therefore be of interest and value in India.

The experiments which have been carried out by means of potcultures,

are being checked by experiments in the field. The crops experimented on have been maize, rice, juar, murwa or ragi (*Eleusine coracana*), kodo (*Paspalum scrobiculatum*), arhar or tur (*Cajanus indicus*) and guar (*Cyamopsis psoralioides*), wheat, oats, barley, linseed, sarson, peas and gram.

The amount of water transpired by the plant, per unit increase in dry weight, has been found to be considerably influenced by the following factors :—

(1) *Manuring.*—The amount of water transpired per unit increase in dry weight was found to be much less from plants grown in manured than from those grown in unmanured soil. From reasons given by the authors the conclusion may be drawn that not only manure but good tillage, a deep soil and indeed any factor which aids in good development of the crop will tend towards an economy of water.

(2) *The length of period of growth.*—In general, it has been found that those crops which mature rapidly use less water per unit increase of dry weight than those whose growing period is spread over longer intervals of time.

(3) *The nature of the crop.*

(4) *Temperature and humidity.*—Daily records of the atmospheric humidity have been kept. On a wet day the quantity of water transpired decreased to about one-quarter or one-fifth of what it was on fine day. Charts reproduced in the memoir show that with every serious increase in the humidity there is either a check in the direction of the transpiration curve or a dip in it.

In conclusion the author discusses the amount of water which various crops use up and gives figures to shew it.

The system water, Calcium carbonate, carbonic acid. Soil gases.

In the course of some investigations on soil gases and available plant food in soils, which are in progress in the Chemical Section of the Agricultural Research Institute at Pusa, more accurate information was required on the concentration of calcium carbonate and carbonic acid in water than exists in the literature of this subject. Accordingly a series of measurements have been made, and the data, together with the general formula expressive of the concentration, have been published as a memoir.

The conclusion drawn by the authors (Dr. Leather and Mr. J. Sen) from their investigations is that with the aid of a general formula

deduced by the authors, it is possible from say, an analysis of soil gases, to deduce the concentration of the carbonic acid and calcium carbonate which are actually in solution in the soil-water or as gaseous carbon dioxide respectively; in this case it is to be recollected that a part of the carbon dioxide obtained as *gas* from any soil, will have been present in solution in the soil-water prior to its removal, and this part has naturally to be computed.

Toxic substances excreted by plant roots.

Mr. F. Fletcher as a result of experiments in the field and by water cultures has concluded that plants excrete from their roots a toxic substance. Dr. Russell, however, criticises his work, and says that with regard to the field experiments, the falling off in yield which Mr. Fletcher ascribes to the excretion of toxic substances by other plants is no proof that toxic substances are excreted and is generally explained as due to lack of water or food.

With reference to the water culture experiments it may be stated here that Mr. Fletcher obtained a "solution of excreta" by growing plants in water culture and then used this solution as a medium for plant growth. He found the medium to be toxic. Dr. Russell says that Mr. Fletcher took no precaution to prevent development of bacteria and that there is no evidence to shew that the toxic substance was excreted by the plant: it might equally well have been a bacterial product. Mr. Fletcher's contention is at present certainly not proven.

Black cotton soil.

Black cotton soils have been shewn by Mr. Annett to contain a black mineral, titaniferous magnetite, to the extent of several per cent. and the deep black colour is partly due to its presence. In consequence of the presence of the magnetite practically the whole of the soil particles are magnetic. Organic carbon, soluble humus and nitrogen determinations shew that the soils are not rich in organic matter. These soils are highly argillaceous. The results are now ready for publication.

Rab experiments.

On the Ghats around Poona the cultivators burn brushwood and vegetation generally on the surface of land which is being prepared for rice seed-beds. By this means the crop is greatly increased, and to a much greater extent than can be accounted for by the manurial effect of the ash. The effect is probably biological and the subject is being worked at by the Bombay Agricultural Department.

Manuring.

Mr. Bergtheil finds that the provision of plentiful plant food for Indigo tends to depress the production of indican and states that he does not think that anything is to be gained at present by further manurial experiments of the ordinary sort.

In the report of the Heeleaka Experimental Station, 1905-08, Mr. Hutchinson states that much further observation of effects of manurial treatment will be necessary before any decided opinions can be arrived at as to the absolute value of any particular style of manuring for tea.

The primary object of the experiments at Heeleaka was to ascertain the relative effect of the various manures on the bushes rather than to determine the optimum amounts to employ. The possibility of lowering of quality, as a consequence of increased yield produced by manuring, is a very serious question and one which has not been lost sight of in the Heeleaka experiments.

The following general conclusions have been arrived at :—

(1) Oilcake as a means of renovating old tea on such light soils as that of Heeleaka, is the most economical in use of any manure tried.

(2) Mineral manures, such as superphosphate, sulphate of potash and nitrate of soda can undoubtedly be utilised successfully for the same purpose, although at a higher cost.

(3) Nitrogenous manures such as nitrate of soda and sulphate of ammonia, produce a better effect if used in conjunction with superphosphate, and potash, these latter in their turn being also dependent for their full effect upon the presence of adequate supplies of nitrogen.

(4) Manures, such as oilcake, produce a very much greater effect if applied in annual small doses than if put on to the same total amount at longer intervals.

The sugarcane manurial experiments at Manjri have been continued and the results may be found in the Annual Report of the Bombay Department of Agriculture, 1907-08.

In his Ninth Annual Report the Mysore Agricultural Chemist discusses the necessity for standardising plots carefully before starting manurial experiments and mentions the result of experiments started at Bangalore. Manurial experiments on paddy have been started.

Green manuring.

For tea at Heeleaka the relative results of five green manuring crops have been tested during three consecutive seasons (1905-07). The crops used were

groundnut, dhaincha (*Sesbania cannabina*), *Crotalaria striata*, mati kalai (*Phaseolus Mungo*), and arhar (*Cajanus indicus*). Arhar was found to give by far the best results.

Experiments are in progress in the Mysore State for the purpose of finding out :—

(*a*) if the growing of a green manure is desirable,

(*b*) what crop gives the best green manure for ragi (*Eleusine coracana*),

(*c*) when can this crop be grown to the best advantage.

In Ceylon the results of green manuring experiments on Gangaroowa tea are very instructive and show a great advantage derived. Poor tea elsewhere is being taken in hand to see how far it can be brought into a high state of efficiency by nitrogenous green manuring with the aid of lime phosphates and potash only.

Experiments on all the chief leguminous plants suitable for green manuring, or as cover plants to keep out weeds have been commenced.

Drainage waters.

The drainage waters from the gauges at Cawnpore and Pusa have been measured and analysed throughout the year.

Irrigating waters.

Samples of canal water from Quetta which were examined in the laboratory of the Imperial Agricultural Chemist were found to be abnormally rich in dissolved salts. Certain samples were found to contain 20,000 parts of dissolved salts per 100,000, the salts being largely sodium chloride and sulphate with smaller amounts of magnesium sulphate.

Normally, however, the amount of dissolved salts in the waters from 6 canals varied from 100 to 2,500 parts per 100,000. Owing to the harmful effect which such waters might have if used for irrigation, the Imperial Agricultural Chemist toured in Baluchistan. As a result of this tour certain recommendations were made to the Irrigation Officer in Baluchistan. In the main the advice given consisted in recommendations that frequent analyses should be made of the water, and that whenever the concentration of the salts is found to have decreased to a sufficient extent the water should be used for irrigation. After rainfall, for instance, it is generally found that the concentration of the salts drops to 150-200 parts per 100,000 and then the water can probably be used for irrigation without harmful effects.

§ v. Analysis of Organic Raw products and Industries connected with them.—Professor Dunstan has reported on the chemistry of Indian gums derived from *Acacia Jacquemontii*, *A. Catechu*, *A. Farnesiana*, *A. modesta*, *A. Senegal*, *Anogeissus latifolia*, *Elæodendron glaucum* and *Prunus eburnea* (Bulletin Imperial Institute, 1908, p. 56). Some of these, he says, may rank commercially as gums of the first grade, *viz.*, those of *Prunus eburnea*, *Acacia Jacquemontii* and *Elæodendron glaucum*, while the rest are second grade. Unfortunately the Indian supply is much greater of the second grade gums than of the first grade; and gums owing to the method of collection are likely to arrive in the market mixed.

Gums.

Mr. Hooper has given an analysis of the roots of *Eremurus Aucherianus* which are made in Persia into a vegetable glue and then moulded into oil bottles (Indian Museum, Annual Report, 1908-09, p. 16).

Mr. Puran Singh has published important work on shellac. He has suggested that instead of washing the lac dye out of powdered lac, the shellac should be dissolved from off the dye and insect-remains by means of wood spirit. The author stated that he is submitting shellac so prepared to manufacturers in order to see if it satisfies their requirements.

Resins.

Some analyses of lac from various sources by Mr. D. Hooper are published in the Annual Report of the Indian Museum. He has also examined Keri or refuse lac left from the ordinary process of preparation of shellac in order to see what proportion is lost in it. The Keri contained 55 to 72 per cent. of resin. He has also taken chemical constants for the resins of the following plants:—*Dipterocarpus lævis*, *D. alatus*, *D. obtusifolius*, *D. turbinatus*, *D. tuberculatus*, of an unnamed *Dipterocarpus* from Chittagong, of *Shorea robusta*, *S. obtusa*, *Hopea odorata*, *H. parviflora*, *Vateria indica*, *V. malabaricum*, *Canarium strictum*, *C. bengalense*, *C. resiniferum*: and he has also examined the resins of which Melipona bees construct their nests—resin not produced by the insects themselves but collected.

The uses of these resins at present are various: they formerly were largely used for torches, but are little used now: they find their way into varnishes, are used for caulking boats, and a little in medicine. But, East Indian dammar from the Malay Islands at present holds a larger market than they.

Mr. Puran Singh's paper on the constituents of Burmese varnish from *Melanorrhæa usitata* has appeared. Its publication was anticipated in

the report for 1907-08, p. 18. The chief constituent he finds to be urushic acid, which is also the chief constituent of Japanese varnish from *Rhus vernicifera*, and he recommends that all the conditions observed by the Japanese worker in lacquer to obtain the best results should be adopted by the Burmese artisan. The original paper should be consulted for these.

Many samples of sealing waxes have been examined by Mr. Hooper during the last few years in the Indian Museum. A good sealing wax should be composed of 55-60 per cent. resins, 30 per cent. vermilion, 15-10 per cent. of loading. Only a few of the waxes examined carry anything approaching this percentage of vermilion. Some were coloured with red lead and some with aniline dyes. Waxes coloured with aniline soon fade.

Rubber.

Endeavours to put rubber on the European market from new sources have resulted in various analyses of Para rubber, Castilloa rubber, and Ceara rubber from Southern India. *Ficus elastica* from Assam and North Malabar have been examined at the Imperial Institute and reported on in the Institute's Bulletin. Several samples of rubber of *Ficus elastica* have been examined in the Indian Museum.

Oils.

Estimations of the oil in oil seeds have been recorded as follows :—

Sterculia fœtida	34 % (Meggitt).
Sesamum indicum (Til)	47—57 % (do.).
Castor oil (Ricinus communis)	38·5—52 % (do.).
Ground nut (Arachis hypogæa)	46—47 % (do.).
Bombax malabaricum (silk cotton tree)	30·8 % (do.).
Moringa pterygosperma	22·6 & 25·6 % (do.).
Gynandropsis pentaphylla	25 % (Hooper).
Salvadora oleoides	45 % (do.).
Litsæa zeylanica	61 % (do.).
Cotton seed (husked)	34·8 % (Indian Trade Journal).

Mr. Hooper's investigations are part of a comprehensive survey of Indian oils undertaken with a view to the establishing of reliable test-tables for identification. Acid value, saponification value, iodine value, specific gravity and melting point are among the constants determined. The work will probably be followed up by a study of commercial adulteration.

Dr. J. A. Pearse in his "Report of the Health Officer of Calcutta for 1907," records on the authority of the Calcutta Municipal Analyst the

detection of adulterants in ghi and adds that of 344 samples bought in Calcutta as ghi 203 were adulterated and 11 fictitious. Doubtless there were grounds for suspecting fraud in these samples before they were bought and the percentage of sophistication in them does not in any way indicate that so much is done in the trade. In recording the work of Municipal Health Departments fuller details than are now given would be useful. Adulteration of mustard oil and of butter is also recorded both by Dr. Pearse and by Mr. C. T. Bennett.

The Municipal Analyst, Bombay, records adulteration in 8 samples of ghi out of 44 examined.

Mr. Hooper has examined the oil of the livers of four large fish brought into Calcutta by the Experimental Steam Trawler "Golden Crown", *viz.*, *Trigon microps*—a sting ray, *Pristis perottetii*—the saw fish, *Stegostoma tigrinum* the spotted shark, and *Ramphobates ancylostomus*. He has also examined the oil of the liver of *Platanista gangetica*—the Gangetic Dolphin.

There was no less than 71·6 per cent. of oil in the liver of the sting ray, as a food possibly of value equal to cod-liver oil: and as the liver weighed 89½ pounds, the fish yielded 66 lbs. of oil. Palmitin was found in different quantities in the different fish. "The large quantity of solid fats would render the oils useful for soap manufacture, while the liquid oil separated from the palmitin would be serviceable for leather dressing, lighting and lubricating purposes."

Dyes, Chemistry of Indigo.

Several publications relating to Indigo have appeared during the past year. Strenuous efforts are now being made by the producers of natural indigo in India to hold their own against the artificial article. The following remarks summarise the contents of the chief papers issued.

Messrs. Perkin and Bloxam have shewn that indican, the glucoside of indoxyl, can be readily isolated from the plant by acetone and as indoxyl condenses with isatin to form indirubin Mr. Bloxam based a method for the analysis of indican upon (i) extraction with acetone and (ii) its conversion into indirubin by addition of isatin. Following this up it was next attempted to find out if the isatin in this method could be replaced by certain aldehydes and with success, for the reaction of p-nitro-benzaldehyde with indoxyl to form p-nitro-benzaldehyde-indogenide was shewn to be quantitative, so that the authors say, "it is thus likely that p-nitro-benzaldehyde can be employed as well as isatin for the estimation of indican in the leaf."

Piperonal was also tried but it does not react with indoxyl quite so readily as p-nitro-benzaldehyde does.

They give an account of the hydrolysis of indican by means of acids.

The results of another investigation shew that when pure indican is hydrolised by its specific enzyme indimulsin, and the indoxyl thus obtained is oxidised with air, considerably less than a quantitative yield of indigotin, admixed or otherwise with indirubin, is thus produced. This is partly explained by the fact that, due to its unstable nature, indoxyl is slowly converted into a product incapable of yielding indigotin on oxidation. This decay of indoxyl is retarded by the addition of a small quantity of ammonia or lime water. Here it may be remarked that addition of ammonia to the indigo vats has given good results in India and that the addition of lime water is an essential feature of the Coventry process.

The authors conclude (Proc. Chem. Soc. Vol. 25, No. 355 (09)) that the best yields of colouring matter were given in their experiments when a small amount of acid was present during the fermentation and the fermented liquid was then oxidised in the presence of a trace of ammonia.

Mr. A. G. Perkin has contributed two papers bearing on indigo, one on "Indoxylic acid" and another on the reduction of indirubin.

A report to the Government of India was issued in 1908 by Mr. Bloxam on the results of work done in India from 1902-04 on indigo in conjunction with Messrs. H. M. Leake and R. S. Finlow. The results of this work were first published in 1905. In the present report Mr. Bloxam states that before being certain of any efficiency of the manufacturing process or of being able to suggest any valid improvement of it, two factors were necessary, (*a*) an accurate process for the estimation of the finished product, (*b*) an accurate knowledge of the amount of colour which could be obtained theoretically from the manufacture, *i.e.*, an accurate knowledge of the indigotin content of the green leaf. He considered, contrary to the opinion of others in India, that these points had not already been elucidated.

Hence the work at Leeds has been largely devoted to the evolution of methods for the analysis of indigo and of plant-leaf for indican content.

Mr. Bloxam has evolved methods which he now considers trustworthy. The present report contains all the publications of Mr. Bloxam and his colleagues and of Mr. A. G. Perkin bearing on the indigo question.

Mr. Bloxam puts forward proposals for the future conduct of experimental work on indigo in India.

Dyeing tests with Indigo.

Dyeing tests with indigo were carried out at Sirseah, attention being paid to the comparative dyeing properties of natural and synthetic indigo. Not very definite results have been obtained; but there are indications that the natural dye "goes further" than the synthetic dye.

Manufacture of Indigo.

Experiments on manufacture at Sirseah were mainly directed to the question of loading the vats: and it is concluded that good quality Java plant should never be loaded more heavily than 80 maunds per 1,000 cubic feet and the loading should be increased as the quality of the plant falls off.

Mr. Bergtheil says that it is no longer worth while trying to improve the efficiency of the process since it is easy to obtain an efficiency by the present methods of 85 per cent. He makes this statement in the belief at variance with Mr. Bloxam that we have a fairly accurate knowledge of the amount of colour obtainable theoretically from the leaf [*vide* statement (*b*) on the opposite page].

Experiments on filtering seet-water point to the fact that this operation will not be profitable.

An indigo powder-making machine has been tried with success.

The theory is put forward that the production of indican is a phenomenon which accompanies semi-starvation conditions (compare the statement at the top of p. 15 above.)

A series of pot-cultures were carried out to find the effect of plant stimulants on indican production. The experiments were not duplicated; but there were indications that small amounts of copper sulphate stimulated the plant growth, and also the production of indican. This line of work is being continued.

The main hope for the indigo industry lies along the line of trying to produce a plant with a higher indican content than we have at present. Preliminary experiments suggest that this is possible. A botanist trained in the best lines of plant breeding is about to be appointed to the Sirseah staff; and there is reason to hope that good will result to the indigo planting community.

Dye of Tephrosia.

Tephrosia purpurea Pers. is a small woody annual, growing luxuriantly during the monsoon in many waste tracts of the United Provinces. Messrs.

G. Clarke and S. C. Banerjee find that its dried leaves yield about 2 per cent. of a crystalline glucoside, which melts and decomposes at 180-185°, and on hydrolysis with dilute sulphuric acid yields quercetrin and dextrose. It appears, therefore, to be identical with osyritrin (A. G. Perkin, Trans. Chem. Soc., 1897, 71, 1134).

Other Dyes.

Mr. A. G. Perkin has examined the dyeing properties of the flowers of two plants related to the cotton plant. One of these, *Thespesia Lampas*, contains quercetrin in small quantity, the other, *Hibiscus Sabdariffa*, contains at least two colouring matters, one apparently a new body of the flavone group and the other a dye very closely resembling gossypetin.

Wiechowski's paper on Peori Dye—the yellow dye obtained from the urine of cattle fed on mango leaves—is interesting. It is in chief part euxanthin—a magnesium salt of a peculiar acid,—and decomposes with heat into euxanthic acid of dioxy-dibenzo-γ-pyron. Wiechowski has been able to extract with alcohol from mango leaves a pale yellow crystalline substance euxanthogen which, acted on in the bodies of rabbits, is discharged as euxanthic acid and euxanthon. It now rests with the chemists to bring about the action outside the animal's body and to see if it can be brought within commercial means. Until that is effected the paper is of academic interest, as this quaintly derived Indian dye is going out of use.

Tanning.

Mr. Hooper has estimated the amount of tannin in Canaigre (*Rumex hymenosepalus*) and in Chebulic myrobalans. The first estimation was to see if Canaigre root grown in Dharwar was equal to its parental stock grown in America. It was not: and a sample grown earlier in the United Provinces was similarly inferior.

The work on Myrobalans showed that certain green and brown myrobalans, supplied for testing, had equal tanning value. The attempt to select brightly coloured nuts for the market by handpicking seems to be misguided.

A complaint was made last year of the loading of hides by a composition apparently of barytes and glucose.

Fibres—Jute.

Chemical changes involved in heart damage of baled jute, have been investigated by Messrs. Cross and Bevan in collaboration with Mr. R. S. Finlow. The salient characteristics of heart damage are entire loss of tensile strength, great diminution in cellulose content and large increase in the

proportion of matter removable from the jute by water and by simple chemical reagents. One of the necessary conditions for heart damage to occur appears to be the presence of an excessive quantity of water. Jute containing nearly 30 per cent. moisture was baled experimentally and exported to London. It was proved not to have suffered damage *en route* and the fibre was sold in the open market as of first quality. In the investigators' laboratories it was shown that the diminution of cellulose may amount to about 25 per cent. of the total quantity present. The bacteriology of heart damage has yet to be investigated.

Other fibres.

Chemical investigations and valuation of Agave fibre from Madras and Sida fibre have been made at the Imperial Institute: and the percentage of cellulose (along with other data) is reported as follows:—

Cellulose in Agave rigida fibre from Madras	73·0 per cent.
„ „ Agave americana fibre from Madras	77·0 „
„ „ fibre of Furcræa sp. from Madras	72·0 „
„ „ Agave sisalana fibre from Andaman islands	76·6 „
„ „ Manilla hemp fibre from Madras	70·5 „
„ „ Sida rhombifolia fibre from Bengal	75·5 „

The writers of this report are convinced of the incorrectness of the second name above; it should be Agave Vera-Cruz.

Paper and pasteboard.

Mr. Hooper has ascertained the percentage of cellulose in the following:—

Ischæmum angustifolium from Nepal	40·4 & 40·7 per cent.
„ „ from Gonda	36·6 „
„ „ from Mailani	40·8 „
Phragmites Karka	41 „
Alpinia Allughas, leaves	21·3 „
„ stems	31·7 „
„ prepared fibre	43·2 „

Building materials.

Professor N. S. Rudolph has investigated the Powell process as a means of preserving Indian soft woods and rendering them available for industrial purposes. The results are satisfactory.

Flours.

Mr. A. Howard and Mrs. G. L. C. Howard have published a brief report on the milling qualities of some Indian wheats. The wheats reported on were submitted to Mr. A. E. Humphries, Past President of the Incorporated National Association of British and Irish Millers, for a report upon their bread-making value and to Dr. J. W. Leather for chemical examination. The order of baking value and of nitrogen content were

found to be practically the same,—a result which supports work done in England. A further report is promised; and it will not be time to review the whole of the suggestions raised until it is to hand.

Dr. A. Lehmann has given the following figures to show that Ragi (*Eleusine coracana*) is not a food deficient in phosphates:—Rice contains ·35 per cent., Ragi ·69 per cent. and oatmeal 1·02 per cent.

Sugar.

Sugar has been the subject of considerable attention. In the first place must be mentioned the work of Mr. G. Clarke and Khan Bahadur S. N. Hadi on Gur boiling in the United Provinces. Working with several races of sugarcane they find in the native method of Gur boiling an average loss of 15·7 per cent. sucrose. This is 5 per cent. more than Dr. J. W. Leather found when in 1896 he conducted 8 experiments at Cawnpur and Poona. The inversion in the process they find to be the same as Dr. Leather found it. It is desirable, they point out, to devise ways of saving as much as possible of this sucrose even at the expense of the appearance of the Gur.

The paper is full of analyses of many races of sugarcane taken from different places.

Analyses of races of cane grown at the Manjri farm near Poona have been done by Mr. Meggitt.

The amount of sugar yielded per weight of cane has been recorded by Messrs. Parry & Co. from land at Pattambakam and Sholavelly and by the Behar Indigo Planters' Association from their Benipore Factory.

Tamarisk Manna, which is used as a sugar on the Baluchi-Persian Border, has been reported on by Mr. D. Hooper.

Starch.

Starch is now manufactured in Eastern Bengal from the root of a Curcuma and also in the north-eastern parts of the Central Provinces. An analysis of Curcuma roots from Eastern Bengal has been made by Dr. Leather, who found 75·5 per cent. of starch in the root.

Plantain meal.

An analysis of plantain meal by Mr. D. Hooper shows a content of 81·3 per cent carbohydrates.

Rice.

Mr. Hooper has examined a very large number of rices from various parts of India. The richest contains of its dry weight 92·2 per cent. carbohydrates and the poorest 82·2 per cent. Albuminoids varied from 11·4 to 6·1 per cent. and the fats from 3·6 to 0·1 per cent. In milling with European

machinery the outermost layer of the grain is removed as rice polish and in it is lost the greater part of the fat which the grain contains.

Other foods.

Among miscellaneous foods, have been examined Singhara nuts (*Trapa bispinosa*) by Mr. W. H. Harrison, a Burmese sea weed (*Catanella impudica*) by Mr. Hooper, and also a preparation from castor oil seed after removal of the oil.

Food accessories—Tea.

Hartwich and du Pasquier find that by means of hydrochloric acid and gold chloride they can precipitate the caffeine which tea leaves contain *in situ* and by this they have been able to demonstrate that caffeine is accumulated chiefly throughout the whole of the mesophyll. They have further quantitatively estimated the caffeine present, and find for instance quite young leaves to hold 9·2 per cent. and older leaves decreasing amounts up to ·8 per cent. at maturity. The wood holds less —·06 per cent. in the stem, none in the root. The calyx holds 2·39 per cent. : the cotyledons about 1 per cent. The authors describe the chemical changes in making black tea thus :—

The greater part of the caffeine is set free in the rolling by the splitting of the caffeine-tannin compound present : next in fermentation part of the tannin turns to phobaphene which gives the leaf its bronze-colour and the caffeine diminishes by about 3 per cent. : lastly in roasting a further 14 per cent. of the caffeine is lost, and of the tannin 8 per cent.

The amount of caffeine in various teas is recorded.

Mr. C. M. Hutchinson traces the cheesy flavour that sometimes spoils tea to wood used for the tea boxes, which has undergone changes due to bacterial decomposition.

A brief note on the proportions of tannin and alkaloids in Indian, Ceylon and China teas appears in the *Indian Trade Journal*, xl, No. 133, p. 63.

Coffee.

Dr. A. Lehmann has given in his report the results of analyses of coffee beans from Mysore, Coorg, the Nilgiris, Nardoobatum, Nelliampathy, Costarica, Guatemala, Nicaragua and the Wynaad, in all 49 samples, undertaken with a view to finding a chemical method of estimating the quality of coffee. He is constrained to admit that the results do not forward his object, and that at the present time the specific gravity of the bean, as pointed out by him in an earlier report, is the most reliable numerical index that we possess of the quality of coffee.

Areca nut.

Mr. A. Rathje has ascertained what fats are present in the areca nut: he found stearic acid 2·25 per cent., palmitic acid 3·1 per cent., myristic acid 21·0 per cent., carmic acid 43·65 per cent., capric acid 1·0 per cent. and oleic acid 29·6 per cent.

Spirits.

There is a considerable amount of work on spirits to record. The "corrected Sikes' Tables" prepared by the Central Excise Laboratory, Kasauli, the new Reduction and Blending Tables and the new method of determining obscuration in spirits were submitted to the Custom Houses of Calcutta, Madras and Bombay for examination, and a member of the staff visited each place in order to demonstrate their utility and initiate practical tests of the same. On the receipt by Government of independent reports from these centres, the final proofs and correction of the Tables were carried out, and the newly compiled Technical Excise Manual completed which was begun last year. The value of the Reduction and Blending Tables being recognised, a much larger edition giving, without calculation, the data necessary for any bulk of spirit required to be reduced from any strength between 60 O. P. to 70 U. P. to any lower strength between the same limits has been in course of compilation and revision during the present year.

The requisite data for a report on the alleged increase in alcoholic strength in spirits stored in casks having been obtained a report on the same is now being prepared.

Potable Spirits.

During the past year, country spirits have been examined at the Central Excise Laboratory from the point of view of general quality, apparent defects in odour, flavour, colour or excessive sediment, for the presence of added substances capable of producing certain harmful effects alleged to be associated with use of the liquor or more generally, for harmful additions of any kind. Under the first heading certain Government distilleries regularly send samples for examination as a control of manufacture. Defects in odour, flavour or colour have been traced to impure water used in dilution, to the absorption of foreign substances from storage vessels or more rarely to errors in manufacture. Direct addition of drugs, etc., has proved almost non-occurrent in the samples as received, but means for effecting such addition at the moment of vend, have been definitely detected.

Important instances of the manipulation of country-spirit to represent so-called foreign spirit have also been dealt with.

The water used for diluting strong spirit in bonded warehouses has been under close examination, impregnation with sulphuretted hydrogen gas being a feature of several samples.

Manufacture of Country Spirits.

On the fermentation side, experimental fermentations have been conducted on samples of 'mahua' sent for examination; distillery washes have been analysed; the composition of 'Marcha' as a fermenting agent investigated; and illicit washes identified for police purposes. The enquiry into the serious contamination of spirit with copper salts, which obtains in certain parts of India, has been further prosecuted and evidence obtained that the cause is to be assigned not to the peculiar type of still employed but rather to certain constituents in the fermentative base (mahua) employed. Various other matters such as the addition of added sugar to toddy, the age at which toddy is to be considered unsuitable for use, and the artificial regeneration of flat beer have also involved experimental work.

Industrial Spirits.

With regard to industrial spirit, trials have been promoted of the type of engine most suitable in India for its utilisation as a motive power, and of the influence, if any, of the new denaturant recommended by the Director of this Laboratory for general adoption in India. Matters relating to the use of spirit methylated in the English fashion, and an abnormal case of caoutchoucined spirit have also been dealt with.

Scent.

Attention has been directed to the composition of country-made Eau-de-Cologne of which many samples submitted have proved to be made with the help of caoutchoucined spirit deprived in part of the legal proportion of caoutchoucine. This is almost invariably found to be the case when no maker's name appears on the bottle. The alcoholic strength of this commodity moreover shows the greatest possible variations between 60 U. P. and 60 O. P.

Drugs and narcotics—Hemp and drugs.

Mr. Hooper having observed that the cannabinol in Indian hemp, whether in the form of Ganja, Bhang or Charas, decreases with age, has devised a satisfactory method of determining their intoxicating power by taking the iodine value of the alcoholic extracts.

At Kasauli a large number of samples of charas, ganja and bhang have been investigated some for suspected adulteration, others for deterioration (destruction of these drugs is compulsory after a certain period of time unless they can be shown to be still active), and others again for comparative purposes, as being genuine samples specially supplied. Progress has also been made with an improved method of examination, in conjunction with physiological tests.

Opium.

A number of genuine or alleged adulterated samples of opium have been analysed at the Central Excise Laboratory as also a series of boiled or 'pukka' opiums with interesting results as to the extremely high percentage of morphine present, on occasion, in the latter.

Quinine.

The last reports of both Cinchona Departments record forward steps in the chemical selection of stock plants. In the Nilgiris a tree was found some little time ago to carry 9·56 per cent. of Sulphate of Quinine in its bark, and by propagation therefrom the Madras Cinchona Department has now a considerable supply of young plants. In Sikkim there has been accumulated a still larger supply of improved plants (selected hybrid No. 2) with a content of 6 per cent. The average annual yield in Sikkim of Quinine Sulphate had been increased from a previous 2·68 per cent. to 2·90 per cent. in 1907-08: and if only the latter part of the year reported on be considered the average yield was still higher.

Camphor, etc.

Mention was made in last year's report of Mr. Puran Singh's work on lævo-borneol or Ngai-camphor from *Blumea balsamifera*. Since then his report has been published. Ngai-camphor is in demand in the East as a drug: and it is now being ascertained if profit could be derived from its preparation in Burma. On distillation of *Blumea balsamifera* and also of other Blumeas, a volatile oil (under investigation) is obtained, which besides the camphor might be a source of profit.

Experiments have been undertaken by Mr. Kelway Bamber in Ceylon on the manufacture of papain from the papaya, and a preparation made which is more active than the plain evaporated juice.

Catechu.

Mr. Puran Singh's two larger reports on cutch were referred to by him in last year's report, section Forest Chemistry; they were not in the hands of the writers of the section of the report for 1907-08 on Industrial and Agricultural Chemistry, and therefore for completeness, mention is made of them here. Mr. Puran Singh has published three short papers in the

Indian Forester. He points out that the medicinal katha can be prepared from each of the three sub-species of *Acacia*, e.g., *A. Catechu*, *A. catechuoides* and *A. Sundra*, whereas up till now the first only has been used to supply it, the others furnishing the tanning extract, dark catechu or cutch.

A. catechuoides apparently yields the greatest amount of catechu tannin. He advocates the use of wood spirit for the manufacture of the extract.

Cattle foods.

It will be remembered that a few years ago an export trade was springing up in Red Rangoon beans, when it was discovered that these seeds during digestion produced prussic acid with consequences fatal according to the quantity eaten. Consequently the trade was arrested. Chemical work on the beans was carried out at the Imperial Institute, where a quantity of related work had already been done. The work on *Phaseolus lunatus* has been recorded in a very interesting form by Professor W. R. Dunstan and Dr. T. A. Henry and again together with the kindred work has been summed up by Drs. T. A. Henry and S. J. M. Auld. Glucosides which yield prussic acid on decomposition are apparently not uncommon in the vegetable kingdom where according to Professor Treub (Annales du jardin botanique de Buitenzorg, vi, 1907, pp. 79—106) they are not waste matter, but a form of stored food atoxic to the plant containing them, and though protective, doubtfully so primarily. Linseed, bitter cassava, the great millet, *Lotus arabicus*, Para rubber are all economic plants containing them; but they are not present in all parts or by any means at all times in several of the above. One of the results of this work most interesting economically is the observation that there are other races of *Phaseolus lunatus* besides the Red Rangoon bean, free or nearly free from a Cyanogenetic glucoside; and if these cannot be grown with commercial success in India, successful races might yet be evolved. Drs. Henry and Auld in summing up say, "it will be seen that the matter of the production of hydrocyanic acid by plants affects the utilisation of a considerable number of feeding stuffs. In all the well authenticated cases of poisoning by these products except those mentioned by Robertson and Wynne, it appears that they have been consumed in a condition in which the enzyme was capable of acting on the glucoside and liberating hydrocyanic acid. If, however, the fact now recorded regarding the occurrence of certain quantities of Cyanogenetic glucoside in linseed cake prove to be generally

true and if further investigation proves that the generally innocuous character of linseed cake is due to the fact that the Glucosidolytic enzyme originally present in the seeds is rendered inactive in the hot process of expressing the oil, this would seem to offer a simple method of rendering some at least of these materials suitable for use in feeding stuffs." The enzyme which accompanies Phaseolunatin in the beans of *Phaseolus lunatus*, cassava and linseed, is rendered inactive if heated to 60° C.

Manures.

Mr. A. A. Meggitt has examined fish manure procurable in Poona. Mr. Main has published a partial analysis of manures used at Dharwar.

A saline soil from Mirpurkhas was examined by Mr. Meggitt. It is described as occurring on the site of an old village and was being largely used with beneficial result as a top-dressing for crops. The presence of about 1 per cent. of calcium and potassium nitrates was held by Mr. Meggitt to account for its beneficial effect.

Mr. W. H. Harrison has described the origin, and method of use as a manure, of a manurial earth which is used in the Kistna Delta. It is collected from the sites of old villages. It may be looked upon as an earth rich in Potash and Phosphoric acid, but contains only about 0·1 per cent. of nitrogen. The amount of this earth now available is very limited.

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FOREST CHEMISTRY.

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The following are the principal investigations conducted by the Chemical Department of the Imperial Forest Research Institute during the year under report :—

Mangrove Tannin Extract.

The investigation into the manufacture of a suitable tannin extract from the highly coloured bark of Mangrove (*Rhizophora mucronata*) which occupied the Forest Chemist for the greater part of the year, was undertaken at the instance of the Government of Burma. The object of the investigation was to work out a commercial process by which the mangrove extract manufactured at the Government Tannin Factory, Rangoon, could be made as similar as possible to Borneo Cutch (or the mangrove tannin extract manufactured in Borneo). The Borneo Cutch yields soft light buff coloured leather and is sold at remunerative prices, while the Rangoon mangrove extract produces harsh leather of a dark brownish colour with a reddish tint. This objectionable colour makes the Rangoon extract quite unacceptable to tanners.

The chief result of this investigation has been the successful decolorization of the mangrove extract on a small scale in the laboratory. A simple process for the decolorization of the extract has been worked out by the Forest Chemist, and so far as this could be done in the laboratory, the conditions for the manufacture of mangrove extract in a marketable form have been determined. It was supposed that the objectionable colour hitherto obtained from mangrove bark was the result of heat during

the concentration of the tannin liquors, but it has been shown that the colour is inherent in the bark. There is no doubt, however, that the colour is somewhat intensified during concentration by the action of slightly soluble tannin and the pectic and resinous substances, which remain suspended in the liquors and which must be separated by clarification before concentration. The new process devised by the Forest Chemist, besides being much cheaper than the sodium meta-bisulphite process recommended some time back by Professor Dunstan, can efficiently decolorise the tannin liquors during the removal of the above mentioned impurities without appreciably diminishing the percentage of useful tannic principles in the finished extract. The method has been tried several times on a laboratory scale under conditions approximating as much as possible to those obtaining in a modern extract factory; and the mangrove extract obtained has been pronounced to be lighter in colour than Borneo Cutch. The extract is moreover soluble in cold water, and has a high strength in tannin (about 80—82 per cent. calculated on dry material). Further it has been shown by comparative small scale tanning trials carried out in the laboratory that the extract prepared by the new process yields soft pliable pale buff coloured leather which has been pronounced by Messrs. Cooper Allen & Co., of Cawnpore, to be decidedly lighter in colour than that tanned with a standard specimen of Borneo Cutch received from the Imperial Institute, London. In addition to the above experiments a series of tanning trials has been made with mixed tanning extracts, and it has been shown that great improvement can be effected in the tanning properties of mangrove bark by mixing it with a small proportion of Jack wood as suggested by Mr. Hamilton, and that the colour imparted to the leather tanned with such a mixed extract or with pure mangrove extract as obtained by the new process is further considerably diminished and rendered more even by finishing off in a bath of myrabolan. The details of all these experiments are given in the Forest Chemist's Report on the Decolorization of Mangrove Extract submitted to the Government of Burma. Further investigation has been postponed till a trial of the process mentioned above is made on a large scale by working the Rangoon factory, from where it is proposed to send samples of the manufactured extracts to different European firms for commercial valuation.

Sál Tannin Extract.

The new process referred to above has also been applied with success to the decolorization of tannin liquors from the bark of the Sál tree (*Shorea robusta*). A

series of tanning trials similar to those mentioned above have shown that the extract of young Sál bark as manufactured by the new process is completely free from the defects which have hitherto characterised experiments made with Sál bark. The extract of the old Sál bark, however, was found to impart a faint reddish tint to the leather tanned with it. This reddish tint can be successfully removed by mixing the extract with lighter coloured materials such as babul or myrabolan. Thus it ought to be possible to manufacture suitable tannin extracts from both old and young Sál bark, of which abundant quantities are available in Northern India as waste products. Samples of Sál extract will also be manufactured at the Rangoon Factory and sent to Europe for valuation.

Forest Oil-seeds.

About 150 different samples of Forest oil-yielding seeds of about 40 different forest species received from different parts of India through the Imperial Forest Economist have been under examination. The oil value of these seeds has been determined. An analytical examination of both the seeds and the oils obtained from them by pressure is now being made with the object of ascertaining their possible commercial uses.

Distillation of Blumea balsamifera DC.

The final report on the distillation of *Blumea balsamifera* on a large scale could not be completed this year, because it was found that the ordinary form of condenser does not give satisfactory results in this distillation. Various trials have had to be made to so alter the form of the condenser as to suit the special case of the distillation of the Ngai camphor. Finally a suitable form of condenser has been designed, which affording as it does a large surface for the condensation of the products of distillation readily condenses the latter, from which the solid camphor can be easily removed after the distillation has been accomplished. When the distillation was conducted with water with an ordinary tubular or warm condenser, camphor oil only was obtained from which it was found extremely difficult to crystallize out the solid camphor. Even with the present condenser camphor oil with a relatively small proportion of the solid camphor is obtained when the distillation is conducted rapidly or at a high temperature. The conditions of the steam distillation as now carried on in the laboratory are such that most of the camphor vapours from the still are deposited as solid camphor, and only a small proportion is condensed as camphor oil of a yellowish or brownish black colour. Determinations of the specific gravity and specific rotatory power of the thoroughly dried (not sublimed) camphor show

that like the refined Ngai camphor of China it consists almost entirely of L.-borneol. It will thus be seen that the conditions of the distillation as now conducted are normal, and do not allow the products resulting from the decomposition of the plant material, to become mixed with the solid camphor as deposited in the condenser. The specific gravity of our camphor is about 1·016 at 27° C., and its specific rotatory power $[a]\frac{28}{D} = -39° 10'$. So far the quantity of camphor oil obtained is insufficient for the determination of its composition and possible uses. It is hoped that the Economist and the Chemist will be able to submit a final report on the subject by the middle of next year.

Bleaching of coloured Match woods.

The enquiry into the utilization of some Indian coloured woods for the manufacture of match sticks was undertaken at the instance of the Imperial Forest Economist, who pointed out that the bleaching of coloured woods, if it could be done by a cheap method, would be of great importance to the match industry in India. Samples of match splints manufactured from 13 Indian coloured woods which Mr. Troup had selected as suitable for the manufacture of match sticks were received from the Economic Branch of the Forest Research Institute. Besides the Japanese process of bleaching match sticks with sulphur dioxide fumes, two other processes were carefully enquired into. These were :—(1) immersion in a bath of chlorine bleaching liquor and subsequent washing with dilute sulphuric acid and water, (2) immersion in a bath of permanganate of potash (a 2 per cent. solution) and subsequent treatment of the splints with a weak sulphurous acid solution. It was shown by a series of comparative bleaching experiments carried out in the laboratory that different woods require different treatment to be satisfactorily bleached. The bleaching process most generally applicable to the 13 different coloured woods referred to above is the chloride of lime process. It was further shown that if perfectly white colour is not required, the simplest and speediest method of bleaching is the permanganate process. The latter is not as widely applicable as the chlorine process, but in cases where it can be applied with success, it should be preferred to the chlorine and sulphur dioxide processes for the reason that it does not in any way injure the structure of the splints. Sulphur fumes as used by the Japanese were found to have a powerful disintegrating action on most of these woods, although in two cases much more satisfactory results were obtained by the Japanese process than by the other two. As a result of the above

experiments a short suggestive Note on the Bleaching of Indian coloured woods was submitted to the President of the Imperial Forest Research Institute. It will be published as an Appendix to Mr. Troup's Memoir on the Match Industry in India.

Clarification of Indian Colophony.

At the instance of the Conservator of Forests, Western Circle, United Provinces, an enquiry was started towards the close of the year into the clarification of Indian Colophony. It is stated that dark coloured colophony is clarified in France by means of common salt. The dark coloured Indian colophony has been treated with common salt, crystalline alum and various other clarifying and decolorizing agents. So far crystalline alum has yielded the best results, but the Forest Chemist is not yet satisfied that the question of the best method of clarifying Indian colophony has been finally settled, although dark coloured colophony when clarified by means of alum becomes fairly light coloured. Since this question is of great economic importance, the enquiry into it will be continued with a view to lighten the colour of the colophony to the extent desired by consumers of the article.

Calorific power of some Indian Woods.

The exact calorific power of about 80 different Indian woods has been carefully determined with a view to their application as fuel.

The Lac Industry.

Lac collection in India is rather a complex industry. A detailed enquiry is being conducted as to the normal conditions under which lac should be collected and washed for the removal of mechanical impurities and puparial remains. The object of the enquiry is to make the lac industry of India as simple as possible.

Shellac manufacture and Lac Analysis.

Fairly large quantities of crude lac derived from Kusum (*Schleichera trijuga*) and from Palas (*Butea frondosa*) and also a small amount of coagulated (Block) lac from Raipur have been extracted with wood spirit according to the Forest Chemist's new process. It has been shown by preliminary analyses of the samples of crude lac extracted that the percentage of the finished extract obtained is in general slightly larger than the percentage of pure lac resin contained in the original material. This is of course due to the simultaneous extraction from the crude lac of that portion of lac wax, which is soluble in boiling hot methyl alcohol and also to the insufficient drying of the extracts. The fact that the percentage of the finished extract even when the influence of these

that like the refined Ngai camphor of China it consists almost entirely of L.-borneol. It will thus be seen that the conditions of the distillation as now conducted are normal, and do not allow the products resulting from the decomposition of the plant material, to become mixed with the solid camphor as deposited in the condenser. The specific gravity of our camphor is about 1·016 at 27° C., and its specific rotatory power $[a]\frac{28}{D} = -39° 10'$. So far the quantity of camphor oil obtained is insufficient for the determination of its composition and possible uses. It is hoped that the Economist and the Chemist will be able to submit a final report on the subject by the middle of next year.

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factors is taken into account has never been appreciably smaller than that of the pure resin in the raw material leaves no room for doubt that the new process of shellac manufacture is almost perfect, at least so far as the yield is concerned.

Further a complete analytical examination of the shellacs prepared from the three different qualities of crude lac has been made, and the results compared with those obtained from the analysis of a pure sample of shellac (free from arsenic and rosin) manufactured at Mirzapur. The results are as follows :—

	Moisture and other volatile matter.	Matter insoluble in hot alcohol.	Acid number.	Saponification number.	Ester number.	Iodine absorption (Hubl) after 18 hours' action.
	Per cent.	Per cent.				Per cent.
Fresh Laboratory samples. Shellac from Kusum lac.	2·7	0·7	61·1	234·3	173·2	9·6
Fresh Laboratory samples. Shellac from Palas lac.	3·3	0·8	60·8	235·9	175·1	9·3
Fresh Laboratory samples. Shellac from Block lac.	3·9	1·1	63·1	235·0	171·9	8·2
Mirzapur Factory Shellac.	2·0	0·6	64·4	273·3	172·9	8·6

The purity of the shellac prepared by the new process has further been tested by an admirable process of shellac analysis recently proposed by H. Endemann with the following results :—

	Shellac prepared in the Laboratory from			Mirzapur Factory Shellac.
	Kusum.	Palas.	Block.	
Endemann number (or percentage of non-condensable resins).	8·43	7·96	9·16	7·39

According to Endemann a good pure shellac contains only about 8 per cent. of non-condensable resins and a quantity over this indicates either undesirable impurities or some hard resinous matter which detracts from

the quality of shellac. It would thus appear that shellac from block lac contains about 1 per cent. of this undesirable hard resinous matter. An investigation into the nature of this constituent is now in hand with a view to eliminate it from shellac manufactured from block lac.

From all the above results it is concluded that the different Laboratory extracts are all of a nearly uniform quality and character and compare very favourably with the best shellac of the market, but in the case of shellac from coagulated lac, a larger number of experiments is required to be made to substantiate this conclusion. In order to confirm the value of the shellac prepared in the Laboratory as indicated by chemical analysis, a large number of samples have been sent to well known American and British firms dealing in shellac for practical trials.

In connection with the chemical examination of shellac a determination has been made of the analytical constants of absolutely pure lac resin* which have not hitherto been recorded. Acid number, 59·2; Saponification number, 225·5; Ester number, 166·3; Iodine absorption (Hübl) after 18 hours' action, 6·3 per cent. All these figures, notably the Iodine value, are lower than those generally obtained for shellac. This is explained by the absence of lac wax in the pure resin. The determination of the Iodine value of the same sample of lac resin after melting gave a slightly lower figure, thus showing that melting of lac resin besides bringing about other changes tends to increase the amount of that portion of the resin which is only slightly soluble in cold alcohol. This conclusion is confirmed by a comparison of the Iodine figures for the shellac prepared in the Laboratory (which was dried only by a gentle heat) and for the factory shellac manufactured by repeated melting. The same conclusion has further been substantiated by determining the relative solubility of these shellacs in cold alcohol after making due allowance for the amounts of wax contained in each. A full discussion of all the above results will be found in the writer's Chapter on the Chemistry of Lac in Mr. Stebbing's Note on Lac (2nd Revised edition). A short Note on the Analytical Constant of pure Shellac and Lac Resin is also under preparation and will be shortly communicated through the President of the Imperial Forest Research Institute to the Journal of the Society of Chemical Industry.

* The lac resin examined was prepared from crude kusum lac. It was completely freed from all traces of wax and red-colouring matter, and thoroughly dried without melting. The inherent yellow-colouring matter (erythrolaccin), however, was not removed from it.

Reports and Publications.

PURAN SINGH .	. Note on the Manufacture of Ngai Camphor.
DO. .	. A Note on the Manufacture of Shellac (The Note also deals with the utilisation of coagulated lac).
DO. .	. A Chemical Investigation of the Constituents of Burmese Varnish (*Melanorrhœa usitata* sap).
DO. .	. A Report on the Decolorization of Mangrove bark tannin extract (not printed).
DO. .	Supplementary Report on the Decolorization of Sál bark extract (not printed).

ASTRONOMY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

Solar Physics.—Researches in solar physics are carried on under the direct control of the Government of India at Kodaikanal, the Director being Mr. Michie Smith and the Assistant-Director Mr. J. Evershed. The chief instruments are :—

(*a*) A spectroheliograph made by the Cambridge Scientific Instrument Company, the object of which is that of making photographs of the sun using the light emitted by one chemical element only. In this apparatus a stationary image of the sun is made by a 12-inch triple-achromatic lens of 20-foot focus, fed by an 18-inch Foucault siderostat. Close up to the image and somewhat longer than its diameter is the narrow vertical slit of a spectroscope arranged in such a manner that the light which has passed horizontally through the collimating lens shall be deflected through two right angles by two prisms and a mirror, and shall so emerge from the camera lens parallel to its original direction. This light then falls upon another vertical slit which can be adjusted in such a position as to allow light of any

desired wave length to pass through. In the Kodaikanal spectroheliograph the collimating and camera lenses, each of 5-inch aperture and 6-foot focal length, together with the prisms and slits, are attached to a rigid framework, while immediately in contact with the slit last described is a stationary photographic plate within a fixed camera. The rigid framework is capable of motion in a horizontal plane in such a manner that the primary slit may pass uniformly across the image of the sun while the secondary slit will move at an equal rate across the sensitised plate; and as in each position an image will be formed at the second slit by light of the desired wave length and no other light can emerge, the result of the movement upon the plate is a complete image of the sun in monochromatic light. At present the H and K lines of calcium are largely used on account of the convenience afforded by the width of their absorption shading and the fact that the centre of the dark line is frequently 'reversed', *i.e.*, is bright instead of dark, indicating that the calcium vapour is abnormally hot in the higher levels of the solar envelope. A photograph so obtained shows bright clouds—called 'flocculi'—of calcium vapour scattered about over the sun and gives a large amount of information that is not otherwise obtainable. Further, by causing the slits to move more slowly the exposure may be lengthened sufficiently to give photographs of the 'prominences' projecting from the sun's margin.

(*b*) Two 6-inch refractors, with one of which an Evershed spectroscope has been used since November 1904. These are used for visual examination of the sun and for spectroscopic study of spots and prominences.

(*c*) A spectrograph consisting of an 11-inch polar siderostat with a 6-inch Grubb lens of 40-foot focus. This is used with a 4-inch concave grating of 10-foot focus mounted on Rowland's plan, or a parabolic grating collimated to cure astigmatism, or a plane grating with collimator and camera lenses of 8-foot focus. A powerful spectrograph has also been erected in the spectroheliograph room, using a 3-inch plane grating. It is employed in photographing the ultra-violet region in spot spectra and in studies on the line of sight movement of the chromospheric gases. Both spectrographs have been fitted with special

occulting shutters for regulating exposures in spot spectrum work.

(*d*) A photoheliograph by Dallmeyer. With this a photograph of the sun in ordinary light is made daily when possible. Originals are sent to Greenwich for the use of the Solar Physics Committee for those days for which photographs are not available from Greenwich or Dehra Dun.

(*e*) An 18-inch silver-on-glass parabolic mirror (the property of the Assistant Director) has been mounted in front of the 12-inch photovisual lens in the spectroheliograph building. It has been found to be very efficient for photographing spectra, particularly in the violet region. The mirror is mounted in a box upon rollers in such a manner that during the operation of the spectroheliograph and associated instruments it may be pushed to one side so as not to obstruct the light incident upon the 12-inch lens. To bring it into use for photographing spot spectra, etc., the mirror and its mounting are run into position in front of the lens, with the centre of the mirror in the axis of the beam of light coming from the heliostat, an operation requiring a few seconds only.

A pier is under construction near the mirror to carry a powerful spectrograph and other apparatus used for investigating movements in the line of sight in sunspots.

(*f*) A new grating by Michelson has been received from the Cambridge Scientific Instrument Company and a considerable amount of experimental work has been done to ascertain the best methods of using it. It has been found that a large proportion of light is concentrated in the higher orders of spectra, so that the grating will be very efficient for photographing spot spectra under high dispersion. The resolution obtained with this grating is larger than that of any of the gratings previously employed.

(*g*) A Littrow spectroheliograph for photographing the sun's disc in Hα light has been partly constructed. Completion has been delayed pending the receipt of a suitable collimating lens and grating.

2. **Routine work.**—In addition to the use of the spectroheliograph and photoheliograph the routine work includes visual examination of sunspots and faculæ, observations of widened and displaced lines in sunspot

spectra and spectroscopic observations of prominences. A monthly article describing the solar activity is contributed to the "Monthly Weather Review," while for more technical purposes bulletins and memoirs of the observatory are issued. Of the former 17 have appeared, while of the latter the first has recently been published.

3. Photographs of spot spectra are now made in which different exposures are given for the spot and for the adjacent photosphere so that equally dense images of both spectra may be obtained: these are then copied and enlarged with a special apparatus so as to bring out clearly the characteristic features of the spot spectrum. Arrangements have also been made by which the slit of the parabolic grating spectroscope can be replaced by a negative lens and enlarged images of sunspots obtained on a scale of about one metre to the sun's diameter.

4. **The solar constant.**—Progress has been made in developing the method for detecting variations in the solar constant by comparisons of the moon and stars, and a small observatory with revolving canvas roof has been erected for facilitating the work. It has been found advantageous to place the convex quartz reflector at a distance of 75 feet from the photographic apparatus: the starlike image of the moon can then be photographed under exactly the same conditions as the real stars used in the comparisons.

5. **Spectroscopic investigations. Comparison of limb and centre of disc.**—A considerable number of plates of the solar spectrum in which the limb and centre of the disc are compared have been measured with a view to determining the cause of the displacements of the lines at the limb discovered by Halm. The displacements are found in general to be proportional to wave length but appear to differ widely in different lines. The subject is one of great importance in solar physics, but it has been considered advisable to defer measuring more plates until new ones of higher dispersion have been secured with the Michelson grating.

A comparison between Kayser's wave-lengths of certain iron lines in the spectrum of the arc and Rowland's wave-lengths of the same lines in the sun has been made for the purpose of estimating pressure in the reversing layer. This has been rendered possible by the publication of Humphreys' and Duffield's tables of the displacements which spectrum lines undergo when the vapours of the elements are subjected to pressure in the arc. The results indicate a pressure in the reversing layer not exceeding one atmosphere. A critical discussion of this and other estimates of pressure in the sun is given in Bulletin No. XVIII of this observatory.

6. **Pressure in sunspots.**—A number of high dispersion plates of selected regions in sunspot spectra were secured early in the year for the purpose of ascertaining whether any pressure effects could be detected in spots by comparison of certain nickel and iron lines which are largely displaced by pressure with other lines which are but little affected. The plates have been measured and reduced and the results published in Memoir No. 1 of this observatory. It is considered that a small pressure effect can be traced and that the pressure in the umbræ of spots is about one-third of an atmosphere less than that in the surrounding faculous region.

7. **Radial motion in spots.**—The plates obtained for the estimation of pressure in spots have revealed a new and important fact concerning the movements taking place within the penumbral areas of spots, and a large amount of work has been done in determining the nature of the movement observed. Preliminary results of a discussion of about 150 plates have been published in Bulletin No. XV of this observatory; it is there shown that the motion in every spot investigated consists of a radial outflow of the gases of the reversing layer parallel to the solar surface, and accelerating from the centre of the umbræ, where the motion is imperceptible, to the outer limits of the penumbræ, where velocities of the order of 2 km. per second are measured in the case of spots having a diameter of about 30″.

Recent results have indicated that there is a small component of motion in a direction at right angles to the radial motion, which proves that the gases are moving outwards in curved spirals, equivalent to a relatively slow rotation of the whole spot system. This movement is of the order of 0·3 km. per second at a distance of 15″ from the spot centre, and appears to be of opposite sign in the two hemispheres of the sun, the direction being contrary to the clock in the northern hemisphere and with it in the southern, as seen in projection upon the sun's disc.

The motion displacements of the lines H_3 and K_3 of calcium vapour over spots are found to be in the opposite direction to that of the lines of the gases in the reversing layer. This indicates that the gases of the higher chromosphere, unlike those of the reversing layer, are flowing inwards towards the spot centre.

All of the above results have an important bearing on Hale's discovery of the Zeeman effect in sunspot spectra and it is believed that much new light may be thrown on the whole problem of sunspots by these investigations.

8. The observatory is now co-operating with the "International Union for Solar Research."

9. There is also at Poona, under the Government of Bombay, the Takhtasingji Observatory, where research in solar physics is carried on by Mr. Naegamvala. The chief portions of the equipment are :—

(*a*) A Foucault siderostat with an 8-inch image lens for use with a spectroscope which is now being improved in England.

(*b*) An equatorial refractor with a Cooke 6-inch triple photovisual lens. This is provided with two 45° objective prisms, and a prominence spectroscope with a Thorpe transmission grating has been constructed locally for attachment to it.

(*c*) An equatorial reflector with a 20-inch mirror by Common. A focal plane ultraviolet spectrograph is now in complete adjustment and it is proposed to employ it for stellar spectra.

The twelve 'most widened' lines in sunspot spectra are observed daily and the results forwarded to Sir Norman Lockyer, and a close agreement is maintained with the observations made at South Kensington. The observatory is also co-operating with the International Union for Solar Research, and is observing the region 5,300 to 5,500 for all lines affected in sunspots.

10. **Solar Radiation.**—Of the three Angström pyrheliometers previously in use in Simla one was taken in January 1908 to the Solar Physics Observatory at Kodaikanal for employment there. The operation of these instruments in Simla and Kodaikanal is, however, difficult and intermittent on account of cloud and atmospheric dust.

METEOROLOGY.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,

Director-General of Observatories.

The Upper Air.—The conditions of temperature and humidity in the upper air have during the last ten years formed a subject of experimental enquiry in Europe and for a shorter period in America. The investigation originated in the work of M. Teisserenc de Bort who from his observatory at Trappes, near Paris, began in 1899 to liberate balloons of varnished paper with recording instruments attached, and offered rewards for the return of the instruments when found on descent. These

balloons were sent up in all types of weather, and their records afforded evidence of the air conditions prevailing up to great heights. It had been known for many years from the experiences of balloonists that the true temperature of the air (*i.e.*, of a body exposed to the air and shielded from radiation) decreased from the ground surface upwards, and the average rate of decrease in unsaturated air, observed up to a height of about 8 kilometres by manned balloons, was found to be about 0·6°C. per 100 m., a rate which agreed with the results of Lord Kelvin's calculations for an atmosphere where convective currents were active. It was shewn by Teisserenc de Bort, however, that this temperature gradient was not continuous when great heights were reached, and that at a certain point, the mean level of which varied at the same geographical position according to the weather from about 10 km. to 13 km., a stratum of air was encountered in which the temperature assumed an almost constant value up to the highest levels reached by his balloons. This condition was unexpected and surprising, and appeared to put a limit at once to that part of the atmosphere in which convective movements can take place, and thus to indicate a probable limit to the layer of air in which those actions proceed which determine the character of weather. The observations of Teisserenc de Bort have in recent years been verified in America, in many parts of Europe, in Africa, and in the sea areas of northern latitudes. The field of investigations has since assumed such proportions that an International Commission has for some years arranged monthly dates for regular ascents from all countries participating, including series of ascents two or three times a year lasting over several consecutive days. Thus in 1907, from the 22nd to the 27th July, balloon or kite ascents were made at seven stations in Great Britain, about twenty-four in other parts of Europe, four in Asia, one in Africa and four in America; while in addition the navies of Germany, Italy and France and a private French yacht took part in the work over the sea areas from Iceland to the south of the Azores. In 1908 a similar series was organised, and for 1909 December has been chosen as the month for the more elaborate work of the year. As a result of the balloon experiments since 1899 it appears :—

(*i*) That the region of isothermal conditions has its lower boundary at heights varying from 8 km. to 17 km. or more, and that it may shew considerable variation of level from place to place at the same time over such a comparatively small area as the British Isles.

(*ii*) That its temperature lies between −40°C. and −70°C., but within these limits varies considerably at a given time over comparatively small areas.

(*iii*) That the lower limit lies nearer the earth in regions of cyclonic weather than in those of anticyclones, for the same latitude.

(*iv*) That the region lies at greater heights near the equator than in higher latitudes and appears to have there a lower temperature.

The phenomenon has been examined mathematically by Gold, who on certain assumptions shews that such a limit to the decrease of temperature is to be expected in an atmosphere such as the earth's, where the heat from the sun, the radiation from the ground and the absorbing properties of the air are taken into account.

2. Investigation has proceeded far enough to shew that important results may be expected from a further knowledge of the isothermal region and the air strata below it; and, with a view to include India in the increasing area over which experiments are being made, the meteorological department began in 1908 to devise instruments and methods, suitable to the climate and within its financial resources, for carrying on aerial work similar in its more general lines to that which is being done elsewhere. A short description of the preliminary part of the work in India was given in the report for last year. Since then the instruments used have been improved in detail to overcome defects noticed in their records, and the methods of liberating the balloons safely in a wind have been simplified. The balloons have to reach heights where there is only a small proportion of the atmosphere left, and consequently are light and very fragile, the more so as rubber—the usual material for such balloons in Europe—has failed to prove serviceable in India, and we have been forced to adopt open non-expanding balloons of guttapercha tissue. It was found in 1908 practically impossible to liberate such a balloon except in a calm, since in a wind it was destroyed in the act of letting out from the hand the 100 feet of cord which had to be used to separate it from the instrument for the purpose of avoiding vibration in the records. To get over this difficulty of damage to the balloon a device has been adopted by which the instrument can be tied up close to the balloon at liberation (the whole being therefore capable of remaining behind a shelter until free of the hand and safe) and after reaching a height of about 50 metres, *i.e.* when clear of all trees, can unwind its long separating cord. The

balloons were sent up in all types of weather, and their records afforded evidence of the air conditions prevailing up to great heights. It had been known for many years from the experiences of balloonists that the true temperature of the air (*i.e.*, of a body exposed to the air and shielded from radiation) decreased from the ground surface upwards, and the average rate of decrease in unsaturated air, observed up to a height of about 8 kilometres by manned balloons, was found to be about 0·6°C. per 100 m., a rate which agreed with the results of Lord Kelvin's calculations for an atmosphere where convective currents were active. It was shewn by Teisserenc de Bort, however, that this temperature gradient was not continuous when great heights were reached, and that at a certain point, the mean level of which varied at the same geographical position according to the weather from about 10 km. to 13 km., a stratum of air was encountered in which the temperature assumed an almost constant value up to the highest levels reached by his balloons. This condition was unexpected and surprising, and appeared to put a limit at once to that part of the atmosphere in which convective movements can take place, and thus to indicate a probable limit to the layer of air in which those actions proceed which determine the character of weather. The observations of Teisserenc de Bort have in recent years been verified in America, in many parts of Europe, in Africa, and in the sea areas of northern latitudes. The field of investigations has since assumed such proportions that an International Commission has for some years arranged monthly dates for regular ascents from all countries participating, including series of ascents two or three times a year lasting over several consecutive days. Thus in 1907, from the 22nd to the 27th July, balloon or kite ascents were made at seven stations in Great Britain, about twenty-four in other parts of Europe, four in Asia, one in Africa and four in America; while in addition the navies of Germany, Italy and France and a private French yacht took part in the work over the sea areas from Iceland to the south of the Azores. In 1908 a similar series was organised, and for 1909 December has been chosen as the month for the more elaborate work of the year. As a result of the balloon experiments since 1899 it appears :—

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(*iv*) That the region lies at greater heights near the equator than in higher latitudes and appears to have there a lower temperature.

The phenomenon has been examined mathematically by Gold, who on certain assumptions shews that such a limit to the decrease of temperature is to be expected in an atmosphere such as the earth's, where the heat from the sun, the radiation from the ground and the absorbing properties of the air are taken into account.

2. Investigation has proceeded far enough to shew that important results may be expected from a further knowledge of the isothermal region and the air strata below it; and, with a view to include India in the increasing area over which experiments are being made, the meteorological department began in 1908 to devise instruments and methods, suitable to the climate and within its financial resources, for carrying on aerial work similar in its more general lines to that which is being done elsewhere. A short description of the preliminary part of the work in India was given in the report for last year. Since then the instruments used have been improved in detail to overcome defects noticed in their records, and the methods of liberating the balloons safely in a wind have been simplified. The balloons have to reach heights where there is only a small proportion of the atmosphere left, and consequently are light and very fragile, the more so as rubber—the usual material for such balloons in Europe—has failed to prove serviceable in India, and we have been forced to adopt open non-expanding balloons of guttapercha tissue. It was found in 1908 practically impossible to liberate such a balloon except in a calm, since in a wind it was destroyed in the act of letting out from the hand the 100 feet of cord which had to be used to separate it from the instrument for the purpose of avoiding vibration in the records. To get over this difficulty of damage to the balloon a device has been adopted by which the instrument can be tied up close to the balloon at liberation (the whole being therefore capable of remaining behind a shelter until free of the hand and safe) and after reaching a height of about 50 metres, *i.e.* when clear of all trees, can unwind its long separating cord. The

arrangement consists of a capillary tube containing air and a single drop of strong sulphuric acid, which is exuded after any pre-arranged fall of air pressure and, by corroding and breaking the shorter string connecting the instrument and balloon, allows the longer string to uncoil slowly from a paper bobbin smeared with viscous material. The cost of this arrangement is only a few annas, while it offers the further advantage that the weight carried by the balloon is less than before, for the releasing apparatus, of weight about 10 grams, falls to the ground when release occurs, while the long connecting cord can be made of fine cotton instead of the coarse string which was previously necessary when the whole pull of the balloon had to be taken by it during liberation from the hand. The results obtained in India in 1908 will shortly be published in detail; they shew among other things that the isothermal region was reached in September at a height of from 14 to 16 km, and that temperature there lay between —55°C. and —65°C. These heights are considerably greater than are generally found in Europe but the temperatures are approximately the same.

3. It is considered that the department is now in a position to undertake a useful part in the international work, and accordingly an effort will be made in December next to liberate instruments on all the days appointed by the commission. Further it is hoped that arrangements will be completed for a project to send off an instrument on every second or third day throughout the whole of 1910 with a view especially to the bearing of the records on our knowledge of Indian weather.

4. Electrical Condition of the Atmosphere.—As stated in last year's report an investigation was undertaken in order to find the electrical condition of rain during thunderstorms. The results have now been discussed and presented to the Royal Society in a paper recently published in its transactions. The following is a short resumé of the paper.

5. The apparatus employed was contained in a hut and in the roof of this was an opening through which the rain fell, being caught in a vessel which was carefully insulated. An electrometer attached to this vessel recorded automatically every two minutes the electricity which had entered the vessel with the rain; an automatic raingauge also was employed to register the quantity of water which fell in each interval. During the course of a rainstorm the quantity of water which fell and the charge which it carried was thus recorded every two minutes; and it was found that the rain of thunderstorm is highly electrified, the

charges being sometimes positive and sometimes negative. As a rule falls of negative and positively charged rain do not rapidly alternate, but the rain during one period of the storm is positively charged and during another negatively charged. One interesting result, which has an important bearing on the theory of the cause of electricity of thunderstorms, is that the heavy rain at the centre of a storm is always positively charged, and that negative electricity is usually associated with light rain.

The charges carried by rain are sometimes very large, on one occasion charges as high as 20 electrostatic units per cubic centimetre of water being measured; in other words, assuming that the rain drops were of a medium size, say, two millimetres in diameter, the potential of each drop would have been 240 volts.

The rain not associated with thunderstorms was found to be not so highly charged, and after the monsoon had well set in it was often impossible to detect any appreciable electricity. It is probable, however, that if apparatus designed to measure very small electrical charges had been employed some charge would have been detected on all rain.

6. In order to determine whether a storm was associated with lightning discharges or not the following well known expedient was employed. A long insulated wire is suspended in the air and one end connected to earth through a coherer similar to those used for wireless telegraphy; each lightning discharge sends out electric waves and these impinging on the insulated wire connected to the coherer cause a record to be made on a strip of paper. Thus every dot on the paper indicates a lightning discharge within a distance of about two miles of the observatory.

7. As no satisfactory explanation of the large generation of electricity in thunderstorms had been given, experiments were made with the object of investigating, as far as possible in the laboratory, the processes in action in thunderstorms, and so determining, if possible, the source of the electricity. After a number of experiments had been made on the mixing of air under different physical conditions with negative results, the electrical effects connected with the breaking of drops of water were examined. Some years ago it had been shown that when drops of pure water fall upon any object and splash, a separation of electricity takes place, the water becoming positively charged and the surrounding air negatively. It was also known that a large amount of breaking up of rain drops by currents of air must take place in a thunderstorm and it therefore appeared desirable to examine the electrical

effects of such a process. Experiments soon showed that there is a considerable separation of electricity when water drops are broken up by passing through the air and it remained to investigate whether the conditions in a thunderstorm are such as to cause results of sufficient magnitude.

8. It would appear that two conditions would be necessary for the manufacture of large charges :—

(1) there must be a considerable supply of water in the form of drops;

(2) the drops must be frequently broken up.

Now it is well known that in thunderstorms there are large ascending currents of air, and these produce by condensation large quantities of water; for as the damp air rises it is cooled by expansion and cannot hold all the water that it contained as vapour. It was also known that the small drops of water which form Scotch mist fall only slowly towards the ground, while every size of drop has a definite rate of fall through still air which it cannot exceed : and further that no drop of water having a larger diameter than half a centimetre can fall through air without breaking up into smaller drops. Thus water cannot fall through still air at a greater rate than drops of half a centimetre in diameter: for all smaller drops fall more slowly, and all larger drops quickly break up : this velocity has been found to be about eight metres a second. It follows that if the air is ascending at a velocity of eight metres a second no drops of water can possibly pass down through it to the ground.

9. It is a well established fact that ascending columns of air exceeding 8 metres a second often occur in thunderstorms and near the head of these columns there must be a great accumulation of water in the form of drops which are continually going through the cyclic process of growing from small into large drops which are broken up by the air current. Every time a drop breaks a separation of electricity takes place, the water receiving a positive charge and the air a corresponding amount of negative electricity : the positively charged water remains behind, but the negative electricity is carried away by the air and is rapidly absorbed by the cloud particles, the cloud thus becoming highly charged with negative electricity. At the top of each ascending current there will accordingly be a large separation of electricity which under certain conditions may give rise to all the electrical phenomena connected with thunderstorms.

10. After the publication of the results obtained it was considered desirable that measurements should be continued for another rainy season at least; and on the removal of the Office to the Yarrows, the apparatus was set up in the new compound; since that time, it has been in constant use. Practically the whole precipitation since May 1908 has been investigated, and although the results obtained during the monsoon of 1909 have not been worked out in full detail they appear to corroborate those found during the previous year.

The apparatus for recording the electrical potential gradient in the atmosphere has worked satisfactorily, and the abundant materials which have been collected are now being discussed.

11. Apparatus has been designed and is at present under construction for obtaining an automatic record of the earth-air current of electricity with the object of throwing light on several questions relating to the maintenance of the earth's permanent negative charge.

12. **Vertical pressure differences.**—If certain assumptions are made it is possible from two readings of the barometer taken simultaneously at the top and bottom of a column of air to determine the mean density of the air between the two stations and thence the mean temperature of the column. On these lines the physical changes in the air over Kashmir are being examined, but the facts so far obtained are very complicated. It is likely that a large amount of work will be necessary before final results can be obtained.

13. **The winds of India.**—The importance of a knowledge of the wind system of the country, for practical as well as for theoretical purposes, had been realised quite early in the history of the Department; and Beckley's anemographs have been in use for periods ranging from seven to forty-two years at thirty stations. It had been Sir John Eliot's purpose to discuss the data of seventeen of these, and at the time of his death memoirs dealing with Rangoon, Chittagong, Saugor Island, Calcutta, Allahabad, and Lucknow, had been published, while those of Belgaum and Port Blair were partially written and those of Roorkee, Lahore, Mussoorie, Pachmarhi and Nagpur, were passing through the press. Three of the last have now been published and it is hoped that the discussion of Belgaum and Port Blair may be completed at an early date.

14. **Publications.**—In addition to the Daily Weather Reports published at Simla, Calcutta, Bombay, and Madras, the Monthly Weather

Reviews, the Annual Summary, and various administrative pamphlets the following memoirs have been published departmentally :—

ELIOT, the late SIR JOHN.	A discussion of the anemographic observations recorded at Roorkee from September 1879 to August 1904, at Lahore from January 1890 to December 1904 and at Mussoorie from May to October 1877-1888. (*Mem. Ind. Meteor. Dept., Vol. XVIII, Part IV*).
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WALKER, GILBERT T.	Correlation in seasonal variation of climate (Introduction). (*Mem. Ind. Meteor. Dept., Vol. XX, Part VI*).

TERRESTRIAL MAGNETISM.

BY

GILBERT T. WALKER, M.A., Sc.D., F.R.S.,
Director-General of Observatories.

Magnetic Observatories.—*Bombay* (*Alibag*).—The Bombay observatory which was formerly maintained by the local Government at Colaba was moved to Alibag in consequence of the introduction of electric trams into the city: it is now directly under the Government of India, the Director being Mr. N. A. F. Moos. The chief instruments are a set of magnetographs of the Watson pattern and a Schulze earth-inductor, in addition to ordinary magnetometers and dip circles. All have given satisfactory results through the year. The results of the sixty years of observations at Colaba are now at the press.

2. *Dehra Dun, Kodaikanal, Barrackpore and Toungoo.*—These observatories were started as base stations in connection with the Magnetic

Survey of India and are all equipped with Watson autographic instruments for declination, horizontal intensity and vertical force. Instead of dip-circles earth-inductors of the Schulze pattern have been set up at each place. Good results have been obtained through the year. At Dehra Dun, however, serious trouble has been experienced owing to heavy rainfall. The magnetograph room had been flooded in 1901 and steps taken to prevent recurrence; in 1905 and 1907 the rainfall was less than the normal and the room remained dry, as it did in 1908 when there was no prolonged period of heavy rainfall although the total amount was in excess. In 1904 and 1906, however, water entered the room.

Experience shows that after three or four days of heavy rain the subsoil becomes waterlogged, water increases in the catchment pit faster than it can be pumped out, and the walls and floor are subjected to a head of 10 feet or more, a pressure which they are ill-calculated to resist. On the 15th August, although pumping with two pumps had been going on day and night for a week, the water had risen to within an inch of the top of the driving clock pillar, and the water level in the catchment pit was 11 feet above the level of the floor of the observatory. It was accordingly deemed advisable to remove the instruments. The horizontal force and declination magnetographs had been working since 1903 with only minor interruptions, and that for vertical force was erected in 1905: the break of record is a great misfortune.

It now appears necessary either to provide a pump capable of raising at least 2,000 gallons an hour direct from the room or the surrounding passage, or to abandon the present observatory and build a new one above ground. Any remedy which aims at excluding water altogether from the present room would involve practical reconstruction, and would be out of the question owing to the inevitable loss of records while the work was being carried on.

3. The mean values of the magnetic elements for 1908 at the observatories are as follows:—

	Declination.	Horizontal force.	Vertical force.	Dip.
Bombay . .	1° 2·25′ E.	·36857	·15922	23° 21·1′
Dehra Dun .	2° 36·7′ E.	·33293	·31819	43° 42·2′
Barrackpore .	1° 5·7′ E.	·37031	·22038	30° 34·5′
Kodaikanal .	0° 45·4′ W.	·37434	·02324	3° 33·2′
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4. **Magnetic Survey.**—The general scheme was to execute a preliminary survey of the whole country and a detailed survey of those areas where, owing to local irregularities, further information was required. The preliminary survey was to consist of observations of declination, intensity and dip at about 1,100 stations, and measurements were to be made in successive years at about 22 'repeat' stations in order to effect the elimination of secular variation.

Field work was begun in November 1901 and up to the end of the year 1907-8 1,190 field stations had been occupied and 22 repeat stations established, in addition to 24 stations on the Seistan trade route where declination had been observed: observations had also been repeated at 31 old field stations.

During the field season under report, which extended from the 26th October 1908 to the 3rd May 1909, operations were continued by four detachments. Two were employed in Burma in completing the areas allotted to the preliminary survey; and the two remaining commenced the detailed survey by the examination of several obviously disturbed areas.

5. The party remained in charge of Lieutenant H. J. Couchman, R.E., until the 31st March 1909, when he was relieved by Captain R. H. Thomas, R.E., on return from furlough. The officer in charge with his assistant Lieutenant H. T. Morshead, R.E., who was temporarily posted to the party, visited all the repeat stations, 22 in number, and also re-observed at a number of old field stations. Comparative observations were also taken at the four survey base stations and at Alibag to determine the differences from the survey standard at Dehra Dun.

6. The number of new stations of the preliminary survey occupied was 41, making a total number of 1,255. Of old stations 26 were re-occupied, so that observations have now been repeated at 57 in all.

A new repeat station was established at Port Blair: this had long been considered advisable but it had been found impracticable to spare the necessary time.

In the detailed survey 122 stations were occupied.

7. During the recess season the computations of the field work and the reduction and tabulation of the base station results for 1908 will be completed. The correction of the horizontal force and declination observations for diurnal variation and instrumental differences in declination is in hand, the repeat stations and re-observed field stations being dealt with in the first instance.

8. With regard to the correction for instrumental differences in H. F., the whole question is now under investigation, the main points being—

(*a*) Whether any correction should be made to the standard on account of change in the moment of inertia.

(*b*) Whether the discrepancies in different seasons in the differences from the standard can be eliminated by using for the distribution factor $\log\ (1-\frac{P}{r^2}-\frac{Q}{r^4})$ instead of $\log\ (1-\frac{P}{r^2})$.

As regards (*a*) observations for the moment of inertia have been taken with the standard magnet No. 17 every year, and allowing for the change in weight of inertia bar No. 17 (see Narrative Report for 1904-05) there appears to be a gradual and regular fall in the value, corresponding in 1908 to a correction of —19γ in H. F.

With regard to (*b*) the expression for the connection between m, H, the deflecting distance r and the angle of deflection u is

$$\frac{H}{m}=\frac{2}{r^3 \sin u}\quad(1+\frac{P}{r^2}+\frac{Q}{r^4}+\ldots\ldots)$$

where P and Q are the distribution constants. The expression $1-\frac{P}{r^2}$ which is now employed, is obtained on the assumption that $\frac{Q}{r^4}$ is negligible; this however is far from being the case, the correction to the observed value of H. F. varying from 0 to +60γ at Dehra Dun with various instruments. The magnitude of the correction moreover is not a constant for any particular instrument, but may vary within considerable limits from time to time; and there is considerable liability to sudden change when there is a sharp drop in the magnetic moment, though the distribution factor now applied may show little or no alteration.

The investigation has necessitated considerable computation but a preliminary reduction of the instrumental differences corrected as above gave promising results, and the investigation will therefore be continued. It may be mentioned that this investigation has considerable bearing on the question of H. F. disturbance corrections owing to the resulting changes in the monthly base lines; it will also affect the secular change values, since various instruments have been used at the repeat stations and re-observed field stations.

An approximate reduction of the H. F. observations at repeat stations and re-observed field stations has also been made. It has indicated that the present number of repeat stations is far too small for the correct appreciation of the annual change, and the present policy of re-observing at a number of old field stations will, as far as time permits, be continued.

9. During the next field season it is intended that the detailed survey shall be continued on the same lines as last year by two detachments.

Two detachments will be employed in re-observing at old field stations particularly in the area lying between Lat. 16°—19° and Long. 73°—78° where the secular change in H. F. appears to be particularly abnormal.

The computing section in Dehra Dun will continue the reduction of the preliminary survey, in addition to its normal work of computing and tabulating the base station results.

GEOLOGY.

BY

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INTRODUCTION.

1. This summary of results obtained by the officers of the Department during 1908 is designedly brief regarding most of the subjects, as they have been dealt with in separate papers published in the *Records* and *Memoirs*. Where, however, the work done cannot be closed and described for some years, as in the case of the great stretch of previously unsurveyed land in Central India and Rajputana, fuller details are given.

MINERALOGY.

New manganese minerals.

2. The examination of the manganese-ore deposits of India carried out by Mr. L. L. Fermor during the last four years, and the subsequent study at headquarters of the material collected has led to the discovery of several new varieties and species of minerals characterized by the presence of manganese in small or large quantities. Three of these minerals—winchite, blanfordite, and hollandite—have been noticed in previous reports. During the year under review accounts of three more of these minerals—vredenburgite, sitaparite, and juddite—have been published in *Records, Vol. XXXVII, Part 2.*

Vredenburgite.

Vredenburgite is a dark, steel-grey mineral of metallic lustre, with a bronze tint as seen in the sun. It has a hardness of 6·5, and a specific gravity of 4·74 to 4·84. Its most interesting property is its strong magnetism, for, broadly speaking, it is as strongly magnetic as magnetite. It has been found at two localities—Beldongri, Nagpur district, Central Provinces, and Garividi, Vizagapatam district, Madras. Although it is possible to interpret the analyses of this mineral so as to show the presence of Fe_3O_4 in the formula, yet the most simple formula is $3Mn_3O_4 . 2Fe_2O_3$. The discovery of such a mineral is perhaps disconcerting to the field mineralogist, for it means that when working in a manganese area, it will in future be unwise to assume that a strongly-magnetic, black mineral is magnetite, for it may be a merchantable ore of manganese.

Sitaparite.

Sitaparite is another bronze-tinted manganese mineral, but its bronze tint is much more pronounced than that of vredenburgite. It is found in the Sitapar manganese-ore deposit in the Chhindwara district. The hardness is about 7, and the specific gravity ranges from 4·93 to 5·09. It is most

easily distinguished from vredenburgite, which it resembles somewhat closely in composition, by its being only feebly magnetic. The one analysis made gave as a result the somewhat complex formula $9Mn_2O_3 . 4Fe_2O_3 . MnO_2 . 3CaO$, assuming that the lime is an essential constituent of the mineral.

Juddite.

Juddite is a variety of amphibole found in association with the manganese-pyroxene, blanfordite, at Kacharwahi in the Nagpur district. It is deep crimson as seen in hand-specimens; as seen under the microscope it shows perhaps the most beautiful series of pleochroic colours yet seen in any mineral. The following scheme is probably close to its true pleochroism:—

a = carmine,
b = blue with a lilac tinge, to pale-green with a lilac tinge,
c = orange or pinkish orange.

The mineral is further distinguished from most other varieties of the amphibole group by the position of its optic-axial plane, which is at right angles to the plane of symmetry.

PETROLOGY.

Singbhum, granophyres.

3. Whilst engaged in investigating the copper occurrences of Singbhum during January, February, and March, Mr. Fermor paid considerable attention to the petrology of the Archæan rocks (gneissose granites, Dharwar schists, and intrusive basic igneous rocks) of the district. The most interesting petrological unit in the area is the complex of basic and acid igneous rocks forming Akarsani Hill near Kharsawan, represented by a pink patch on Ball's map of Singbhum and Manbhum, given in *Memoirs, Vol. XVIII.* The basic rocks are probably intrusive in the acid rocks, and of the same age as the other basic dyke-rocks intrusive in the Dharwar phyllites and schists of the area. The acid rocks are hypabyssal in character. They can be best described as *granophyres* and granophyric granite-porphyries. The most characteristic feature of the rock is the lilac-grey blebs of quartz, by which it can be distinguished, even when it has been rolled out into a schist, the roundish quartz phenocrysts being then represented by drawn-out lilac-grey streaks. A band of this rock has been traced for some 16 miles, to a point as far east as Gomharia,

and there is no doubt, judging from the evidence obtained, that the rock is intrusive into the Dharwars. The rock is, however, so different from the main mass of the gneissose granite of Singbhum that its intrusive character cannot be taken as evidence that the common gneissose granites are also intrusive, although such is possibly the case.

Dalma trap.

4. Another interesting petrological unit in Singhbhum is the *Dalma trap*, forming a range of high hills along the northern border of the district, and separating it from the Lohardaga and Manbhum districts. An examination of it at two or three points showed that it is of complex constitution, having folded up with it bands of Dharwar schists. In composition it consists mainly of varieties of epidiorites, representing, probably, corresponding original varieties of dolerite. In places it is found to contain small quantities of pyrite, chalcopyrite, and in one case pyrrhotite. Considering the epidioritic nature of the trap, it is probable that the sulphides sometimes found in it are of secondary origin, although the metals they contain may have been contained in the original dolerites. It will need a very detailed examination to determine whether the Dalma trap is of contemporaneous formation with the Dharwar schists, or intrusive into them. The balance of evidence points to the latter view, and in this case it seems possible that the Dalma trap and the Akarsani granophyres may be respectively the basic and acid differentiation products of one original magma.

Magnesian rocks.

5. Some highly *magnesian rocks* have also been found in association with the Singhbhum Dharwars. Such are the serpentines of Suru Pass near Chaibasa, in which chromite is found (which see), and the steatitic rocks of Turamdih, in which magnetite occurs (see under iron).

Central Provinces: the Gondite series.

6. In Chapters XV to XVII of Volume XXXVII of the *Memoirs*, in the press during 1908, and issued in 1909, a comprehensive account is given of a series of rocks to which Mr. Fermor has given the name *gondite series*, after the aboriginal tribe of Gonds of the Central Provinces. The rocks of this series are supposed to have been formed by the regional metamorphism of manganiferous sediments deposited in Dharwar times. Where the sediments were fairly pure manganese oxides, the only result of metamorphism has been to consolidate them and convert them into crystalline manganese-ores (*primary ores*). But in cases where the chemically deposited manganese-oxide sediments were

mixed with mechanically deposited sediments, such as clay or sand, metamorphism has brought about an interaction between the manganese oxides and the clay or sand, with the production in the former case of spessartite-garnet and in the latter of rhodonite. The rock composed of a mixture of spessartite and quartz is known as *gondite*, and varieties of this rock containing other minerals are designated by qualifying terms; such as rhodonite-gondite, composed of rhodonite, spessartite, and quartz. Owing to the way in which the rocks of this series have been formed they tend to occur as banded masses, the bands representing original layers of different composition.

After these rocks were formed they seem to have been subjected to altering influences, probably waters containing oxygen and carbon dioxide, with the formation of manganese-ores. Such ores may be designated *deep secondary ores*. There are reasons for believing that this alteration of manganese-silicate to manganese-ore took place at the end of the Dharwar period and that therefore, as in the case of the primary ores, the depth to which the deep secondary ores extend bears no genetic relation to the position of the surface of the ground. The rocks and associated manganese-ores of the Central Provinces are found developed typically in the Nagpur-Balaghat area, and also in Jhabua, Narukot, and Gangpur (see page 27). They are to be distinguished from the rocks of the kodurite series (see *Records*, Volume XXXV, page 22), which are of igneous origin.

PALÆONTOLOGY.

Orbitolina.

7. Mr. E. Vredenburg has recorded an addition to our knowledge regarding the larger foraminifera of India, by his recognition of the important genus *Orbitolina*, which characterises rocks of Lower and Middle Cretaceous age and has not been previously recorded in India. (*Rec. Geol. Surv. Ind., XXXVI, p. 314*). The Indian specimens were collected by Mr. Hayden between Gurez and Astor, in north-west Kashmir. The Geological Museum also contains specimens collected by Griesbach near Firaiman in Persian Khorasan. In either case the palæontological material is insufficient to establish the exact age of the *Orbitolina* bearing sandstones.

Marine Tertiaries of the Peninsular Coast.

8. In a note published in Volume XXXVI of the *Records* (page 321) Mr. Vredenburg has reviewed the available fossil evidence regarding the age of the Tertiary strata

underlying the coastal laterite that forms an almost continuous belt round the peninsula. Concealed beneath lateritic and alluvial formations, these Tertiary beds have yielded fossils at very few points along the vast extent of their outcrop. The only instances recorded up to the present are the marine fossils discovered by Mr. P. N. Bose in Mourbhanj, the fossil wood of the Cuddalore standstones, the marine fossils of the "Orbiculina beds" of Quilon, and an extraordinarily rich marine fauna discovered between depths of 115 and 145 metres during the sinking of an artesian well at Karikal. The mollusca from the Orbiculina beds have been partly referred to species occurring in the Gaj beds (Upper Aquitanian to Burdigalian) of North-Western India. The marine beds in Mourbhanj contain an *Ostrea* closely related to an undescribed species from the Upper Gaj.

Out of 101 species so far described by Cossmann ("Faune pliocénique de Karikal", *Journal de Conchyliologie*, Volumes XLVIII, 1900, and LI, 1903) from the Karikal fauna, the richest Tertiary fauna as yet discovered in India, sixteen are identical with fossils from the Miocene of Java. The proportion of recent species in the Karikal fauna is 35 to 40 per cent. This figure agrees with the percentage of recent forms in the Miocene faunas of Java (35 to 50 per cent.) and Burma (30 to 48 per cent.). In the title of his work Cossmann has referred the Karikal fauna to the Pliocene (which, it should be remembered, for the author of the monograph as for many other geologists, includes the Pontian horizon). There seems no doubt that the Karikal beds belong to the same horizon as a portion of the Java and Burma series. Recent researches have tended somewhat to lower the horizon ascribed to the Java beds (Douvillé, *Bull. S. C. F.* Vol. V. (4), p. 435). A much closer palæontological connection than was originally anticipated has also been detected between the Miocene beds of Burma and those of Western India, according to which the Burma series appears to range from Lower to Middle Miocene. This would therefore appear to be the approximate age of the Karikal fauna. It might of course reach into Upper Miocene if one adopts the system of classification that unites the Pontian with the Pliocene. This result agrees with the age indicated by the Mourbhanj fossils and by those from the "Orbiculina beds," and suggests that the Tertiaries in the Coastal System all belong to one period. Yet this palæontological evidence, however satisfactory, is so local as compared with the vast extent of the coastal outcrop that it would be unsafe to generalise from these results.

Bagh beds, ammonites.

9. The Bagh beds first discovered by Keatinge in 1857 are of particular interest as a marine representative of the fluviatile Lameta or "Infra-trappean" series. Their total thickness is insignificant, but they have escaped denudation owing to a protective covering of Deccan Trap, and can be followed up the valley of the Narbada from the plains of Gujrat to Barwaha, some 240 miles from the sea-coast. Among the fossils collected by Keatinge, Blackwell, Blanford, and Bose, the echinoids studied by Duncan were found to include several species known from the Cenomanian beds of other lands, such as *Salenia Fraasi*, *Cyphosoma cenomanense*, *Echinobrissus Goybeti*, *Nucleolites similis*, *Hemiaster cenomanensis*, *H. similis* (*Q. J. G. S.*, XXI, page 349, 1865; *Rec. G. S. I.*, XX, page 81, 1887). This palæontological evidence suffices for referring the Bagh beds to the Cenomanian.

The ammonites collected from these same beds by Mr. P. N. Bose during the years 1880 to 1883 form the subject of a paper by Mr. Vredenburg, published in Volume XXXVI of the *Records* (pages 109 to 125). They belong to three species previously undescribed, which Mr. Vredenburg has named *Placenticeras Mintoi*, *Cœlopoceras Scindiæ*, and *Cœlopoceras Bosei*. Being all three new species, they do not add any further weight to the palæontological evidence furnished by the echinoids, at the same time not clashing with it, since *Placenticeras Mintoi* belongs to a group of forms abundantly represented from the Gault to the Lower Senonian, while the species of *Cœlopoceras* so far described are attributed to the Turonian.

The *Placenticeras* specimens are very numerous in Mr. Bose's collection. This ammonite, originally regarded by Feistmantel and Bose as identical with *Pl. tamulicum* from the Trichinopoli beds of South India, has been found to belong to a distinct species, which Mr. Vredenburg has described under the name *Placenticeras Mintoi*.

In comparing the Bagh *Placenticeras* with previously described species, Mr. Vredenburg has been led to classify the members of the genus into four groups distinguished from one another by the gradually increasing complexity of the suture line. The simplest suture is that of *Pl. Warthi* of the Muravatur beds of South India; the group of *Pl. Fritschi* includes a number of species ranging from Gault to Lower Senonian; *Placenticeras syrtale*, with its numerous varieties, characterises the Santonian; the newest group, that of *Pl. placenta* with excessively ramified sutures, characterises the Campanian. *Placenticeras*

Mintoi belongs to the numerous group of forms related to *Pl. Fritschi*, whose geological range is very extensive.

The two other ammonites *Cœlopoceras Scindiæ* and *C. Bosei*, included in Mr. Bose's collections, are each represented by a single fragment. They represent a generic form closely related to *Placenticeras*, for which Mr. Vredenburg proposed the name *Namadoceras*. Subsequently to the publication of his paper, Mr. Vredenburg noticed that his generic diagnosis coincides with that of Hyatt's genus *Cœlopoceras* (*Rec., XXXVI, p. 239*).* The American species of *Cœlopoceras* occur in the Colorado group which is regarded as Turonian. The European *Ammonites Requieni*, which Mr. Vredenburg regarded as closely allied to the Bagh fossils, and which is likewise referred to *Cœlopoceras* by Hyatt, is also Turonian. If the two Bagh ammonites are included in the same genus, the range of *Cœlopoceras* must be extended downwards into the Cenomanian.

Molluscan fauna of the Ranikot series.

10. Mr. Vredenburg's translation of Messrs. Cossmann and Pissarro's description of the Molluscan fauna of the Ranikot in Sind, the publication of which had to be postponed owing to the preparation of the illustrations to the stratigraphical introduction, will shortly appear.

The Ranikot strata in Sind are the only authentic representatives of the Lower Eocene so far known in India, and their interest is further increased by their extremely restricted extent. Compared with the enormous development of the Middle Eocene of India, the area occupied by these Lower Eocene beds is quite insignificant, more so even than would appear from the original maps published by Blanford and Fedden: the area as first defined has been considerably reduced in consequence of the withdrawal of the "Meting shales" which were originally incorporated in the Ranikot, but which the palæontological and stratigraphical researches of Mr. Vredenburg have shown to be separated from the Ranikot by an unconformity, and connected with the overlying Laki stage of middle Eocene age. The removal of the Meting shales curtails the outcrop of the Ranikot, as originally mapped, by nearly 200 square miles. This leaves only some 276 square miles as the total area of the Lower Eocene outcrop, of which less than 200 square miles belong to the Upper Ranikot with marine fossils, the Lower Ranikot yielding nothing but plant remains, with the exception of a thin oyster-bed occasionally present at its lowermost limit.

In a previous volume of these *Records* (*XXXIV, pp. 85—94 and*

172—198), Mr. Vredenburg has indicated the possibility of recognising four principal zones in the Upper Ranikot, the uppermost of which contains the species *Nummulites planulatus*, indicating its approximate correspondence with the "Sables de Cuise." According to the scheme of correlation advocated by Mr. Vredenburg, the underlying zones approximately correspond with the horizon of the London Clay. One of the papers above referred to contains a tabular representation of the distribution of the echinoids within these four zones. In the stratigraphical introduction to Cossmann and Pissarro's description of the molluscan fauna, Mr. Vredenburg has reproduced this list, and has also added a similar table giving the zonal distribution of the Ranikot corals originally described by Duncan (*Pal. Ind., Ser. XIV, Part 2*). In the case of the echinoids and corals, the distribution of the described forms through the successive zones, or at least through the three upper ones, is fairly even, though the species represented in the uppermost zone (zone 4 of Mr. Vredenburg's classification) are somewhat more numerous owing to the greater richness of the collections from this upper horizon. Comparatively scanty collections have been obtained from the three lower zones, whose outcrops are situated in a region rendered somewhat inaccessible from the want of drinking water.

In the case of the Mollusca, the preponderance of material from the uppermost zone is so overwhelming that an attempt to represent the zonal distribution of these fossils in tabular form would be premature. Amongst the materials available for study, by far the greater proportion represents the collections gathered from the uppermost zone by Mr. Vredenburg in 1900 in the neighbourhood of Jhirak, at places very rich in molluscan remains, but which have added nothing of importance to the previously described echinoids and corals. The zone of *Nummulites planulatus* includes no less than 73 out of 100 forms described by Messrs. Cossmann and Pissarro; 53 of these are restricted to the uppermost zone, but this large proportion is due to its preponderating share in the available collections.

The fossils so far described by Messrs. Cossmann and Pissarro include the Cephalopoda, Gastropoda, and Scaphopoda. Out of a total of 100 species, 22 had already been described by d'Archiac and Haime in their classical monograph on the Tertiary fauna of India. The remaining species are all new to science. There are no instances of identity with European fossils, though the relation of certain species to Eocene fossils from Europe or other areas, even as far distant as North America, is sufficiently close for them to be regarded as representative forms.

Certain genera or sub-genera (*Alocospira, Aulicina, Volutoconus*) absent from the European Tertiaries, exhibit Australasian affinities.

The *Cephalopoda* include the genera *Belosepia, Styracotheutis, Nautilus.* The species *Styracotheutis orientalis* Crick, very abundant in the uppermost zone, is particularly interesting as an example of one of the last of the extinct group of the belemnites, intermediate in its characters between the Upper Cretaceous genus *Belemnitella,* and the Eocene genus *Vasseuria.* The species was originally described from a specimen collected on the Oman coast of Arabia, thereby indicating the presence of Lower Eocene beds along the Arabian as well as along the Indian shores of the Arabian Sea.

Amongst the *Gastropoda,* the *Opisthobranchia* are represented by the genera *Tornatellæa, Bulla, Acera.* Of the various families of the *Prosobranchia,* those most abundantly represented are the *Pleurotomidæ* (10 species), *Volutidæ* (8 species), *Strombidæ* (9 species), *Turritellidæ* (6 species), *Naticidæ* (13 species). The species of *Strombidæ* in particular are represented by numerous specimens. Amongst species that are particularly abundant may be mentioned: *Surcula Voyseyi* d' A. and H. (zone 4), *Volutospina Sykesi* d' A. and H. (all horizons), *Cassidaria Archiaci* C. and P. (zone 4), *Gisortia Murchisoni* d'A. (zones 2 to 4), *Calyptrophorus indicus* C. and P. (principally zone 1), *Rimella Prestwichi* d'A. and H. (principally zone 4), *Terebellum distortum* d'A. and H. (zones 3 and 4), *Terebellum plicatum* d'A. and H. (zones 3 and 4), *Chenopus dimorphospira* C. and P. (zones 3 and 4), *Rhinoclavis subnuda* d'A. and H. (zones 2 to 4), *Rhinoclavis angystoma* d'A. and H. (zones 2 to 4), *Turritella angulata* J. de C. Sow. (all horizons), *Mesalia Mecquenemi* C. and P. (zones 2 to 4), *Ampullina sindensis* C. and P. (zones 2 to 4), *Ampullina aulacospira* C. and P. (zones 2 to 4), *Velates Noetlingi* C. and P., closely related to the European fossil *Velates Schmideli* (zones 2 to 4), *Delphinula Cordieri* d'A. (zone 4).

Nummulites Vredenburgi Prever.

11. In describing an interesting nummulite from the eocene of northwestern India under the name *Nummulites Douvillei* (*Rec. G. S. I., Vol. XXXIV, pp. 79—95, 1906*) Mr. Vredenburg was unaware that this name was preoccupied by a species from the Apennines described by Dr. Prever in a monograph which was not then available in the library of the Geological Survey (*Mem. Soc. Pal. Suisse, Vol. XXIX*). Dr. Prever has proposed to substitute the name *Nummulites Vredenburgi* Prever, for the Indian fossil (*Rec. G. S. I., Vol. XXXVI, p. 239.*)

Liassic and Neocomian of Baluchistan.

12. Mr. G. H. Tipper has nearly completed an account of the Liassic and Neocomian fossils of Baluchistan. The collections which form the basis of his report were obtained mainly during the field-season 1905-06, while surveying the Native States of Kalat and Las Bela in Baluchistan. But there are also included collections made previously by Mr. Vredenburg in the vicinity of the Takatu, and by Kishen Singh, late Sub-Assistant, from near Kalat. In 1907-08, while on study leave at Cambridge, Mr. Tipper made a preliminary examination of the whole of the material and a direct comparison was made with the chief European fossils. The detailed examination, continued since, so far as other duties have allowed, has given the following results.

The divisions suggested from the study of the deposits in the field have been fully borne out; that is, the Baluchistan Lias may be divided into Lower, Middle and Upper. The character and distribution of these three are roughly as follows:—

Liassic fossils.

Lower Lias.—Crinoidal limestones and shaley beds. Shirinab valley, south of Mastung.

Middle Lias.—Black limestones of the Takatu Oolitic limestones and shales of Sarawan and Northern Jhalawan. Black shales and limestones of southern Jhalawan and Las Bela.

Upper Lias.—Black shales of the Natrani river, Las Bela.

The Lower and Upper Lias are but poorly developed, while the Middle includes almost all the exposures examined in Sarawan, Jhalawan and Las Bela.

The place of the lower and upper divisions is readily established by the fact that they have yielded ammonites closely related to, if not identical with, well-known European forms. Thus the Lower Lias has yielded *Arietites sp. aff. bisulcatus.* The presence of this fossil shows that only the lowermost zone is represented. Other fossils are by no means well preserved, and their affinities cannot be made out with satisfaction.

The Upper Lias of the Natrani river yielded a rich collection of ammonites, which, although not very well preserved, are yet good enough for their affinities to be made out. The following species have been recognised:—

Harpoceras cf. serpentinum.
Dactylioceras cf. annulatum.
Hildoceras sp.
Oxynoticeras sp., young form.

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The Upper Lias of the Natrani river yielded a rich collection of ammonites, which, although not very well preserved, are yet good enough for their affinities to be made out. The following species have been recognised :—

Harpoceras cf. serpentinum.
Dactylioceras cf. annulatum.
Hildoceras sp.
Oxynotoceras sp., young form.

These forms are typically Upper Liassic in age. All these ammonites were weathered out and collected from one gentle dip-slope, so that the whole of the Upper Lias in this locality is crowded into a thin band of shale. The only other fossil found associated with these ammonites is a *Spiriferina*, which occurs in large numbers. This graceful ribbed form with a rather high area is distinct from any described form, and is undoubtedly new.

The Middle Lias has yielded a very rich and interesting fauna, in which unfortunately ammonites are very rare, and exact correlation is a matter of difficulty. There are three areas where the Middle Lias is well developed, and, as these areas seem to correspond to differences in fauna, they may be treated separately. The faunistic differences may be more apparent than real and are probably due to hurried collecting. The areas may be designated (1) the Takatu, (2) Sarawan and Northern Jhalawan, (3) the Porali river.

Taking them in order, the Takatu area has yielded a fauna rich in numbers, but poor in species. It includes among the brachiopods *Spiriferina nov. sp.* No less than 989 specimens of this species occur. Although there is a considerable variation among them, yet it is not definite, and the specimens cannot be grouped except as a whole. Specimens of this species are small in size and generally smooth. Those specimens which have passed maturity show faint ribs, and are much stouter in habit than the young and mature forms.

Spiriferina rostrata Schloth. There are several specimens which may be referred to this species.

A single specimen of a peculiar *Spiriferina* occurs. It is extremely broad and very thin. Although very distinct, it is probably a sport and not a new species. Under the designation *Terebratula synophrys* Uhlig, *T. pacheia* Uhlig and *T. synophrys* var. *polyptycha* del Piaz. may also be included. All these forms occur, and are to be considered as variations of the type form. The young of this species is quite smooth.

The occurrence of *Eudesia sp.* in the Lias of Baluchistan must be considered as one of its chief peculiarities, as elsewhere it is not found at a lower horizon than the Inferior Oolite. This genus occurs in considerable numbers not only in the Takatu area, but also to the south. Several specimens closely related to the European form *Rhynchonella tetraëdra* Sow. occur. Of the lamellibranchs, the chief representative is the genus *Pecten*, with two species, the first related to *Pecten* (*Aequipecten*) *æquivalvis* Sow., and the second to *Pecten* (*Entolium*) *hehlii* d'Orb.

The rich and varied fauna of the Sarawan and Northern Jhalawan area has not been thoroughly worked out yet, but the following are the most interesting points:—

(1) The presence of the genus *Eudesia*, represented by a species different from that of the Takatu area.

(2) The occurrence of a very peculiar *Pecten*. This at first sight resembles *P. alatus* von Buch of the Lias of South America, but it differs in several important particulars; the ribs are more numerous, angular, and bear distinct spines, and during part of its life it was fixed by the left valve. This has led to the formation of a distinct angle, the upper part flat or concave and the lower, convex. The appearance of this *Pecten* is so striking that it is used as a charm by the inhabitants of Jhalawan.

Spiriferina di Stefanoi del Piaz found in this locality, is a species with a high triangular area and peculiar ornamentation; according to Dautzenberg it ought to be raised to subgeneric rank. The occurrence of a new genus of echinoids is also of considerable interest. This and the remaining forms will be described in Mr. Tipper's memoir. No ammonites were discovered in this area.

The Porali river area is particularly interesting, not only on account of the splendid preservation and number of the fossils, but also because many of them closely resemble Liassic fossils from Madagascar recently described by Thevenin in the *Annales de Paleontologie, tome III, fasc. III*. Thevenin describes a Middle Lias fauna comprising, among other forms, a new genus of ammonites *Bouleiceras, Pecten ambongoensis* and *Spiriferina rostrata* var. *madagascarensis*. These three forms can be matched from the Porali river collection. At the time of collecting three well-preserved fragments of an ammonite were obtained and at once recognised from the peculiarity of the suture as probably new. There is now very little doubt that they belong to the genus *Bouleiceras*. *Pecten ambongoensis* can also be matched by a number of specimens. This Pecten belongs to the same class as, and is closely related to, that already mentioned as occurring in the northern area. Thevenin's figures show perfectly the distortion of the left valve by the attachment area. This latter fact is sufficient to distinguish it from any other Pecten, and if Mr. Tipper's suggestion is correct, that it is due to fixation during part of its life, it ought to be raised to subgeneric rank. Similarly with *Sp. ros-*

trata var. madagascarensis and its different forms figured by Thevenin, these three examples as well as and many others show the close resemblance of the Porali river fauna to that of Madagascar.

Of the other forms occurring may be mentioned :—

Lima cf. punctata Sow.
Lima (Plagiostoma) gigantea Sow.
Pholadomya cf. idea d'Orb., and many others.

Neocomian.

13. The opportunity was also taken by Mr. Tipper, while on study leave, of examining a small collection from the Belemnite Shales, a formation very widely developed in Baluchistan. The age of these shells was fixed by Dr. Noetling as Neocomian from the presence of *Belemnites (Duvalia) dilatata* Blainv. The known fauna is so small that any additions are of interest. Broken and unidentifiable ammonites have been collected by several observers, but the field-season 1905-06 yielded several well-preserved specimens. They have been identified as follows :—

Hoplites amblygonius Neum.—One specimen agreeing perfectly with Neumayr's species.

Olcostephanus sp., group of *O. asterianus*.—Although not specifically identifiable, there is no doubt that it belongs to this group.

Perisphinctes ? sp.

Phylloceras cf. velledæ d'Orb.

Phylloceras sp.—Young form, perhaps the young of *Phyll. cf. velledæ.*

Crioceras sp.

In addition occur fragments of *Aptychi*, belonging to the groups *imbricati* and *punctati* of Zittel. This association is typically Neocomian, and bears out Nœtling's correlation. From the presence of *Hoplites amblygonius* and *O. sp.* group of *asterianus*, the fauna may be considered as belonging to the Volgian type.

Tertiary of Upper Burma.

14. Messrs. E. H. Pascoe and G. de P. Cotter have added considerably to our knowledge of the palæontology of the oil-bearing Tertiary strata in Upper Burma. Mr. Cotter has identified the collections made by the late Mr. L. G. Boyd of the Burma Oil Company in the Pegu series of Singu, Payagyigon-Ngashandaung, Padaung (near Prome), Kabat in the Myingyan district, Taungtha hill, and hills near Kwatalin, 20 miles south of Taungtha. The lists of species from each area are given in *Records, Vol. XXXVI, pp. 131 and 132.*

15. During the field-season 1906-07, marine fossils were found for the first time in the Pegu (Miocene) beds of the Yenangyaung inlier, occurring at two horizons. Neither of these corresponds well with any of Dr. Noetling's zones, but the discovery proves that although the Pegu beds at Yenangyaung are less fossiliferous than at Singu, Yenangyat or Minbu, they were deposited under similar conditions. The questions are discussed by Mr. Pascoe in a paper published in the *Records* (*Vol. XXXVI, Part 3*). Among other fossils described Mr. Pascoe gave a provincial name, *Twingonia*, to a fairly abundant form then regarded as of doubtful zoological affinity but since identified as fish otoliths.

Pegu beds.

16. In addition to the classical locality, east of Minlindaung, from which specimens of the freshwater forms *Batissa crawfurdi* and *B. petrolei* were first obtained by Crawford ninety years ago, Mr. Pascoe has found two others in which these two species occur and one yielding the gigantic *B. kodaungensis*. Distorted specimens of a variety of *B. crawfurdi*, named *yedwinensis*, have also been found in the Pegu beds, 300 feet below the Pegu-Irrawaddi boundary, thus pointing to the local, temporary establishment of freshwater conditions. These occurrences have been described by Mr. Pascoe in a special paper (*Rec. Geol. Surv. Ind., Vol. XXXVI, Part 3*).

Freshwater fossils in the Pegu beds.

17. Messrs. Pascoe and Cotter have described and figured (*Rec., Geol. Surv. Ind., Vol. XXXVI, Part 3, p. 147*), a new species of the coral *Dendrophyllia, D. macroriana*, found in the Singu and Minbu fields.

Dendrophyllia.

18. The occurrence of an estuarine bed under Calcutta was described by Mr. E. Vredenburg in 1904.[1]

Dr. N. Annandale, Superintendent of the Natural History Section, Indian Museum, has since identified the animal remains found. Most of the specimens collected are remains of molluscs, including *Telescopium fuscum* Ch., *Paludina* (*Vivipara*) *bengalensis* Lam., *Ampullaria globosa* Swains, *Aricia* (?) *moneta* Linn., *Planorbis exustus*, Desh., *Anomia achæs*, Gray, *Arca adamsiana*, Dkr., *Ostrea cucullata* Bow., and *Ostrea canadensis*, Tk. All these can be identified with living species, either in the freshwater tanks, in the brackish estuarine distributaries of the Ganges, or, in one case, in the clear sea-water. The most interesting is the last-named

Estuarine beds under Calcutta.

[1] *Rec., Geol. Surv., Ind., XXXI, 174.*

oyster, which seems to have had a wide distribution, for the specimens found are not, as once suggested, imported to Calcutta as ship's ballast, the same species being found still living and common in the Sunderbans.

Lameta Fossil Fish.

19. An occurrence of Lameta beds at Dongargaon in the Central Provinces was long ago brought into prominence by Hislop's discovery of fossil fish-remains. Recently some of the specimens collected at this locality came into possession of the Geological Survey, and Dr. A. Smith Woodward has now completed their examination (*Palæontologia Indica, New Series, Vol. III, No. 3*). All the remains appear to differ in specific characters from previously known forms, and three species have been distinguished. One of these, a Teleostean, is sufficiently strange to constitute a new genus, *Eoserranus*, while of the other two one is especially interesting, as it is the first-described specimen of the remarkable genus *Lepidosteus* that has been found in Asia, Dr. Woodward's description thus confirming Hislop's suspicion regarding the occurrence of this genus in the Lameta beds. All three genera have their nearest known relatives in the early Tertiary rocks of Europe and America. No true Percoid fish has been found hitherto in typical Cretaceous strata, and the oldest known member of the group to which *Eoserranus* belongs is *Prolates* of the Montian stage in France. *Lepidosteus* also ranges from the Lower Eocene to the Lower Miocene in Europe and from the Lower Eocene to Recent in North America, while the third genus, *Pycnodus*, represented in this collection has not been found outside the Eocene. Thus, judging by the evidence of the fossil fishes alone the age of the Lameta bed from which they were obtained would be between the Danian and Upper Eocene.

Gondwana plants, Pench valley.

41. Captain F. L. Ditmas and Mr. S. D. Ware have sent to the Museum some fossil plants collected in the Pench valley coalfield between the villages of Dongor Porashea and the boundary of the Deccan Trap, north of the village of Hurreye. The specimens were obtained in an area marked as Barakar on the map accompanying the late Mr. E. J. Jones' memoir on the Satpura coalfields (*Mem., Geol. Surv., Ind., Vol. XXIV, Part 1*), but according to the donors the beds are above the coal measures. The collection, identified by Babu Bankim Behari Gupta, Museum Assistant, includes *Phyllotheca indica* Bunb., *Glossopteris indica* Schimp., *Gangamopteris cyclopteroides* Estm. and several other forms apparently new. The material identified is hardly sufficient to settle the age of the beds, and it is hoped that further discoveries of fossil

plants in this area will be made in order that the Pench valley beds may be compared with the Mohpani coalfield, which, on the other side of the Satpura basin, has yielded Karharbari plants.

ECONOMIC ENQUIRIES.

Alum.

Mianwali District, Punjab.

21. Mr. N. D. Daru was deputed to the Isakhel tahsil, Mianwali district, Punjab, early in the year, to report on the indigenous industry of alum manufacture and on the pyritous shales which were considered to be of possible value for the manufacture of sulphuric acid.

At Kalabagh the total length of the shale outcrop is about a mile and a half, with an average thickness of eight feet. About the same length of outcrop is accessible at Kotki, but the average thickness is four times as great, and the shale bed extends for eight miles east of Kotki. Patches only in the shale have been found to be rich enough for working. In these the average sulphur-content is 9·5 per cent., and there is besides bituminous matter present to the extent of about 3 per cent. The pyrite which mainly contributes to the sulphur-content is as a rule extremely comminuted, and can be distinguished only under the microscope. There is just a trace of gold in the shale. The shale is fissile to compact, light-gray to deep-black, and breaks with a conchoidal fracture. When freshly-mined it will take finger impressions, and when containing bituminous matter it has a greasy feel and can be easily given a lustre.

There is no systematic mining. The mines often are narrow, low, tortuous passages or screw-shaped shafts, and do not reach below the level of the adjoining springs. There is no provision for ventilating these hot mines and timbering is rarely found necessary.

At Kalabagh the alum manufacturer pays one rupee for twenty-five maunds of the shale ; one-third of this amount going to the Malik of Kalabagh as royalty. At Kotki, the price is 35 maunds to the rupee, all of which goes to the miner.

The shale is roasted in the open, and there is considerable loss of sulphur dioxide. In roasting, the fresh shale is mixed with an equal quantity of previously used, but not quite exhausted, shale, which has been subjected to spontaneous oxidation for a year or more. The roasting is continuous, portions of the heap being cut away on one side

to supply the works, and fresh and old shale added on the other. Owing to the low sulphur-content, fuel has to be used.

The roasted shale is lixiviated, allowed to settle, and then boiled. When sufficiently concentrated, a mixture of crude chlorides, nitrates and sulphates of sodium (chiefly) and of potassium, is added, and the liquor transferred to crystallization tanks. When the crystals from these are removed after a week, the mother liquor is added to the fresh liquor from the roasted shale in the lixiviation tank. The crystals are allowed to accumulate for ten days, when they are fused in their water of crystallization, and the melt is poured into earthenware pots sunk into the ground. When it has recrystallized, the alum is ready for the market. The alum is mainly sodium-alum with a small proportion of potassium-alum. It goes to Delhi, Hissar, Sirsa and other centres of tanning and dyeing industries. The price of alum at Kalabagh in February 1908 was ₹4-12-0 a maund, and at the end of March 1908 it was ₹4-8-0.

The practice at Kotki is essentially the same as at Kalabagh. The output was 16 maunds a day at Kalabagh, where only one factory (which had been restarted on a rise of price of alum in November 1907 to ₹5 per maund) was working; at Kotki, each of the three factories, which work for only six or seven months in the year, has a daily output of 25 maunds. The annual output of Isakhel Tahsil may be put roughly at 20,000 maunds or 750 tons. Kalabagh, in spite of the high cost of shale there, can compete with Kotki owing to its proximity to the Indus and the railway, whereas Kotki manufacturers have to haul in part of their alkaline salts and haul out the whole of their alum output, by camel transport over a distance of nearly ten miles.

Improvements in the manner of roasting the shale, and in the construction of the fire-chamber for the boiling-pans are desirable. What is of perhaps greater importance still is the abandoning of the use of lime in the linings of the various tanks, and the substitution of plaster of Paris for it, there being plenty of gypsum near at hand. This change would probably prevent a waste of over six rupees' worth of the acid at each factory every day.

The alkaline salts come from Mandakhel and Kamar-Mashani in the Isakhel Tasil, Rokhri and Thatli near Mianwali, and Shahpur. At the first two places they are obtained by concentrating and crystallizing the product of lixiviation of the scrapings of the soil of the neighbourhood.

Dandot.

22. Mr. Daru visited the Dandot Colliery of the North-Western Railway, where pyritous shales are also known. The shale here, on account of its high carbonaceous contents, is unfit for acid-making, but can be used for alum-making more advantageously than the shale of Isakhel Tahsil. The markets are 125 miles nearer, the source of the best alkalies is only half as distant as from Kalabagh.

China-clay.

Rajmahal Hills, Bengal.

23. In addition to an examination of the sands supposed to be of value for glass-making, Mr. Murray Stuart paid special attention to the clays of the Rajmahal hills said to be suitable for the manufacture of china and porcelain. Good material was found at three localities on the west of the hills, namely, Paturghatta near Colgong, Buskia near Katungi (24° 28′; 87° 29′) and Dodhanee (24° 17′; 87° 29′). There is evidence at the first-mentioned locality that the kaolin is of wide extent and that the quantity, speaking from a manufacturer's point of view, is unlimited. The quality of the clay is good, and it resembles strongly the Cornish china-clays. The extent of the deposits of kaolin at the other two localities is undetermined, but there are indications that there is a fair quantity at each place. In quality the clays from the last two localities seem to be equal to that of the clay obtained from Paturghatta.

In addition to these deposits, kaolin occurs in the white Damuda sandstone of the district and it is being extracted from the same sandstone at Mangal Hat near Rajmahal for use by the Calcutta Pottery Company. In quality it seems to be good and at Mangal Hat it is obtained very free from mica. On the west of the hills, however, the Damuda sandstone is more micaceous, and therefore would not be so suitable for the extraction of kaolin. Mr. Stuart's full report will be published in the *Records*.

Chromite.

Singbhum, Bengal.

24. In April Mr. Fermor paid a visit to an occurrence of chromite discovered in a serpentine at the Suru Pass on the road from Chaibasa to Senua, B. N. R., by Mr. R. Saubolle, prospecting on behalf of Messrs. Martin & Co. of Calcutta. Twelve small excavations had been made, and from each

chromite had been obtained. In three of them the chromite was seen *in situ*; it occurs as bed-like veins and disseminations in serpentine. These veins range up to about 10 inches in thickness, and in one of the pits formed a network. The junction between the chromite and the serpentine is usually sharp, but some specimens show a passage from chromite with very little serpentine, through serpentine containing disseminated grains of chromite, to serpentine practically free from chromite. The ore is of fairly high grade. A sample taken from the little stacks of ore—perhaps 10 tons in all—lying by the side of each opening, yielding 50·05 per cent. of sesquioxide of chromium Cr_2O_3. Further prospecting has led to the discovery of other occurrences of chromite in this area; but none has yet been proved to be of commercial value.

Copper.

Singbhum, Bengal.

25. During the field season of 1907-08, geological and mineral work in Singbhum was continued by a party, consisting of Messrs. L. L. Fermor and K. A. K. Hallowes, with two students, Mr. G. G. Narke of Nagpur and Babu Kiran K. Sengupta of Calcutta, who were being instructed in methods of field-work. Mr. Fermor's time was spent in making a general examination of the ground with reference to the origin and mode of occurrence of the copper deposits, the relationships of the various rocks one to another, and the examination of various mineral deposits other than copper The various portions of his work are noticed under petrology, chromite, iron, and manganese. With regard to the mode of occurrence and origin of the copper deposits he is in more or less general agreement with Mr. Hallowes' conclusions and descriptions, as embodied in his progress reports.

Mr. Hallowes took up his work where he left it in the previous season, namely, at Matigara in Dhalbhum, and continued the examination of the copper belt to the south-east and south-south-east as far as Bhairagora near the Mourbhanj border, beyond which locality he was not able to find any further old copper workings; all his work this season thus lay in the Dhalbhum Estate. Old copper workings are now known to occur at intervals along a belt stretching for some 80 miles from Duarparam on the Bamini River in the Kera Estate on the extreme west, through the Kharsawan and Saraikala States. So far the general trend of the belt is practically due east; but on entering the Dhalbhum Estate,

within which it lies for the remainder of its course, at Landup the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Rajdoha Copper Company, Limited, and then through the wild south-east portions of Dhalbhum to Bhairagora, at the extreme south-east end of the belt. This curving round of the strike is an expression of the fact that throughout its course the strike of the copper belt follows that of the Dharwar schists and phyllites in which the copper deposits occur; the strike of the Dharwar rocks themselves is determined by the shape of the enormous area of granite occupying central and southern Singbhum, as they dip away from it everywhere.

The copper-ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well defined bands, but very frequently it occurs in the form of grains disseminated through a considerable thickness of schists so sparsely as to be unworkable; whereas if the same amount of copper minerals had been concentrated into smaller thickness of schists workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore. The development work being carried out from the Gladstone shaft in the Matigara mine by the Cape Copper Company, on an option held from the Rajdoha Copper Company, has given somewhat encouraging results, but; until a considerably larger amount of drilling and underground development has been accomplished, it will not be possible to speak with certainty of the prospects of this mine. As seen at the outcrops the lodes seem to be very poor indeed, where they have not been removed by the ancients. Typically, they consist of small thicknesses of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of libethenite. In depth, as seen in the diamond-drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in

their position as rather indefinite lodes following the bedding of the schists, subsequent to the arrival of the schists in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartz layers. Apatite and tourmaline are also common minerals in these schists.

The diamond drilling accomplished during the year included :—

(*a*) *Matigara*, three miles west of Moholia, B. N. R., in the Dhalbhum Estate. This hole was put down to a depth of 837 feet to test the extension in depth of the lode exposed at a depth of 229 feet in the Gladstone shaft, the Cape Copper Company bearing half the expense of the hole. The most valuable portion of the lode was cut at a depth of 736 feet from the surface, but the rocks were cupriferous for a vertical distance of 46 feet (dip of lode $=38°$). The cores were assayed in sections by Mr. Hallowes with the following results :—

Portion of core.	Actual thickness.	Copper.
693′—697′	3·15′	2·0 per cent.
697′—701′ 8″	3·67′	1·29 ,,
733′ 5″—736′ 1″	2·10′	1·01 ,,
736′ 1″—736′ 5″	0·26′	12·81 ,,
736′ 5″—739′	2·03′	0·42 ,,

(*b*) *Lankiśra*, to the south-west of Gharsila in Dhalbhum. This hole was put down to a depth of 392 feet to test a lode indicated by some old workings. The cores were found to be noticeably cupriferous between the depths of 150 and 184 feet. Taking the dip of the rocks as 21° the thickness of cupriferous rock or 'lode' is about 23 feet. The lode was assayed by Messrs. Snelus and Duff of the Cape Copper Company, with the following results :—

Position of core.	Actual thickness.	Copper.
150′—168′	16·80′	2·65 per cent.
169′—171′	1·86′	2·13 ,,
179′—184′	4·66′	1·37 ,,

The results of these borings confirm those previously obtained, showing that generally speaking the ores of Singbhum are of low grade, and on the whole just below what is likely to be payable, except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise. The 3-inch layer of ore giving 12·81 per cent. copper found at 736 feet in the Matigara hole is also of considerable interest, because this band happens to be identical in its mineral peculiarities with a persistent band of chalcopyrite, with blebs of quartz, ranging from 6 inches to 2 feet in thickness and found in the Matigara mine at a depth of 228 feet. It may so happen that at the depth of 736 feet the drill passed through a very thin portion of this characteristic band of ore, which is typically very variable in thickness. The encouraging feature is that this hole indicates the persistence of this band of rich ore from the depth of 228 feet to that of 736 feet. The Geological Survey drills have been lent to the Cape Copper Company, which is now further testing the Matigara lodes.

Engineering Questions.

Central India and the United Provinces.

26. At the request of the Chief Engineer, United Provinces and of the Consulting Engineer for Protective Works in Central India, Mr. LaTouche reported on the geological features of certain sites selected as suitable for reservoirs and canal heads. These include :—(1) Murwari, on the Ken river in the Panna State, at the point where the river issues from the scarp of Upper Vindhyan sandstones and shales near the southern boundary of Bundelkhand ; (2) Kota, on the Bairma river, a tributary of the Ken, at the foot of the same scarp further west ; (3) Gangao, where the Ken river issues from a gorge in the Lower Vindhyan sandstones at the head of the plateau of northern Bundelkhand ; (4) a weir site on the Ohen river near Karwi, in Vindhyan sandstones ; (5) a canal head on the Paisuni river, also near Karwi, where it is proposed to build the dam on a band of Vindhyan limestone, which forms a bar across the river ; and (6) a dam in course of construction at Pahari on the Dhasan river near Harpalpur, where the foundation consists of Bundelkhand gneiss traversed by dykes of basic rock.

Fire-clay.

27. While examining the china-clay deposits of the Rajmahal hills, Mr. Murray Stuart recorded notes regarding some deposits of excellent fire-clay in the Hura, Chuperbhita and Pachwara coalfields. The deposits are rather difficult of access at present and are not very large, being distributed through the fields in beds seldom exceeding six feet in thickness.

Rajmahal Hills, Bengal.

Glass-making Sands.

28. Mr. Murray Stuart was deputed to the Rajmahal hills in January to examine certain occurrences of sand reported to be suitable for glass-making, and his report is published as a separate paper in *Records, Volume XXXVII, Part 2.*

Rajmahal Hills, Bengal.

He concludes that the sand met with in this area is generally unsuitable for the manufacture of any but the commonest kinds of bottles. Sands occur as—

(*a*) recent river-sands, and
(*b*) Damuda (Gondwana) sandstone.

The river sands, of which the Ganges sand is the purest and most free from iron, yield a dark-green glass, which is only suitable for the cheapest beer—and wine—bottles, and is too dark to be affected by the admixture of manganese with the raw materials before fusion.

The white Damuda sandstone yields a sand with a high percentage of silica, and is the one mentioned by Mr. J. G. Cumming, I.C.S., in his report on the Industrial position and prospects in Bengal in 1908 (page 28, paragraph 2). The sand obtained from this sandstone yields a glass which is only faintly coloured by iron; consequently, by the admixture of manganese with the raw materials before fusion, a colourless crystal glass can be obtained. The objection to the use of this sand for glass-manufacture lies in the fact that it contains a somewhat large quantity of kaolin which it is practically impossible to eradicate under working conditions. The result of this kaolin is that the glass contains small inclusions, about the size of a pin's head, of a white opaque substance which is practically pottery; this of course renders the sand of little value for glass-manufacture, as no increase in temperature will affect the inclusions.

Gypsum.

Hamirpur District, United Provinces.

29. Information having been received from the Collector of Hamirpur District in the United Provinces that deposits of gypsum had been found at several places near the Bairma river, a tributary of the Betwa, Mr. LaTouche was deputed to examine them, as it was thought that, if the deposits formed a continuous bed, such as their reported mode of occurrence seemed to imply, they might possibly be of Lower Tertiary age, and afford a clue to the presence of Tertiary strata along the southern edge of the Gangetic basin beneath the alluvium. The examination of the beds, however, disclosed the following facts :—

(1) That the gypsum, in the form of crystals of selenite, is entirely confined to the older alluvium in the neighbourhood of the rivers, and that it is of recent origin.

(2) That the crystals are found at certain definite spots at a depth of from 4 to 6 feet over very limited areas, the largest of which, near the village of Puraini, measured about 600 square yards, and that the mineral does not form a continuous bed or layer, being very limited in quantity.

(3) That the selenite crystals appear to have been deposited in a plastic clay occurring at these spots by water percolating from below, holding sulphate of lime in solution, and evaporating before reaching the surface.

Iron-ore.

Chota Nagpur.

30. Whilst working in the Singbhum copper area Mr. Fermor took the opportunity to examine various deposits of iron-ore being developed by the Bengal Iron & Steel Co. for their smelting works at Kulti.

These may be divided into two groups—the Turamdih deposits, some 4 miles from Kalimati, Bengal Nagpur Railway ; and the Hakigora deposits, some 8 miles from Kalimati, and separated from Turamdih by a high intervening range of hills, which may be called the Dhoba Hills ; this is composed of quartzites, slates, and phyllites of Dharwar age, which is also the age of the rocks with which both groups of iron-ores are associated.

The Turamdih deposits occur in some foot-hills at the north base of the Dhoba Hills in the villages of Talsa, Turamdih, and Kudada. The ore is magnetite ; it is found in a series of schistose magnesian rocks, which have not yet been closely studied, but which contain steatite, as an important constituent. The magnetite occurs in the magnesian schists in four ways :—

(1) as scattered granules ;
(2) as large patches of irregular shape ;
(3) as definite veins traversing the magnesian rocks in any direction ;
(4) as veins up to 3 feet thick, composed of magnetite, with vein quartz, secondary limonite and chert.

The magnetite is probably the result of segregation from the igneous rocks from which the magnesian rocks have doubtless been derived. At the surface the magnesian schists have been much weathered, with the liberation from its matrix of a large quantity of magnetite in the form of granules and small lumps. These are recovered by sifting and picking by women and children, and form the chief portion of the ore won here. A certain quantity is, however, obtained *in situ*, by following up the thicker veins in open excavations.

The Hakigora ores occur in some small hills to the south of the Dhoba range. They consist of the banded magnetite and hematite quartzites so typical of the Dharwars in many parts of India. As at Turamdih the chief source of the ore is a detrital deposit formed by the breaking down of these ferruginous quartzites, in the course of which the layers of iron-ore are to a certain extent separated from those of quartzite. A small quantity of ore is also won by working the rock *in situ*, wherever there happen to be bands of iron-ore of sufficient thickness.

Manganese.

31. During the year Mr. Fermor completed his monograph on the Manganese-ore Deposits of India, issued as Volume XXXVII of the *Memoirs*. The chief results, briefly mentioned in previous Reports, are now brought together in a form that will be of great practical value to those engaged in manganese mining ; but the work is equally important as a contribution to the purely scientific questions connected with the ore-deposits and associated rocks. From every point of view this memoir

supersedes anything hitherto published on manganese-ores, and will take a prominent place in geological literature.

Singbhum, Bengal

32. In January, 1908, Mr. Fermor visited two deposits of manganese-ore discovered since his previous visit to this district (in 1905). One of these—Tutugutu, near Chaibasa—is exactly like those previously examined in this area. The other is Leda Hill, which rises to a height of about 1,000 feet above the plains level near Goilkora, Bengal-Nagpur Railway. It is the only example in the district of a manganese-ore deposit occupying the top of a hill. But like the deposits of the Chaibasa area, this deposit has been formed by the superficial replacement of Dharwar slates, phyllites, and quartzites. The quantity of merchantable ore is small.

Central Provinces.

33. In November, during a visit of inspection to some of the manganese mines of the Central Provinces, Mr. Fermor obtained at the Gowari Warhona deposit in the Chhindwara district, an important piece of evidence bearing on the age of the manganese-ores. Now that this mine has become deeper it is found that the manganese-ore band, which at the surface was fairly continuous, is much broken up by pegmatitic intrusions. These are seen abruptly truncating the beds of manganese-ore; and in one place a thin vein of pegmatitic rock was seen traversing the manganese-ore beds, and containing a small isolated inclusion of high-grade manganese-ore identical in physical appearance with the ore on either side of the vein. From this it is evident that the high-grade manganese-ore of this part of the mine was in existence at the time of intrusion of the pegmatitic rocks; the date of the latter is to be regarded as Archæan in the absence of evidence to the contrary; and hence it seems fairly certain that a portion at least of the manganese-ore of the Central Provinces was in existence in Archæan times, so that the present position of the deposits can have no genetic relation to the surface of the ground, and therefore the deposits may be expected to continue to depths that have no relation to the level of ground water, *i. e.*, possibly to very considerable depths. The deductions drawn from this occurrence at Gowari Warhona agree with certain evidences of intrusion of pegmatitic rocks into manganese-ores obtained at other deposits in the Central Provinces.

Gangpur State.

34. In December, Mr. Fermor visited some manganese-ore deposits opened up during the year in Gangpur State, in Bengal. These are of considerable

interest, because the ores contain braunite, and are associated with spessartite and rhodonite. In fact the occurrences resemble in every way the deposits typical of the Central Provinces rather than the superficial deposits of Singbhum, the only other part of Bengal in which manganese-ore deposits of any note have been located. The discovery of the gondite series in Gangpur is of considerable interest, since it means that this series has now been found at intervals over a belt, aligned roughly east and west for a distance of 700 miles, extending from Jhabua and Narukot on the west, through the Nagpur-Balaghat area of the Central Provinces, to Gangpur State in Bengal on the east. The gap between the western exposures and the Central Provinces is largely occupied by the Deccan Trap formation; but in Chhatisgarh, occupying the gap between the Balaghat district and Gangpur, there are several areas of Archæan rocks, and consequently it will not be surprising if future prospecting leads to the location in this area of manganese ore deposits associated with gonditic rocks. The Gariajhor deposit in Gangpur seems to be of considerable value, the ore being first grade; owing to the small lead to the sea board as compared with the Central Provinces, it will be possible to export ore at a profit from this deposit at times when most of the mines of the Central Provinces are closed down.

Inspection of mines, Central Provinces.

35. While on duty at Nagpur in connection with the Central Provinces and Berar Exhibition in November and December, 1908, Mr. Fermor was also deputed to make a third inspection of the manganese quarries. During this tour the following deposits were visited:—

Chhindwara District.—Gowari Warhona, worked by the Indian Manganese Company, Limited.

Nagpur District.—Mansar and Kandri, worked by the Central Provinces Prospecting Syndicate, Limited; Kacharwahi and Pali, worked by the Central India Mining Company, Limited.

Bhandara District.—Chikhla, worked by the Central Provinces Prospecting Syndicate, Limited; Kosumbah and Sukli, worked by the Central India Mining Company, Limited.

Balaghat District.—Thirori, worked by Mr. D. Laxminarayan.

As in all his previous work on the manganese-ore deposits of the Central Provinces, Mr. Fermor received the friendly assistance of the managers, and his report has been submitted to the Central Provinces Administration for communication to the Companies concerned.

As a result of his investigation Mr. Fermor is satisfied that there is now a general desire throughout the manganese area to work the deposits on sound principles, and in many cases considerable expenditure has been incurred in developing deposits by improved methods.

The point on which the future of the manganese industry of the Central Provinces turns is whether or no the manganese-ore deposits continue of workable quality to any depth below the surface, or whether they are purely superficial in their mode of occurrence. Judging from the evidence discussed on page 27 it will be seen that some of the deposits probably continue to considerable depths. But this question cannot be settled satisfactorily until some of the typical deposits are tested by boring. When, in any given case, a company wishes to plan out the underground working of a deposit it will be wise first to test the deposit by boring to as great a depth as it is proposed to work it.

Petroleum.

36. The first three months, up to the third week in January, were spent by Mr. Pascoe on the Yenangyaung Oil-field. Part of this period was spent in office work and in the consideration of the numerous points connected with the proper development of those portions of the field known as the Twingôn and Bémé Reserves. The rest of the time was taken up with the completion of the geological map of the Pegu inlier enclosing the oil-field. The anticline, on its flanks, is studded with small dip-faults, which, though unimportant in size, are interesting as indicating the direction of strain at the time the post-Irrawadi sandstone fold was produced. The direction of the anticlinal axis is 28° W. of N. to 28° E. of S., whilst the general average direction of these faults is north-east to south-west. Besides these flank faults, which are usually observed crossing and displacing the boundary bed between the Pegu beds and the Irrawadi sandstone, there are numbers of minute faults or slips having no constant system of orientation, in the more central area including the crest. Some of them may very possibly account for some of the anomalies in the petroliferous horizons. Around and south of Bémé mud veins take the place of these faults and in some cases are actually widened and plugged faults: they probably represent some former outflow of mud in the form of "mud volcanoes," which have since been entirely removed.

Mr. E. H. Pascoe.

February was spent in the Lower Chindwin District, examining the numerous oil indications west of Kani and Kin. Small quantities of oil have been obtained by Burmans by digging pits, and these as well as natural seepages, occur on or near the crest of an anticline similar in structure to that of Yenangyat, having steep or vertical dips on its eastern, and comparatively gentle ones on its western flank. The rocks consist largely of hard impure limestone or calcareous sandstone, and conglomerate with limestone pebbles. The impervious nature and consequent small liquid-retaining capacity of the strata, as well as the dense and often impenetrable jungle clothing the hills, render prospecting hazardous and unpromising. The petroliferous rocks are presumably of Pegu age, as they are succeeded eastwards by fossil-wood-bearing, soft sands of the ordinary Irrawadi sandstone type.

The rest of the season was spent on the volcano, Mount Popa, in the Myingyan district. The bulk of the volcanic material is evidently post-Irrawadi sandstone in age, but a thin bed of ash and tuff intercalated among the latter sediments shews that activity commenced before the end of that period. The volcanic deposits consist mostly of conglomerates, tuffs, ash and andesitic lava flows.

Mr. G. de P. Cotter.

37. After initiating Mr. Sethu Rama Rau into his work at Singu, Mr. Cotter commenced at the end of November an examination of the southern portion of the Gwegyo Hills in the Myingyan District, and early in December continued his survey southwards along the same fold, including the Payagyigon-Ngashandaung Oil-field. The results of this work have already been published (*Rec., Geol. Surv., Ind., Vol. XXXVII, Part 3.*) In February Mr. Cotter removed to the Pakôkku District. The hills north of Myaing village were found to consist of igneous rock, and an examination of the country around the oil seepages near Kyaukwet and Seewin shewed that the area was one of great faulting and contortion. In the latter region there is no simple anticlinal structure and the prospects of obtaining oil in any quantity are problematical. One point of some interest was the occurrence here of fossil-wood and marine fossils (*Pecten, Turritella,* etc.) in the same conglomerate.

With the exception of a brief visit, at the request of the Burma Government, to the Taungu stone quarries, the rest of the season was spent on the northern part of the Yenangyat Oil-field. The results of the latter will very shortly be published.

38. With the exception of about two months around Yenangyat and a brief visit to Thayetmyo, this season was spent on the Singu Oil-field, mapping the various fossil bands in the Pegu series. Some of these were traceable for a considerable distance, and could be recognised on both sides of the anticlinal crest. The fossil bands mapped were sufficient to demonstrate nicely the structure of this portion of the fold, and should be of some assistance in drawing the boundaries of the oil pools in the separate sands. Among the fossiliferous bands is one noticed by Grimes as the basal bed of Noetling's Yenangyaungian stage, consisting of a fissile clay containing sandy nodules, in each of which is found a cast of a fossil, usually *Tellina* or *Cardium:* these nodules recall forcibly the "box-stones" of the English Red Crag. Another easily recognisable horizon, low down in the series, is characterised by abundance of the coral *Dendrophyllia macroriana:* this horizon was also identified at Yenangyat. Several specimens of *Batissa kodaungensis* were found along the Pegu-Irrawadi boundary bed in block 28, Yenangyat. In block 31, Yenangyat, many specimens of a *Melania* were found in the red boundary bed. Two or three dip-faults were traced in the Singu field, the most conspicuous running through blocks 55° N. and 56° N. The boundary also between the Pegu and Irrawadi series (both in Singu and Yenangyat) is described as a strike fault.

M. R. Ry. S. Sethu Rama Rau.

39. Mr. Cotter has published an account of his observations on the Tertiary strata in the Taungtha hills in the Myingyan District. He finds the structure of these hills to be that of an asymmetric saddle-shaped anticline, or a single fold comprising two united elliptical domes, the direction of the axis being 30° west of north. Faults occur, but the most interesting point observed was the nature of the asymmetry of the anticline. Contrary to the usual condition, it is the dips on the west of the crest which are steep, while those on the east are gentle.

Results published.

Taungtha Hills.

The hills consist of Pegu beds as shown by fossils and the occurrence of selenite. The rocks have been subjected to considerable pressure, and Mr. Cotter concludes that the prospects of obtaining oil in this area are poor, owing to contortion and faulting (*Rec., Geol. Surv. Ind., Vol. XXXVI, Part 3, p. 149*).

40. Mr. Cotter has also summarised his work on the southern part of the Gwegyo hills, including the Payagyigon-Ngashandaung Oil-field (*Rec., Geol. Surv. Ind., Vol. XXXVII, Part 3.*)

Gwegyo Hills.

The field-work was undertaken in December 1907 and January 1908 in order to obtain some idea of the prospects of oil-prospecting at this end of the Gwegyo anticline. The most characteristic feature in the Pegu beds is the great predominance of soft shale over sandstone, and the consequent flatness of the country. The thickness of Pegu rocks exposed near Nyaungnigyin is perhaps over 4,000 feet, and the junction of these beds with the Irrawadi sandstone on the east is a faulted one. In the Payagyigon-Ngashandaung area the eastern junction is faulted in an exactly similar manner, and the western junction is probably an unconformable one: the fault, as in the northern part of the anticline, appears to have occurred along or very close to the crest. Numerous fossils, including two species of Nautilus, were found in this southern area, and the evidence points to a marine origin for these beds. Oil has been obtained here, but the prospects of obtaining it in paying quantities are poor. A remnant of the crest of the fold exists in block 5, but the anticline is pitching southwards.

The Twinza Reserves.

41. My services were placed at the disposal of the Government of Burma from the 1st September to preside over a Committee appointed to investigate the present conditions of exploiting the Twingôn and Bémé Reserves in the Yenangyaung Oil-field, to examine the alleged dangers arising from flooding, fire and wasteful methods of working, and to make proposals for the better government of the field.

After examining the information obtainable from the companies' agents at Rangoon, the Committee proceeded to Yenangyaung and collected information on the ground.

The reserved areas of Twingôn and Bémé cover jointly an area of about 450 acres, lying about ¼ mile apart, and separated from each other by the Khodaung block which is leased to the Burma Oil Company. The surface area of both Reserves is intersected by deep ravines, many of them having precipitous sides. The Twingôn Reserve having proved to be, by far, the richer in oil has been most thoroughly exploited, and it is in this area only that the close drilling and dovetailing of independent companies with the Twinzas (still working with the primitive system of hand-dug wells) is distinctly marked; it is consequently in this area only that the dangers feared are imminent, especially in the central part of the Reserve known as the Aungban. At the time of the Committee's visit there were 145 drilled wells in this Reserve together with 333 Burmese hand-dug wells, and of the drilled wells 76 were concentrated

on an area of only 46 acres in the Aungban. In this section of the Reserve sites of only 60 feet square were valued and sold at prices often exceeding Rs. 40,000.

The Committee were convinced, as the result of examining the history of numerous wells, that those in close proximity often drain the same oil-sand below, and consequently affect one another in production. The sand-banks in which the oil is stored appeared, however, to be so irregular in shape that no constant rule could be laid down for the way in which the adjoining wells affect one another's supplies of oil; but it was evident that cases of mutual interference were sufficiently numerous to impress the companies with the desirability of rapid drilling in competition with their neighbours; consequently hasty drilling incurred dangers of fire, and (by the imperfect shutting off of oil-sands) danger of water penetrating and interfering with the productive capacity of the oil-sands.

As regards the dangers of fire the Committee noticed that no attempts were made to provide lightning conductors for the tall wooden derricks, and no guy-ropes were provided to pull the derricks over in any safe direction during fire. The oil in the receiving tanks near each derrick was measured by the use of a dip-rod inserted through a hole in the cover of the tanks, and the measurements being made by uneducated subordinates, who were only partially aware of the dangers involved, considerable risk was incurred by the use of naked lamps at night. Forges for dressing bits and boilers for driving the pumping and drilling engines were scattered indiscriminately among the wells, and were a source of constant danger in consequence of the frequent incoming of new spouting wells. The hand-dug Burmese wells were distributed irregularly among the drilled wells and were worked by people who are habitual smokers under conditions that would lead to a serious loss of life in case of any widely-spread fire. Casual strangers and pedestrians ignorant of the dangers around them were allowed free access to the congested part of the field. No provision had been made for the cutting off of flowing wells during fires, and the whole area was covered naturally with a network of oil and gas pipes. Although the drillers were generally fairly cognisant of the dangers around them, and a general understanding had been established as to the precautions that ought to be observed, it was evident that in a field already congested and likely still more to be developed with sharp competition, there was urgent necessity for detailed and exact regulations.

It had been alleged that, in consequence of the rapid exploitation of the oil, there was a tendency for the sands to become clogged by paraffin,

with a consequent reduction in the total quantity of oil obtainable by drilling; but the committee found that the deposition of paraffin could not in any way reduce the amount of oil finally extracted from the field.

A number of schemes were discussed for the resettlement of holdings in order to divide the interests into sufficiently large areas to prevent the ill-effects of competition and consequent hasty drilling. They found, however, in consequence of the objections raised by the companies themselves and the difficulty of treating the *Twinzayos* equitably, that the present system of ownership could not be disturbed, and that it was possible only to take steps to regulate the work of oil-winning in the Reserves. They consequently drew up a series of proposals for enforcement through a new Regulation. They suggested the appointment of a Warden for the field, who would have the powers and duties of a first-class magistrate, and they suggested that he should be assisted by an Advisory Board composed of one officer of the Geological Survey together with two members nominated by the Oil Companies themselves. They made proposals for the allotment of new sites and for the distribution of those sites which had been resumed by Government in consequence of breaches of the conditions under which they were originally allotted. They also formulated rules for the control of operations whilst drilling through water-bearing sands, and for governing surface operations likely to incur danger from fires. Proposals were also made for revising the form of grant in order to make it consistent with the new regulations. The companies having unanimously agreed provisionally to accept the proposed regulations, steps are now being taken to put the proposals into law by the Burma Government.

Punjab.

42. At the request of the Punjab Government, Mr. Daru while in the Mianwali district studying the alum shales, also visited the oil-springs at Jaba in the same district. The total monthly output from ten springs is about 50 gallons only of thick, dark-green, sulphuretted oil. He found the strata to be so disturbed that he doubted the feasibility of obtaining larger supplies.

Salt.

Rajputana.

43. In the General Report for 1907 (*Records, Vol. XXXVII, p. 37*) reference was made to the theory which I had offered to account for the origin of the salt accumulations in the Rajputana desert. Dr. W. A. K. Christie having

designed the apparatus required to sample the desert winds and having made a series of preliminary tests under Laboratory conditions, volunteered to undertake the work in the desert during the hot weather of 1908. He set up his apparatus near Pachbadra (25° 55′ N.; 72° 11′ E.) in April and carried on daily observations until early in June when Sub-Assistant Vinayak Rao carried on the field work alone. Both officers deserve the greatest praise for the way in which they cheerfully faced the hardships of camp life in the desert during the hottest part of the year.

Observations were made throughout each day regarding the speed of the wind and the atmospheric temperature and pressure. Samples were collected at regular intervals until the burst of the monsoon in July, and these, with samples of sand and rain, were afterwards investigated by Dr. Christie at headquarters. A joint paper will shortly be issued by Dr. Christie and myself detailing the results of this interesting enquiry, and the following are our chief conclusions:—

It has now been shown by actual observation during the hot weather that large quantities of sodium chloride in the form of fine, dry dust are carried into the desert region of Rajputana from the south-south-west. Concluding from the daily observations made at Pachbadra during the hot weather of 1908, the amount of salt passing a front 300 km. broad and 100 m. high during the four hot-weather months might be indicated as 130,000 tons. The hot weather of 1908 was a season of unusually weak winds, and this figure (which has little more than qualitative value) is probably well below the annual average influx of salt dust.

When it is known that these hot winds blow steadily towards the north-north-east for three or four months every year, that they are strongest (often attaining the speed of gales), during the day time when the salt dust is dried by the scorching sun under a cloudless sky, that there is no reflux and very little variation in direction, with a gradually diminishing speed as the heart of the desert is approached, and that the period of hot, dry, southerly winds is followed always by a downpour of rain, with the formation of a lake in each small area of internal drainage in the Rajputana desert, it is easy to account for the great accumulations of saline silt which are left after the annual desiccation of the salt lakes.

These winds from the south-south-west blow over the arm of the sea known as the Ran of Cutch, which is covered with a layer of white salt during the hot, dry season. Every disturbance of this crust by pedestrians and animals helps to form the salt dust which is wafted away towards Rajputana. The winds blow strongly in the day time, with a lull at nights, but the movement is all in one direction at the time of year when the dust is dry and can be carried most easily; and there is no set-back until after the monsoon period of rain, when all the finely-divided salt dust that may have reached the heart of the desert is washed into the hollows occupied by brine lakes. The strength of these winds is indicated by the fact that small

foraminifera have been carried bodily (not rolled) as far as 500 miles inland from the coast of Cutch.

An idea of the quantities of salt to be accounted for is given by a special examination of the Sambhar Lake: the silt of this lake partly fills a depression in the Aravalli schist "country;" it has been shown by two borings that the silt is about 70 feet thick in places, and, as the result of detailed samplings at regular intervals, it has been shown that the uppermost 12 feet of this silt over an area of 68 square miles includes 55,000,000 tons of sodium chloride. There are many other smaller salt lakes of the Sambhar type on the Rajputana highlands, and there may be many such bodies of silt buried under the mantle of sand.

We consider that the action of the wind alone is sufficient to account for the large accumulations of salt in Rajputana. The instance is one of special importance from the circumstance that on the Rajputana highlands no other explanation offered will account for any but unimportant quantities of salt; there are no inflowing large rivers; there are no traces of ancient rock salt deposits; no known saline springs; no likelihood of subterranean water rising to the surface; no probable connection throughout most of the areas lying on the crystalline schists with the water which is possibly percolating underground from the lower-lying Punjab plains towards the still lower depression of the Indus valley.

While admitting that rock-salt deposits may be formed in other ways also, our observations in Rajputana go far to strengthen the evidences gathered by the late J. Lomas and others to show that many rock-salt deposits, like those in the British Trias, are dependent on desert conditions. Large desert-areas are regions of indraught during the hot, dry seasons, when any salt available is easily pulverised. Where these are regions of internal drainage, the salt becomes "fixed" in local hollows after rain; in the Rajputana salt-lake region we find deposits of gypsum, nodular limestone, and plano-convex, lenticular masses of calcareous mud stained black with ferrous sulphide, which, on oxidation would give rise to the red colour so characteristic of the marls and sands associated with rock-salt deposits.

The well known estimates of the age of the ocean made by Professor J. Joly included a ten-per-cent. correction due to the sea-salt carried inland by winds and brought down by rain to add to the quantity carried to the ocean by rivers. References to the salt carried inland by sea breezes have generally assumed that the principal quantities leave the ocean as fine spray; but it appears from our observations that, under special conditions like those in Western India, where a desert region forms the hinterland of a salt-incrusted temporary arm of the sea, far larger quantities of sea-salt may be carried inland as finely divided dust. It is impossible, however, to say from our results that Professor Joly's allowance for sea-salt in river waters should be materially increased. The process by which the salt is formed in the Ran of Cutch tends to eliminate the rarer and more soluble magnesium and potassium salts, leaving the windborne chloride to be more purely that of sodium than would be the result of an inland transportation of simple sea-spray. The iodine and bromine in the Sambhar brines are found to be in a smaller ratio to the chlorine than in sea-water, possibly for a similar reason, but these two halogens bear in Sambhar just the same ratio to one another as they do in the sea.

Tin.

Geology : Mergui Archipelago.

44. Mr. Page continued his survey of the Mergui district, devoting the first quarter of the year to an examination of the archipelago. In these islands granite forms the prevailing rock-feature, and it occurs both in the gneissoid form apparently similar to the usual Archæan gneiss, and in a distinctly intrusive form, the latter penetrating both the older granitoid gneisses and the sedimentaries.

Granites.

The islands in which granite was observed may be divided into six groups :—

(1) The western group, consisting of Moscos, Metcalfe, Great Western Torres, Hayes, Fetcher and Clara. All the intermediate parts of this outer group are also probably granitic. Both kinds of granite were observed in this group.

(2) An ill-defined group comprising the western part of Elphinstone, south-east Elphinstone, Grant, the northern half of Ross, Maingay's and smaller islands as far east as Cantor. The larger portion is of gneissose granite, into which the younger granites, and numerous quartz porphyry dykes have penetrated.

(3) A large domed outcrop, a little south of King's Island Sound, all the south of King's, Mergui, Sellore, Tucker, Julian, and the central ranges of Kissering. In this group gneissose granites predominate.

(4) Parker and Domel down to and including High Island form another series of basal granites ; they may be traced north through the Pickwick group into Cantor and south through the Gregories and down the coast to Victoria Point and the adjacent islands.

(5) Davies Island is apparently an isolated granite outcrop, but extremely bad weather prevented the adjacent islands being carefully examined, and there may be granites in the interior of St. Matthew's.

(6) Koolagyun, and the low islands mostly covered by swamp, which extend for miles down the coast, are composed of granite, usually of the basal variety with intrusive granites and pegmatite veins penetrating them in all directions.

Quartz-porphyries form a very important factor in group 2. They occur intrusive into granites and the sedimentaries. Mount Elphinstone (west coast Elphinstone Islands), the peak on Maingay's, and Cantor are all examples of intrusion into granites; and Hayes, Julia, the extreme south of Cantor and some islands east of Ross show examples of intrusions into slates. Johnny, Paton, Allan and other islands near are composed for the most part, if not entirely, of quartz-porphyries.

Mergui series.

45. Above the granitic rocks there is a series of indurated sandstones, quartzites, slates and schists. These rocks are as a rule much crushed, at times sparsely mineralised, and generally do not cover any considerable area. They are usually met with in small mountain streams. Above these comes a series of slates, sandstones, grits and conglomerates. But they are not always all present, denudation having generally removed the last-mentioned rocks. As far as is known Pataw is the only island formed of conglomerate. The series may be observed in the following groups of islands: Central Kings, some 7 miles from the east coast line, Iron, the north-east of Maingay's island and the adjacent islands, central and north-east Elphinstone, Macleod's, Southern Ross and adjacent islands, the Warden, Christmas, Bentinck, the Five Sisters, St. Luke's, St. Matthew's in parts, Bushby, Father and Son, Lord Loughborough, and Governor Swinton and Cavern are all of sandstone and belong to the lower part of the Mergui series. Hayes, Julia, Cantor (South end) and Sulivan are all slate islands, and may be classed with the above.

In connection with the above sedimentaries, there is a series of sandstones, slates, and breccia-conglomerates which at times exhibit a schistose character, and are difficult to connect with the lower part of the series. They dip irregularly and show the effects of the intrusive granites to a much more marked extent than the older group. These formations may be seen in islands near to and north of Governor Swinton, the small islands south-west of Bentinck, some of the Marien group, islands south-west of Sir William James Islands and in a series of reefs along the east coast of St. Matthew's. In this last case, there are granite boulders, some as much as six feet long, well water-worn, and resting irregularly in a matrix of limestone sands, forming a granite-limestone conglomerate. Subsequent upheaval has given the whole a much crumpled and schistose appearance.

Similar deposits were met with in the Tavoy district in the Hindu

and Gt. Tenasserim rivers; and there are somewhat similar occurrences in the vicinity of the Tavoy river.

Moulmein Group.

46. No rocks were discovered that could be safely attributed to this group. The limestones forming the Eleh ant group and also those on the south-east of St. Matthew's Islands being probably older than the adjacent slates and conglomerates. They are very crystalline and apparently unfossiliferous.

Recent deposits.

47. There still remain three younger deposits which cannot be classed as one, and yet are probably of about the same age. Between them they cover quite a considerable area of the low flat islands, mentioned in group 6 of the granites, and also some of the islands on the south, the swamps and parts of the mainland. They are laterite, a partly cemented boulder-breccia and lithomarge.

They are all shallow, the laterite being seldom thicker than 14 feet, the conglomerates even less, and the lithomarge seldom over 60 feet. They all appear near granite and overlie them and the adjacent slates, schists, etc., of the older Mergui series.

The laterites and the conglomerates are often found associated, as also the laterites and the lithomarges in the more southern parts of the archipelago.

The laterites on Koolagyun and some of the adjacent islands are sufficiently rich in iron to be used as an ore.

The conglomerates when near water often present a deceptive lateritic appearance. In Tavoy district the cementing material of the conglomerate often carries a little gold.

The lithomarges in the vicinity of Yengan-Bokpyin often cover workable tin-bearing gravels, and were probably derived from the older slates, schists, and some of the felspar of the granites. The mottled appearance (red to blue) being due to the oxidation of iron derived from the dark mica, the tourmaline and the magnetite of the granites. The islands, Pumpkin, Pig, the Gregories, Carnac, Collins, Jenkins, etc., all furnish examples of these three younger deposits.

Geological disturbance.

48. Split, crushed and otherwise disturbed rocks, which indicate pressure applied in an east and west direction, are abundantly evident. Nearly all the small islands, composed of sandstones show their strata up on end, and only in the larger islands, *e.g.*, Bentinck, are dips as low as 30° found. The slates are nearly always crushed and penetrated by quartz veins,

and in the case of Hayes Island there are two distinct folds roughly at right angles to one another. Owing to the numerous granite and quartz-porphyry intrusions, it is rather difficult to delineate the principal lines of disturbance through the district, as separate from purely local disturbances.

Cassiterite.

49. Cassiterite is found in gravels on King's, Kissering and Davies Islands. On the first named it has been worked. Kissering is the best of the three and is worth prospecting, the cassiterite occurring within six feet of the surface. The tin on Davies Island, to judge by the places tested in the stream which enters the sea near the south-east corner of the island, would not pay to work. All the granite of sub-group 2 is worth prospecting for cassiterite. Although quartz lodes were frequently found, none carried visible minerals of economic value.

Gold.

50. Gold is found on Horsborough Island and has been worked. It occurs as small flakes in gravels at comparatively shallow depths. On Russel Island there is a series of pyritic veins a little above sea-land which yield 10 dwts. gold on assay. These veins are crossed by several quartz stringers.

Lead and iron.

51. The only galena met with was on the west coast of Maingay's Island and this has already been reported on. Various laterites would furnish a certain amount of iron-ore were there a local demand.

Tavoy district.

52. At the end of March Mr. Page proceeded to the Tavoy district. In this district tin-mining was found to be at a standstill.

The following localities in which stream washing is carried on during the monsoons were visited :

(*a*) Maungmeshaung river.
(*b*) Ongbingwin.
(*c*) The Hindu river and its tributary streams, including the Hinda river.
(*d*) Old workings in the vicinity of the granites near Wagon, and about the village of Pagayé.

The results of investigation hold out no great hopes of the future of a tin industry in this district.

The following is a more detailed description of these localities.

(*a*) *Maungmeshaung.*—In this area washing is carried on also by the most primitive methods. Even ground sluicing is apparently

unknown to the villagers engaged. The cassiterite is derived from the granites as well as from quartz veins at the slate-granite junction. Boulders of each of these rocks carrying cassiterite are to be found in the stream. Apparently two concentrations have taken place, one in which the cassiterite was concentrated on a thin clay layer on the denuded slates, whence they were washed by the present stream. The gravels are irregular, and the concentrated cassiterite will only pay to wash at intervals. European prospectors will find it more profitable to search for lodes in this locality than to work the gravels.

Wolfram is associated with the cassiterite, and occurs in rather large irregular segregations and thin veins in larger quartz veins in the slates.

(*b*) *Ongbingwin.*—At this place the cassiterite occurs in quartz veins; the widest cassiterite-bearing vein found was only 12 inches thick. Cassiterite also occurs in small quartz stringers which have penetrated the sandstones near the granites in directions which cause the sandstones to split in irregular rhomboidal masses. It is probable that most of the cassiterite found in the gravels about the base of the Kehdaung is derived from this source. For a long time to come cassiterite will be concentrated in the streams during the monsoon in quantities that will pay to work. Whether it would pay a company to attack the hill on a large scale is extremely doubtful.

The natives are able to work the gravels only down to about 6 feet, and from one or two who worked with European prospectors, provided with pumps, it was ascertained that the concentrate proper is some 30 feet below the present surface.

In this locality and along the east shore of the Heinza Basin, tin-stone, wolfram, and gold are found. The auriferous specimens collected have not yet been assayed.

(*c*) *The Hindu river and its tributaries* drain a portion of the central range east of Wagon. The Hindu enters the Khamaungthway, and the Hinda the Bean river, each tributaries of the Great Tenasserim. Cassiterite, in quantities that should be payable, exists within a few feet of the surface, and in the valley of the Hindu, gold is found with the tin concentrate. The Golden stream is perhaps the richest known locality, but very little has

been done in exploring to depths over 8 feet. The streams for 15 miles to the north of the Hindu carry gold, but in no case were values obtained that would appear to make it worth while to mine the gravels. From evidence obtained from boulders there is a strong probability of a quartz lode existing between the Hinda and Hindu. The boulders discovered carry tin in payable proportion, and indicate that the lode is at least 30 inches wide. This lode will cross streams which are already leased for lampan workings.

(*d*) At the base of the *granite hills near Wagon* and north of the road there are old workings, and in isolated patches cassiterite, sufficiently concentrated to be worth washing on a small scale, may be found. This locality is approximately south-south-east of the tin-workings on the Maungmeshaung stream. There is a possibility of lodes being found, but pits will be necessary. At Pagayé there are tin-bearing gravels, which are, however, worked out. Some wolfram remains, and was traced to its source in quartz veins some 3 miles up the Sanché stream, a tributary of the Panuk Tein. Here there is a series of almost vertical quartz reefs varying from 30 inches to an inch or two in thickness. Only one of some 50 veins carried wolfram, but this was very rich, the wolfram forming a very large percentage of the lode, which was 14 inches wide.

The quartz veins occur in slate of the Mergui series which is partly metamorphosed to schist. This locality gives promise of future success to the prospector.

Besides visiting the above localities a tour was made from the Tavoy river, in a general south-easterly direction to near Mount Myinmolet-kat and down the Bean river to Myitta. The structure of this region is much the same as that of the archipelago. There are numerous gravel areas which looked as if they might contain cassiterite, but testing them in stream cuttings even down to 14 feet proved unsuccessful.

In the month of November a tour was made across the country from the Tavoy to the coast and along the granite hills to the Heinze Basin. All the high land is granitic, and there are large flats covered by the disintegrated granite sands. Floods prevented panning in the streams, but from the general appearance of the country there should be gravels worth working as well as lode formations near the granites worth testing.

53. There is one geological feature prominent in the Myitta valley that is not met with in the archipelago, and that is a Tertiary deposit which can be traced almost 60 miles north and south, and is some 12 miles wide in parts.

Tertiary strata.

It consists of a series of shales, which dip generally at angles less than 18°. They strike roughly N. and S. and rest unconformably on the denuded older rocks, which form the flanking hills. These shales have numerous plant and fish remains not yet determined. On the shales rest conglomerates, which to a large extent have been derived from granites, and in many places the appearance of the arkose is so deceptive that it exactly simulates a granite. In some localities these conglomerates and shales are interbedded. A sandstone bed is apparently associated with them, and fossil-wood has been discovered in the Ayu stream, a few miles north of Myitta.

GEOLOGICAL SURVEYS.

Baluchistan.

54. Dr. G. E. Pilgrim was engaged during the field season 1907-08 in a survey of the Bugti and Marri country in Baluchistan, paying special attention to the Upper Tertiary fresh water formations from which vertebrate and invertebrate fossils were obtained thirty years ago by Dr. W. T. Blanford and more recently by Major McConaghey, the latter collections being already described by Dr. Pilgrim in *Records, Vol. XXXVI, Part I.*

Dr. G. E. Pilgrim, M. R. Ry. Vinayak Rao.

Dr. Blanford was compelled to limit his work in this area to a mere reconnaissance, and naturally his conclusions, published in *Memoirs, Vol. XX,* need a certain amount of revision after this more detailed examination of the ground, the most important changes being made in the Upper Tertiary fresh-water beds. Although in the northern portion of the area Dr. Blanford had recognised the existence of three distinct formations in the Upper Tertiary—Upper Nari, Lower Siwalik and Upper Siwalik—and had mapped them as far north as Dera Ghazi Khan, he did not recognise the Nari further south, and referred all the fossils there collected to the Lower Siwaliks.

Dr. Pilgrim, however, has found that the lower 1,000 feet of the formation, mapped as Lower Siwalik in the Bugti Hills by Dr. Blanford, is Nari, and is separated from the Lower Siwaliks by a marked unconformity. In the Nari occur anthracotheroid remains, *Aceratherium blanfordi,* and

the remarkable molluscan fauna described by Blanford, while the Lower Siwaliks have yielded *Dinotherium indicum, Mastodon angustidens* and *Mastodon pandionis*. Dr. Pilgrim has made from the Nari beds a large collection of bones and teeth, which he has partially examined and briefly described. Although the wealth of species is not great the fauna clearly indicates an Aquitanian age. With the *Rhinocerotidæ* anthracotheroids (and in especial the genus *Brachyodus*) dominate the fauna. Representatives of the genera *Dinotherium, Tetrabelodon, Macrotherium, Cephalgale, Amphicyon* and *Pterodon* occur. Full descriptions of these will appear later. At the base of the series there occurs fairly constantly and over a wide area a band of marine rocks containing characteristic Nari nummulites. The marine beds pass gradually upwards, through estuarine strata containing mammalian bones and oysters, into true river deposits. Lithologically these beds are similar to the Naris of Sind, and especially to those exposed at Bhagathoro, near Lehwar. The greater coarseness of the sandstones and the abundance of ferruginous matter renders them readily distinguishable from the Lower Siwaliks.

There is a close lithological resemblance between the Lower Siwaliks of Sind and those of Baluchistan, the most typical beds being certain concretionary conglomerates with clay pellets, and there is no doubt that the fossiliferous horizons in the two areas are identical.

The occurrence of *Tetrabelodon angustidens* fixes an Upper age limit for the Lower Siwaliks in the Sarmatian, while a consideration of their fauna, as compared on the one hand with the Nari and on the other with the Middle Siwaliks of the Potwar in the Punjab, inclines Dr. Pilgrim to think that they are most probably of Tortonian age.

The Middle Siwaliks were not found in the Bugti and Marri hills, the characteristic Upper Siwalik brown sands and clays, conglomerates and boulder beds resting unconformably either on the Lower Siwaliks or on the Nari.

55. Post Tertiary deposits, differing but little in appearance from the Upper Siwaliks, but horizontally bedded and often resting unconformably on the latter, were seen in many places. Dr. Pilgrim considers that many of them like the older portion of the Indus alluvium, are of Pleistocene age.

56. The division between the Lower Tertiary Kirthar and Laki series was recognised and marked on the map, which also covers a small area of the Cretaceous formations which, a little further north, have furnished the well known Mazar Drik collections.

Central India and Rajputana.

Linking up with older work to north and north-west.

57. In the last General Report the hope was expressed that the then ensuing season would witness the linking up of the work with that completed many years ago to the north and north-west by Messrs. Hacket and Kishen Singh.[1] To a certain degree this has been realised: at several points the new survey has come into touch with the old one, so that the early months of the current season should see the junction complete. The junction is, however, a superficial and provisional one only; there still remains the difficult and delicate task of accommodation and revision along the boundary between the old and the new, and this may further necessitate revision of parts within the old surveyed tract, which has only been very generally described by Mr. Hacket (*loc. cit.*) In that paper, also the various sub-divisions of the Vindhyan system (including the Lower Vindhyan shales and the Kaimur, Rewah and Bhander series) are described as having been recognised, whilst the large-scale maps contemporaneously produced represent these same sub-divisions with the utmost nicety—although no convincing reasons are given for correlating them thus minutely with their supposed far-distant eastern equivalents, from which in fact their outcrops are separated by enormous areas of obliterating Deccan Trap and alluvium. With no fossils to guide and with discontinuous outcrops, the arbitrary splitting up of them in this western area to accord categorically with the divisions in the typical eastern area appears unwarranted, as it may also be very misleading.

The Central India party has already been compelled to make use of one tentative grouping of the Vindhyans in the neighbourhood of Bhopal, a grouping which has only with some reserve been proved to hold across the intervening area between it and the typical region; whilst for detached outlying masses separated from the main outcrops by many miles and buried in a sea of trap it was occasionally found necessary to be content with marking the outcrops simply as "Upper Vindhyan." In conformity with this caution, and from what has been already seen of these western representatives of the Vindhyans near Rampura and Neemuch, we are at present unprepared to accept without further enquiry the sub-divisions originally given them by Mr. Hacket.

[1] Mapped on the 1″=1 mile scale and briefly reported on, *Rec., Geol. Surv. Ind., Vol. XIV, Part 4, p. 279 (1881).*

58. The work done last season includes the completion of sheets 211 (already begun in the preceding season) and 210. Sheets 239, 240, 241, 271, 272 and 273 were also completed with the exception of the portions of Gwalior State within them. Sheets 177, 178, 208, 209, 238, and 270 were partially surveyed. The area embraces portions of Rutlam and Sailana, Banswara, Partabgarh, Jaora, Sitamau, Dewas and Indore.

Area surveyed.

59. The Aravalli series, already touched for the first time during the previous season, were again further explored along the westward margins of the Deccan Trap, but even this further acquaintance with them is not yet sufficient to warrant any generalisations of importance. A number of highly inclined bands of different rock types, all having a metamorphic or crystalline character and striking roughly north-north-west—south-south-east or north-west—south-east build up a sort of platform at the 900 feet level, on which the horizontal layers of Deccan Trap come to an end in their westward extension as fringing scarps or as detached outliers. In the Progress Reports sent in by Mr. Middlemiss and Mr. Heron much detailed information is given regarding the slates, phyllites, schistose conglomerates, mica-schists, quartzites, horn-blende-schists, crystalline limestone bands and the curiously related limonite-quartzose or cherty bands with in some cases grünerite, mixed gneisses, granitic gneiss, porphyritic hornblende syenite-gneiss and acid pegmatites, etc., but with the exception of a provisional attempt to map some of the crystalline limestone and ferruginous cherty layers which build a set of rocky ridges following the usual strike, no endeavour has yet been made to separate the series as a whole according to age or mode of origin. Having only so far been seen in the bottoms of the valleys cut out among the trap plateau, or in the vicinity of its western margin, it seems premature to attempt any such comprehensive classification for the present. Among such difficult rocks it will be necessary to proceed slowly and with caution, for some time to come. Nevertheless there is but little doubt that the rock series here called Aravalli represent the series of the same name as defined by Hacket, at least in the main; but whether any of the quartzites should be separately grouped with the much younger Alwar or Delhi series which along certain lines in the Aravalli range has been described by Hacket as caught up in folds among the older Aravalli schists, it is impossible to say. It is equally uncertain whether or not

Aravalli series.

the mixed gneisses are the equivalents of those referred to as "gneiss" by Hacket and coloured separately by him on his maps. Mr. La Touche in his more recent survey of Western Rajputana (*Mem., Geol. Surv., Ind., Vol. XXXV, Part I, p. 6*), found the rocks west of the Aravalli range, marked "gneiss" by Hacket, to be granites of two distinct ages, namely, the Erinpura and Siwana granites, differing widely in texture and composition. It seems quite likely, from what has already been seen during the past season, that there may well be exposed in this region both ancient Archæan gneisses and later eruptive plutonic masses.

Delhi series.

60. Standing apart from the quartzites enfolded among the crystalline schists, and outcropping at much higher elevations among the Deccan Trap plateau to the east-north-east of Partabgarh town, occur a set of nearly horizontal quartzites or quartzitic sandstones and siliceous shales forming bare scarped hills. They represent one of the points of actual junction between the present and the old surveys, having been identified by Hacket and marked on his published map as the southernmost extension of his Delhi series. The same rocks are stated by that author to be overlaid unconformably to the north beyond Neemuch by the shaly series which he marks as Lower Vindhyan. The former were examined by Mr. Middlemiss' party, but the question of their relation to Hacket's Lower Vindhyans was not then gone into, and remains one of those that must be taken up immediately for important stratigraphical reasons. The first of these reasons is connected with the general doubts which have already been alluded to concerning the strict applicability of the sub-divisional scheme adopted by Hacket for his Vindhyan system. The second reason is that two earlier observers, Medlicott and Mallet, each referred the so-called Delhi quartzites to the Vindhyan system in the first instance, although the former afterwards expressed himself as satisfied with Hacket's relegation of them to the much lower Delhi series (see *Rec., Geol. Surv. Ind., Vol. XV, Annual Report, p. 3*). The impression now obtained of these strata is in favour of the earlier view, or at least that there is not sufficient difference between them and the Rampura scarp of Hacket's Kaimur to place them in separate systems. They are found to be not very strongly altered, the original rounded grains, the pebbles and other evidence of a sedimentary origin being quite appreciable to the naked eye.

Quasi-organic remains.

In some yellowish or pinkish siliceous shales locally becoming calcareous, which lie beneath

the coarser quartzose rock, some very obscure leaf like impressions were noted and some markings, including rows of pittings of very much the same nature as those described and figured by Mr. Vredenburg (*Rec., Geol. Surv. Ind., Vol. XXXVI, Part 4, p. 241*) from the Pab and Vindhyan sandstones of other localities. None of these shales show any mineralisation or foliation. Whatever be the final judgment as to the age of these beds, it is quite clear that they can have nothing in common with the phyllites and other schistose rocks found in the lower zone of so-called Aravallis as just described further west below the crest of the Deccan Trap plateau.

Lower Vindhyan, or Suket Shales and Kaimur scarp (Hacket and Kishen Singh).

61. The next point where this survey touched the old mapped area is near Kukresor and Rampura in northern Indore, where Hacket's and Kishen Singh's Lower Vindhyan (or Suket) shales and Kaimur quartzite scarp occur. These rocks were examined by Messrs. Middlemiss and Jones, and they exhibit the shales everywhere in conjunction with the Deccan Trap plateau to the south; so that it was impossible to know what came immediately below them. Mr. Jones has made a careful study of these two formations and filled in the gaps in the mapping left over by the earlier survey. His Progress Report is amply illustrated by photographs and drawings.

The shales may be concisely described as being much softer than those below the Delhi quartzite. They are also generally much more fissile, breaking up into little cakes, not into splinters. Their colours vary from a drab or buff on the lower slopes of the scarps to darker and sometimes chocolate, purple and green tints in the lower river-bed sections. They are so soft and fragile that one can hardly make a specimen of them. Glauconite-bearing bands occur high up under the quartzitic scarp, and harder, micaceous, flaggy beds and free-stones (much used for building purposes) occur at lower horizons, with some rare calcareous beds, showing 300 feet at least, the base not being attainable. They lie practically horizontally but with small, sudden warpings and puckerings. There are no traces of porcellanic beds (compact fine ash, see *Mem., Geol. Surv. of Ind., Vol. XXXI, Part I, p. 93*) which in the Son valley sections characterise the Lower Vindhyans, and there are also no important limestones to correspond with the Rhotas and other limestones of the typical Lower Vindhyan area.

Fossils.

62. It may well be that the survey of this area may best be signalised by the finding by Messrs. Middlemiss and Jones of some very minute organic bodies

in these shales. Mr. Jones, who subsequently examined them more carefully in Calcutta, describes them as small concentrically wrinkled discs of carbonised chitinous substance, and he thinks it not impossible that they may represent the genus *Obotella* or *Chuarsa circularis*, described by C. D. Walcott from Pre-Cambrian rocks of Arizona[1] or possibly the operculum of *Hyolithellus*.[2]

Quartzite scarp (Kaimur of Hacket).

63. The quartzite scarp which follows above these shales is a very striking formation, building a wall-like rampart, and stretching as far as the eye can see. It is a quartzite rather than a sandstone, not unlike some of the Delhi quartzite just described, but without being identical in any particular. It breaks with roughly conchoidal fracture and may be trimmed into good rough blocks, suitable for building purposes, but it cannot be got out in slabs like the typical Kaimur.

Detached blocks.

64. A curious set of rather small outliers of this quartzite occur generally some way south of the main scarp and at a much lower elevation, lying on the Suket shales not far from the Deccan Trap boundary. These outliers, according as they approach the Deccan Trap boundary more nearly, become of the nature of isolated crags or blocks arranged in clusters on the summit of gentle rises in the shales. An enormous number have been mapped by Kishen Singh, but many more would require delineation. Their most remarkable feature is their disturbed dips near the edge of the trap plain. The disturbance is not uniform. From block to block, separated perhaps only by a few feet, the dips vary widely in amount and direction. The whole at first sight presents an appearance of chaos. A number of these were plotted on a large scale by Messrs. Middlemiss and Jones.

Lametas.

65. Lametas were found at one place only by Mr. Heron on sheet 214, forming an irregular horizontal shelf, unconformable on the metamorphics. The bed is 10 feet thick and composed of impure, pale-purple limestone with grains and pebbles of quartz.

Deccan Trap Intertrappeans, Laterite, etc.

66. The great spreads of Deccan Trap (with its occasional intertrappeans and cappings of laterite) was naturally met with over very large areas surveyed during the season. Its characteristics remain much as

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[1] Bull. Geol. Soc. of America, Vol. X, p. 234 (1899).

[2] Bull. Geol Soc. of U. S., Vol. IV, p. 141 (1886), with Pl. XIV, fig. 2 *c*.

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before, and a number of separate studies of individual occurrences have been made and submitted in the reports by Messrs. Jones and Heron, with numerous sections and photographs in illustration of the chief fact. Intertrappeans were met with principally in parts of north-west Jhalawar and thin bands of clay were also noticed at a few places. Laterite occurs largely as cappings to small hills, principally in the States of Jhalawar, Rampura and Sitamau, with occasional masses of residual blocks and lateritic gravel. In some cases Mr. Jones has described rock dwellings cut out of the laterite, and rock temples, such as the Dhamnar cave temples, where the laterite is about 60 feet thick.

Peculiar position of the trap.

67. With reference to remarks made in a previous General Report (*Rec., Geol. Surv. of Ind., Vol. XXXIII, Part 2, p. 108*) on the subject of the almost universal absence of recognisable outliers of trap on Vindhyans, it may also be noted that in the area surveyed last season the same peculiarities are equally prominent. It is almost impossible ever to find a denuded natural section cut out of trap and showing Vindhyans below. But the case is entirely different as regards the behaviour of the trap to the Aravallis. In this case the usual position at the margins is to find the former as outliers capping hills of steeply-dipping schists, or running out as a sheeting on long spurs from the main plateau. An explanation of this anomaly is still wanting, but the theory advanced by Mr. Middlemiss that local extrusion with fissure eruptions may sometimes explain the extraordinary positions of the trap to the Vindhyans seems to be supported by what has been written above regarding the detached blocks of Kaimur sandstone on the Suket shales near the trap margin. We might understand it on the assumption that large sections of the Vindhyan country subsided *en masse*, with a corresponding welling up of the molten trap to some level of equilibrium. The margins in such a case would be liable to much disturbance, slipping and disintegration. In this connection it may be noted that the only place where the Delhi series near Partabgarh show steep dips is just at their junction with the trap south-west of Malhargarh, where they suddenly curve over to a vertical position.

Central Provinces.

Mr. P. N. Datta.

68. The work in the Central Provinces was directed as before with a view to filling in the gaps in the general geological map. Mr. P. N. Datta spent the whole season mapping previously unsurveyed ground in the Chanda district. A small portion of this district in the neighbourhood of

Brahmapuri (20° 35′; 79°55′) had been examined towards the close of the previous season (1906-07), and survey work was, therefore, extended from this point eastwards, south-eastwards and southwards.

The larger portion of the area examined was found to be occupied by Archæan crystalline rocks; but Mr. Dátta also mapped exposures of sandstones referred with hesitation to the Vindhyan system in some cases, and with doubt to the Gondwanas in others, as well as quartzites of probably Vindhyan age. Among the schists there are exposures of rocks resembling the typical Dharwars. A band of these, traced during the previous season as far as the latitude of Munjewara (20° 30′; 80° 8′) was followed to its termination at Wyragarh (20° 26′; 80° 9′). In the northern parts of this band, which lies partly in Bhandara and partly in Chanda, the rock varies from micaceous schist to argillite which shows little signs of alteration. Near Wyragarh these rocks strike roughly north-west to south-east and stand at a high angle. The general mass of crystalline rocks include ordinary gneiss, hornblende schist and mica-schist with occasional quartzitic rocks. These rocks occupy the lower levels, and are consequently covered by a mantle of cultivated soil, which effectually hides large areas. The eastern half of the area surveyed is occupied by rocks of a distinctly granitic character, the granites sometimes being porphyritic. Outcrops of quartz rock form prominent hills, the general geological character being not unlike that of the typical Bundelkhand areas.

Iron Ores.

Mr. Datta has drawn attention to the iron-ore deposits near Lohara (20° 24′; 79° 46′) in the Chanda district which were described by the late T. W. H. Hughes in 1873,[1] and to some other smaller occurrences of hematites. These are rich in iron, but were considered by Messrs. Tata Sons & Company to be insufficient in quantity to support any large industry conducted on a modern scale. The only other materials recorded as of possible economic value are the building stones of various kinds obtainable from the sandstones, crystalline rocks and laterite.

Kashmir.

Mr. C. S. Middlemiss.

69. The remarkably interesting discoveries in Kashmir bearing on the age of the Lower Gondwanas have been described in previous Reports.[2] During the past year Mr. C. S. Middlemiss added very materially to the

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[1] *Rec. Geol. Surv. Ind.* Vol. VI, 77.

[2] General Reports for 1902-03, 1903-04 and 1906. See also H. H. Hayden, *Rec. Geol. Surv. Ind. Vol. XXXVI.* pp. 23—39, 1907.

value of these discoveries by his unexpected find of a more complete and richly fossiliferous section in the Golabgarh pass, on his march from Jammu across the Pir Panjal range into Kashmir.

In this section Mr. Middlemiss found clearly displayed in a closely-folded syncline resting on the Panjal volcanic series :—

(*i*) Limestones, without recognisable fossils, corresponding in character and position to the Triassic limestones of other sections ;
(*h*) Black shales with *Spirifer Rajah*, 10 to 20 feet thick ;
(*g*) Earthy, micaceous sandstones with *Marginifera*, 300 feet thick ;
(*f*) Black shales, thin bed ;
(*e*) *Protoretepora* limestones, 200 feet thick with abundant fossils ;
(*d*) Earthy and (above) calcareous sandstones ;
(*c*) Sandstones and carbonaceous shales, with Lower Gondwana plants, 400 feet thick ;
(*b*) Siliceous and carbonaceous shales, 180 feet thick ;
(*a*) Basal conglomerate, 6 feet thick.

These beds form an apparently conformable series, from the basal conglomerate resting on the Panjal volcanics up to the limestone of probably Triassic age. The chief interests are centred in the beds (*c*), as in these beds Mr. Middlemiss found, in addition to *Gangamopteris* previously recognised in the Kashmir valley sections, two or three species of *Glossopteris*, with the supposed rhizome *Vertebraria indica*, and groups of leaves resembling those of *Psygmophyllum*. The *Glossopteris* remains were found in the higher beds of the series, and the order is that of the lowermost Gondwanas of the Peninsula – the Talchirs and the lowermost of the coal-bearing series, distinguished as the Karharbari beds.

Mr. Middlemiss re-examined several previously described sections of the Zewan beds and associated strata in the Kashmir valley and demonstrated beyond doubt that the Lower Trias, formerly thought not to exist in Kashmir, is present and is richly fossiliferous in places. The results of these observations are described with characteristic clearness and charm in a special paper.[1]

[1] C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, *Vol. XXXVII, Part 4.*

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[1] C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, *Vol. XXXVII, Part 4.*

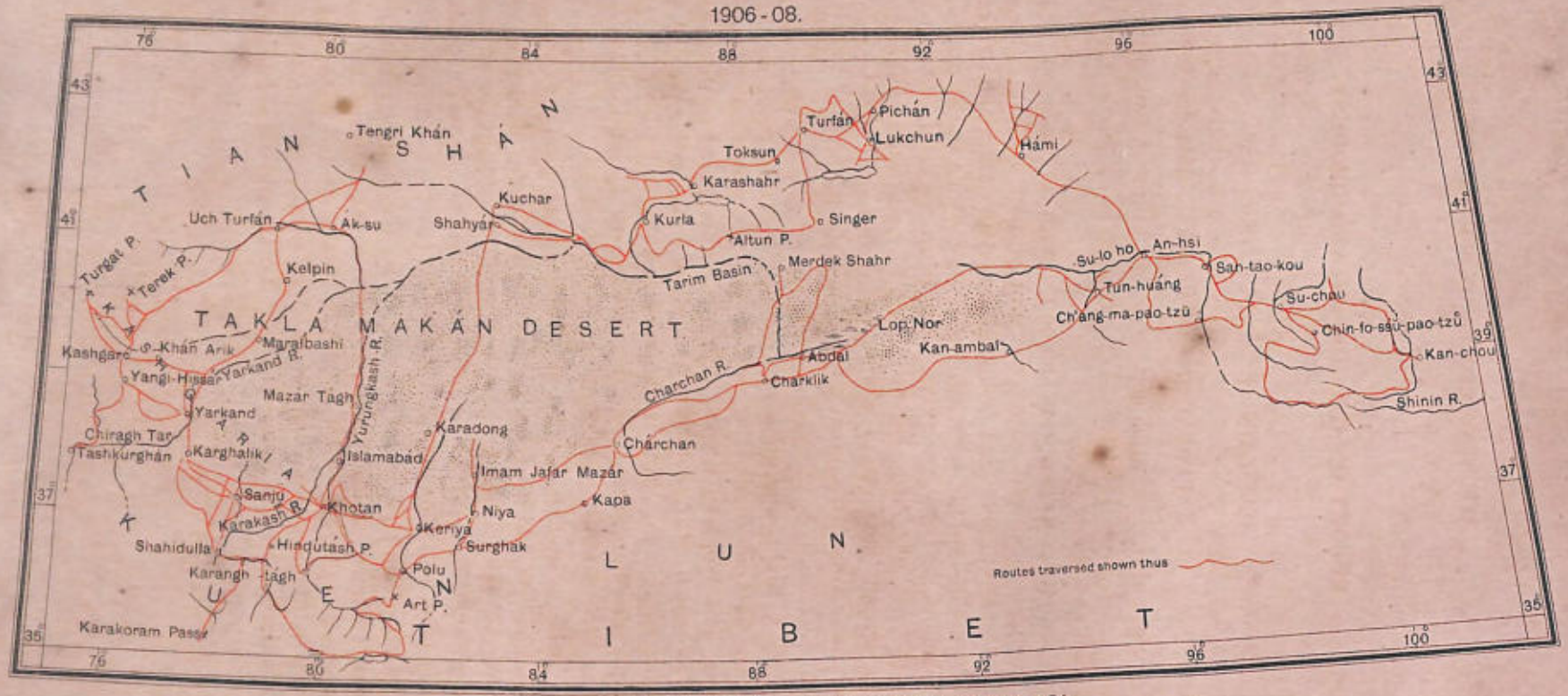
EXPLORATIONS IN CHINESE TURKISTAN & KANSU

BY

Dr. M. A. STEIN AND SURVEYORS RAM SINGH & LAL SINGH

in

1906 - 08.



Heliozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún.
December 1909.

REPORT ON GEOGRAPHY AND GEODESY.

BY

CAPTAIN H. H. TURNER, R.E.

EXPLORATIONS IN CENTRAL ASIA.

The close of the year 1908 witnessed the return of two distinguished explorers, Dr. Sven Hedin from Tibet and Dr. M. A. Stein from Chinese Turkistan and Kansu.

Dr. Sven Hedin started from Leh on the 12th August 1906 and made two complete journeys across the greater part of Tibet. He crossed in a south-easterly direction the great mountain ranges and overcame by his indomitable courage all obstacles. When, owing to the opposition of the Tibetans, he was prevented from returning from Shi-ga-tse by a northerly route, he made his way back to Leh, thence again set out on his second journey and worked his way south in order to obtain a better knowledge of the great range of mountains north of the Brahmaputra.

Dr. M. A. Stein in addition to obtaining rich stores of archæological treasures has contributed largely to our geographical knowledge of Chinese Turkistan and Kansu. He was accompanied in the earlier part of his journey by Rai Sahib Ram Singh and on the latter portion by Rai Bahadur Lal Singh. Both these men, surveyors of the Survey of India, are experienced explorers; with their assistance Dr. Stein was enabled to bring back detail surveys of much of the country.

Dr. Stein started from Chitral in the spring of 1906, crossed the Baroghil and Wakhjir passes to Kashgar; thence, taking an easterly direction, he skirted the southern edge of the great Tarim basin and passing through Western and Central Nanshan, arrived at his most easterly point Kan-Chou in August 1907.

In passing from the great Tarim basin to the higher level of Kansu the route followed a well-marked depression, which gradually narrowed into a regular valley descending from the north-east and water was easily obtained by digging wells. Dr. Stein considers that the presence of this valley indicates that the waters of the Su-Lo Ho and Tun-Huang rivers at

one time made their way down to Lop-Nor. This would make the original eastern limit of the great Tarim basin extend as far as meridian 99°, that is 7 degrees beyond its present limit. Beyond this valley the expedition came to a wide basin enclosed on the north by the Kuruk Tagh range and to the south by ranges of dunes; within the basin were a succession of dry lake beds with high clay terraces between and around them. The lake shown on the map as Kara-Nor, where the Su-Lo Ho and Tun-Huang rivers were believed to end lay still more than a degree to the east, yet this was the only source from which the great basin could be filled. It was discovered later that a considerable river flows out of the Kara-Nor during the spring and summer floods and, after draining a series of small lakes and marshes, carries its waters through to these lake beds.

The return journey was commenced from Kan-Chou early in September 1907. From An-Hsi the expedition made its way across a stony desert *viâ* Hami along the southern slopes of the Tian Shan range to Turfan, from thence it passed through Karashahr to Kurla and along the northern edge of the Tarim basin to Kuchar. The expedition then struck across the Takla Makan desert to Keriya; this journey was nearly leading to fatal consequences; before the party reached the point where the Keriya river dies away in the sandy desert the water supply was almost exhausted and the ration for some days had been only one pint per diem a man. The Keriya river was found to have formed a new bed a considerable distance to the west of the one given by Hedin. From Khotan the desert was recrossed to Ak-su *viâ* the Khotan river. Thence the expedition again returned to Khotan *viâ* Yarkand and, after some final surveys in the Kuen Lun range, made its way over the Karakoram range to Leh. It was in carrying out this last survey work that Dr. Stein had the misfortune to get his feet frost bitten. After undergoing an operation at Leh, he was enabled to continue his journey, finally reaching India in December 1908. Dr. Stein, in spite of his anxiety to reach England and the pain that he was still suffering from the effects of his operation, did not leave India until he had personally brought the services of his energetic Surveyor-Assistants to the notice of the Government of India and secured them ample rewards for their labours. This recognition of his assistants' work is much appreciated not only by the surveyors themselves, but by the Surveyor-General and other members of the Survey of India. Dr. Stein has now recovered the use of his foot and it may be hoped will be able to carry out further exploration work in the future.

Dr. Stein's own route between Mastuj and Leh amounted to a total distance of some 6,500 miles. The route has been mapped throughout by plane table traverse either by Dr. Stein himself or by one of his survey assistants and in addition the following detail surveys have been made :—

Rai Sahib Ram Singh commenced with a survey of the eastern slopes of the Muztagh Ata peak and of the head waters of the rivers between Tashkurghan and Yangi Hissar continuing it from Kizil Bazar to Kok-Yar.

He then obtained a survey of the Karakash river to Sumgal above Shahidulla and the watershed between that river and the Yurungkash. He crossed the Kuen Lun by the Hindutash pass, and made a connection with the work of 1900.

Dr. Stein and Ram Singh then carried out a joint survey of the Nissa Valley in the Kuen Lun range and made an unsuccessful attempt to reach the head waters of the Yurungkash river from the west. Dr. Stein noticed the fact that old moraines in this valley could be traced 3 miles below the present foot of the Kash-Kul glacier.

From Khotan Ram Singh surveyed along the northern slopes of the Kuen Lun and Altyn Tagh ranges as far as Charklik, including a triangulation which he connected with points of Captain Deasy's survey, a most valuable piece of work. On his return journey he continued this survey from Tun-Huang back to Charklik.

In travelling eastward from Tun-Huang Dr. Stein and Ram Singh surveyed the watershed between the Su-Lo Ho and the Tun-Huang rivers in Western Nanshan, then, passing to Central Nanshan, a survey was obtained of the northern mountains of that district. In all an area of 24,000 square miles was mapped between An-hsi and Kan-chou.

On the return journey at An-hsi, Rai Sahib Ram Singh was relieved by Rai Bahadur Lal Singh and the latter obtained surveys in the neighbourhood of Hami and Turfan and of the portion of the Tian Shan range, which lies to the north of these places. He was then employed on a survey of the Kuruk Tagh range from a point directly south of Turfan to Kurla and surveyed the range separating the Karashahr Valley from the Turkistan plains.

From Ak-su Rai Bahadur Lal Singh carried a continuous survey through the outer Tian Shan range as far as Kashgar, while Dr. Stein surveyed the route *via* the Uch-Turfan Valley to Kelpin and on to Yarkand.

Lal Singh then succeeded in mapping the only remaining unsurveyed portion of the northern slopes of the Kuen Lun range west of Khotan.

Finally on the return journey from Khotan to India Dr. Stein and Lal Singh obtained a survey of head waters of the Yurungkash river. A previous survey had demonstrated the impracticability of approaching from the west, the attempt was therefore made from the east, through the confined gorges above Polur to the northernmost high plateau adjoining the outer main Kuen Lun range. Here Dr. Stein obtained a guide and together with Lal Singh made his way through the Zailik valley, and ascended a series of high spurs of the main Kuen Lun range. By establishing survey stations close under the crest line of this range, which here rose to an average height of 20,000 feet, they were enabled to map with theodolite, planetable and photographic panoramas the greater portion of the grand mountain system containing the head waters of the Yurungkash. Thence they carried the survey along the southern slopes of the Kuen Lun over the Aksai Chin, which instead of being a continuous plain was found to consist of continuous snowy spurs with broad valleys between them. They at length struck the old route between Ladak and Khotan travelled by Mr. Johnson of the Survey of India in 1865, when he visited Haji Habibullah, chief of Khotan. This route was traced to the valley, which must have led up to the pass over the main Kuen Lun range, but the route became obliterated at the head of the valley. The explorers, in order to fix their position and link up with former surveys, climbed to a height of 20,000 feet on the watershed. Their descent was delayed till late in the afternoon and on return to his camp Dr. Stein discovered that his feet had been frost bitten.

In addition to the above surveys Dr. Stein has mapped the line of the existing great wall of Kansu and also the line of the old defensive wall The first traces of this latter were found in the desert some five marches west of Tun-Huang and was followed as far as An-hsi, later its extension was traced from its junction with the present great wall at the Chia-yu Kuan gate back to An-hsi. This ancient wall, Dr. Stein considers, dates back to the second century B.C. So long as it runs parallel to the prevailing wind from the east and north-east its preservation is almost perfect; it is evident that the same conditions must have prevailed for the last 2,000 years. He gives a remarkable instance of the permanence of tracks in the gravel soil; all along the great wall he could trace the path of the sentries, who, two thousand years ago, had marched up and down their beat behind the wall. Dr. Stein mentions how the existence of this

defensive line brings out the important geographical fact, that the desert hill region north of the Su-Lo Ho marshes, now quite impracticable owing to the absence of water, must then still have been passable.

The following table shows the difference in position with that formerly accepted of some of the principal places visited by the expedition :—

	Old value of other explorers.		Dr. Stein's new value.		
	Latitude.	Longitude.	Latitude.	Longitude.	
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
Kashgar	39 26 0	75 54 33	39 26 5	75 57 50	Latitude observation by Ram Singh.
Yarkand	38 26 0	77 18 33	38 24 30	77 16 6	Ditto ditto.
Maralbashi	39 46 0	78 43 33	39 46 25	78 25 19	Obtained by plane-table traverse.
Karadong	38 32 0	81 47 33	38 32 29	81 54 15	Latitude observation by Ram Singh.
Charchan	38 10 0	85 23 33	38 8 18	85 34 15	Ditto ditto.
Kuchar	41 45 0	82 59 33	41 42 58	83 10 0	Lal Singh's Latitude observation.
Ak-su	41 13 0	80 43 33	41 8 32	80 2 32	Obtained by 3 separate planetable traverses.
Charklik	39 4 0	88 0 33	39 1 50	88 13 0	Ditto ditto.
Niya	37 6 0	82 44 33	37 3 31	82 45 40	Fixed by triangulation by Ram Singh.
Khotan	37 8 0	79 54 33	37 7 40	79 58 30	Latitude observation by Ram Singh.
Karashahr	42 3 30	86 43 0	42 6 50	86 31 40	Obtained by plane-table traverse.

The Longitude of Keriya, obtained by Captain Deasy from chronometer observations, coincided with Rai Sahib Ram Singh's value, which was obtained by connecting Keriya by traverse with his Kuen Lun triangulation.

Dr. Stein's map consisting of 94 sheets is now being drawn at the Trigonometrical Survey Office, Dehra Dun, on the scale of 4 miles to the

inch. On completion of this map, which contains only the work of Dr. Stein and his assistants, the information obtained by him will be incorporated in the Survey of India Maps.

Apparatus for measurement of geodetic bases.

The Invar wire measuring apparatus, mentioned in last year's report as having been ordered from M. Carpentier of Paris, has been received. The wires have been standardised at the Bureau International des Poids et Mesures at Sévres and the apparatus is complete in every detail.

In order that wires used for base measurements may be periodically tested, it is necessary to have a permanent base against which they can be checked. An alley 97 feet in length is now being constructed in the grounds of the Trigonometrical Survey Office at Dehra Dun, in which a base 24 metres long will be laid down. The base will consist of 7 isolated pillars, placed at intervals of 4 metres from centre to centre; on the face of each pillar a projecting brass plate will be embedded, on which will be engraved the referring mark for measurements. The intermediate pillars will be 2 feet square in section and the two end ones 3 feet by 2 feet the extra length being given to the end ones to enable lengths of 25 metres and 80 feet to be laid down.

The alley forms the south side of a building having pendulum and seismograph rooms on the north side. In order to keep the temperature of the alley as equable as possible, no windows will be placed in the south wall, lighting and ventilation will be obtained by raising the roof of the alley above that of the main building and putting in north lights.

The base will be laid out by means of the new 4 metre Invar standard bar now being manufactured at Geneva. In each of the end walls a frictionless pulley will be fixed, over which the wire to be tested will be strained.

Invar, although having a very small co-efficient of expansion, is subject to secular changes. These secular changes which take the form of a gradual shortening, decrease in magnitude as the alloy increases in age. The treatment, to which the wires are subjected at Sévres, may be said to prematurely age the wires, that is, it hastens on these secular changes and the wires, when finally issued by the Bureau International, may be considered practically free from this drawback. They have probably never been used in the extremes of heat and cold to which they will be liable in measurements of base lines in countries such as Baluchistan and it will be necessary to watch their behaviour very closely.

Nine wires have been received from the maker. Of these, three wires will always remain at head-quarters being termed the standard wires and frequent comparisons will be made with them against the base. The remaining six wires will be taken into the field, three of them being used as field standards and the other three used for the actual measurement of the base.

METHOD OF CHECKING TRAVERSE WORK.

Where a topographical survey has to be carried over a large extent of flat country, secondary and tertiary triangulation, owing to its prohibitive cost, has to be dispensed with. In the plains of India Principal Triangulation, mostly along meridional lines, has been run at intervals varying from 40 to 120 miles apart; these were executed many years ago by building towers of 30 feet and over. The substitute for tertiary triangulation is a net work of traverses, but these need controlling at points at closer intervals than those given by the principal triangulation. The method proposed is to run accurate main traverses at suitable intervals, starting and closing, if possible, on principal triangulation series.

A trial has been made this year of running a main traverse by using wires in catenary for the linear measurements. M. Yaderin's apparatus, which was obtained some years ago, was utilised for the purpose; a slight alteration being made so as to enable the wires to be strained mechanically.

The first line run was about 80 miles in length; it started from Burala T. S., a principal station of the Jogitilla series, and was to have closed on the secondary station of Shorkot, unfortunately this was found to have been destroyed and could be only approximately located; the accuracy of the line could not therefore be tested. Starting from a point on the first line a second line, 41 miles in length, was run, a cheaper personnel being employed. In addition to checking traverses, it was executed for the purpose of locating the position of the secondary station of Dorewala, on which much of the traverse work in the Southern Punjab had closed.

The operators were quite new to the work and at first progress was slow but an average rate of about three miles a day was eventually obtained. This work was carried out with an 80-foot wire, the 160-foot wire being used only when the ground would not permit the use of the shorter wire; it would probably both facilitate and cheapen the work to use the

160-foot wire throughout. There is no doubt that a traverse run in this manner is unnecessarily accurate as a basis for traverse work and the cost even with the cheaper personnel is greatly in excess of other methods.

It has, however, been demonstrated that it is possible to run a long traverse line by these methods over approximately flat country. The great difficulty experienced seems to have been the placing of the trestles in the required position; this difficulty, however, can easily be obviated by either forward or backward tape measurements.

Throughout the length of the line levels were taken to each trestle and astronomical azimuths at intervals of about 11 miles.

A second and cheaper method of running sufficiently accurate main traverses is by measurements along the ground with a tape or crinoline chain starting and closing on fixed points. This was likewise tried one season, an aggregate length of 50 miles being measured. The result of this method gave an error of about one in eight thousand, a sufficient accuracy on which to base traverse work. This method will in all probability be largely utilised in future.

The great advantage that the wire in catenary possesses over this latter method is that, since the level staff is read on each tripod placed, the line gives fairly accurate heights at every wire interval.

Principal Triangulation.

During the year four detachments were employed on Principal Triangulation and in consequence the addition made to the Geodetic Survey of India has again been large. In all a length of 270 miles of triangulation covering an area of 9,600 square miles has been added.

The districts in which the detachments were working were :—

1. Northern Baluchistan.
2. Shan States (Burma).
3. Kashmir.

Northern Baluchistan.

In May 1908, Lieutenant Oakes commenced the Northern Baluchistan Series. He started from the base Zawa-Zibra of the Kalat Longitudinal Series and working along meridian 66°30′ carried the new series north-

wards to parallel 31°. From here onward the series will take an easterly direction, following as closely as possible the Afghan-Baluchistan frontier, eventually closing on the Great Indus Series.

Lieutenant Oakes completed a length of 100 miles of triangulation, which covers an area of 3,500 square miles. The 8 completed triangles have an average error of 0″·41. The side Koi Maran-Takatu of this series 68 miles in length is the longest side of the Indian triangulation.

An Astronomical Azimuth was observed at Mashelak H. S. (Lat. 30°14′ Long. 66°·47′) and the difference found between the value so obtained and that computed from the triangulation was 1″·25: the sign of this difference was positive as are all values as yet obtained in Baluchistan. This shows that the triangulation in that region is trending south of its true direction. The work was greatly hindered by the thick dust haze and consequently this year it has been decided to work in the early autumn.

Mr. Tresham recommenced work in September 1909 at the point where Lieutenant Oakes left off.

In order to secure the early completion of the Northern Baluchistan Series and give points on which the Topographical Survey in North Baluchistan could adjust its minor triangulation, it was decided to carry on the work of the series simultaneously from both ends. In the autumn of 1908 Lieutenant Cardew was instructed to start the work from the eastern end from the side Umarkhel-Maidan of the Great Indus Series. The station at Maidan, however, was found to have been destroyed: this necessitated starting from the base Sakesar-Bani.

Lieutenant Cardew executed 50 miles of triangulation enclosing an area of 1,900 square miles. The seven completed triangles have an average triangular error of 0″·548. Owing to unforeseen difficulties having arisen, it is possible that the junction of the North Baluchistan Series with the Great Indus Series will have to be made further south in the neighbourhood of Dera Ghazi Khan.

An Astronomical Azimuth was observed at Umarkhel and the difference found between the value so obtained and that computed from the triangulation was 7″·66: the sign of the difference is positive. Lieutenant Cardew then ran a secondary series across the Bannu plain to pick up the junction of the tertiary triangulation of the Tochi and Kurram Valleys.

A comparison between the values obtained and those determined by Lieutenant Phillimore in 1904-05 of the three most important points are given in the table below :—

Name of Station.	Lieut. Cardew's values.		
	Latitude.	Longitude.	Height.
Pakkalota	32 58 19·045	70 25 28·936	3,151·2
Jinighar	33 10 35·637	70 40 12·762	3,989·4
Darweshtar Sar	33 09 41·933	70 20 00·459	5,056 2

Name of Station.	Lieut. Phillimore's values, 1904-05.		
	Latitude.	Longitude.	Height.
Pakkalota	32 58 18·95	70 25 29·01	3,169·3
Jinighar	33 10 35·48	70 40 12·70	3,997·7
Darweshtar Sar	33 09 41·48	70 20 0·56	5,073·1

The difference in Azimuth of Jinighar from Pakkalota amounts to 3″·02.

Shan States, Burma.

In Burma Captain Browne continued the Great Salween Series: the new triangulation is 120 miles in length and encloses an area of 4,200 square miles. It consists of 9 triangles with an average triangular error 0″·47.

By the extension of this series the Indian Arc of parallel has been increased to 38½ degrees of Longitude, extending from Longitude 60°·54′ on the western border of Baluchistan to Longitude 99° 24′ on the eastern border of the Shan States.

An Astronomical Azimuth was observed at Klip Ma and the difference found between the value so obtained and that computed from the triangulation was 8″·60, the sign of this difference was negative which is in accordance with the other values found in Burma.

In addition many of the stations of the Topographical Triangulation, then in progress in that locality, were fixed.

The work was much hindered by the continuance of heavy monsoon rains in November which prevented any work being done until the beginning of December, even then the heavy mist greatly interfered with the observations.

On the 2nd of March the dust haze became so thick that work had to be entirely stopped.

Kashmir.

In Kashmir Mr. de Graaff Hunter has started a new series, which emanates from the side Nerh-Khagriana of the North-West Himalaya Series. It is proposed to run this series north as far as Gilgit, it will then trend eastward and meet the old triangulation again on the side Marshala-Thalanka. From thence the old triangulation will probably be revised southwards and the series will finally close on the side Gurhagarh-Somnabanj of the North-West Himalaya Series. The old triangulation, a magnificent work carried out by Major Montgomerie, R.E., during the years 1855—63, with 14-inch Vernier theodolites, is not classed as principal work; it emanates from the side Gurhagarh-Somnabanj of the North-West Himalaya Series, runs northward to Skardu and thence up the Indus Valley to Leh, where it breaks up into three separate series none of which close on the Indian triangulation.

The present work will prove a formidable undertaking, many of the proposed stations being at altitudes of 16,000 feet and over, two at least are over 18,000. When completed the series will form the most northerly extension of the principal triangulation of the Great Trigonometrical Survey of India and the stations will far exceed in height those of any principal triangulation yet executed.

Mr. de Graaff Hunter commenced work in April of this year; after a break of two months during the rainy season he recommenced the work early in September.

Secondary Triangulation.

In addition to the principal triangulation reconnaissances were made and stations built for secondary series in Burma and Assam which will be observed in the coming field season.

Tidal Operations.

During the past year tidal registrations by automatic tide-gauges have been taken at the ports of Aden, Karachi, Apollo Bandar (Bombay),

Princes Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. The registrations at these ports have been satisfactory.

At Moulmein a new observatory was erected in August 1908 on a site close to the old one which was dismantled in 1886. The tide-gauge was duly installed and registrations were commenced from the 1st of January 1909. The true zero of the gauge is identical with that adopted in 1880 when the gauge was first started. The results derived from the observations which are now being registered will serve as a check on the accuracy of the predictions already published.

Levelling Operations.

The total outturn of double levelling of precision completed during the field season of 1908-09 was 1,085 miles, in the course of which observations were taken at 13,223 stations. The bench-marks determined were 25 standard, 90 embedded, 623 inscribed, and 34 belonging to other departments. The heights of 3 Principal and 8 Secondary G. T. stations were also determined by levelling as a check on the heights deduced by triangulation.

During the field season the line of levels, which was commenced in season 1906-07 from Ferozepore with the object of breaking up the large level circuit Karachi-Ferozepore-Sironj and Bombay by direct levelling across Rajputana to Ahmedabad, has been completed, and the lines (1) Katni to Nagpur, and (2) Wardha to Hyderabad (Deccan), have also been completed.

Standard Bar Comparisons.

Comparisons of the Standard Bar A of the Indian Survey were made in 1907-08 with the secondary Standards IB and IS, preparatory to the sending of Bar A to Sévres for comparison with the International Metre. The reasons for this undertaking and the results deduced from the observations were communicated to the Board of Scientific Advice in the Report for 1907-08. Briefly, the results of the comparisons were :—

IS—A at 62°F = 83·12 millionths of a yard.
IB —A at 62°F = 196·73 millionths of a yard.
Length of Bar A at 62°F = 3047·996 millimetres.

On completion of the comparisons with the International Metre, Bar A was returned to Dehra Dun, where a second series of comparisons

was undertaken for the purpose of ascertaining whether the length of the Bar had undergone any change during the journey to Europe and back and in the event of an alteration of length having occurred, of determining the amount of the change. These comparisons were made in November and December 1908 at Dehra Dun. Twenty sets of comparisons were made of Bar A with each of the Secondary Bars IB and IS. In the case of Bars A and IS the temperatures during the comparisons ranged from 61°·2 to 64°·9 and during the comparison of A with IB from 57°·6 to 65°·5. The final results were—

IS—A at 62°·F=81°·13 millionths of a yard.
IB—A at 62°·F=193·38 millionths of a yard.

A comparison of the values obtained before the journey to Sévres with those derived from the observations of December 1908 show that it is probable no change took place in the length of the Standard Bar A between the time of its departure from Dehra and its return from Sévres and that, therefore, reliance may be placed in the value of Bar A in terms of the International Metre given above.

Pendulum Operations.

One of the spheres of research to which pendulum determinations will be devoted is the investigation of the constitution of the earth's crust, a discussion which embraces the nature of mountain masses; whether these are merely incidents of the surface, affecting only the outer configuration or whether they are more important features producing by their weight inequalities of density in the underlying matter. About the middle of the nineteenth century, Archdeacon Pratt put forward the theory of compensation of the visible masses on the earth's surface. His theory was that as far as visible land masses are concerned, "in the land portions of the earth's surface there is a deficiency of matter below the sea level approximately equal to the amount of matter above it." Generally stated, his theory was that at all places the amount of matter contained in a vertical column in the earth's crust was the same. One of the aims of gravimetric research has been to ascertain to what extent this theory is correct, whether it holds good for all places, for all geological formations and for all heights above sea level and all degrees of relief of surface configuration.

The amount of compensation at any place is readily shown by a comparison of the actual intensity of gravity, as derived from observations

with the theoretical intensity deduced from established formulæ. This comparison will show by how much the force of gravity at any chosen place is in excess or defect of the theoretical value. Using this result in combination with the results of geological research, we shall be enabled, it is hoped, to learn something of the interior constitution of the earth's crust.

With this end in view gravity operations have been carried out in India, at points in the Himalayas, the Siwaliks, the Nilgiris, Baluchistan and in the submontane plains. During the winter of 1908-09 they were undertaken in western Central India, where, though the relief above the sea level is not so great, the amount of matter in the geological formations the Central Indian basalt overflows, is known to be excessive. The investigation has here embraced a somewhat different array of conditions to that prevailing in Himalayan regions. In the latter the research deals with the compensation of surface masses which have been caused by folding of the crust. In the former case, we are enquiring into the effect of overloading of the surface by the basalt overflows.

The data available at present is insufficient for formulating any theories of crustal structure and the operations at present being undertaken are directed to the acquisition of facts from localities exhibiting varied conditions, which facts will later enable us to enter into discussions bearing on the general theory of compensation and the extent to which its teachings are affected by local conditions.

The stations visited by No. 23 Party of the Survey of India during the season of 1908-09 were :—

UJJAIN .	. on the gentle northern slope of the Vindhya hills, in the middle of basalt region.
MHOW,	. near the crest of the same hills, also on the basalt.
MUKHTIARA, MORTAKKA	} in the Nerbudda valley, close to the line of division of the basalt and the submetamorphic formations.
KHANDWA .	. in the middle of the trap area, between the Nerbudda and the Tapti rivers.
ASIRGARH	. on the crest of the Satpura hills, on trap beds.
JALGAON .	. in the Tapti valley, on the edge of the trap close to the alluvial deposits of the Tapti valley.

These seven stations are all in approximately Long. 76.

AMRAOTI, ELLICHPUR } in the Berar plains south of the Satpuras, close to the line of division between the trap and alluvium, the former on the trap, the latter on the alluvium.

BADNUR . . in the central portion of the Satpura hill tracts, on the edge of the trap and metamorphic rocks.

SHAHPUR . . a little to the north of Badnur, on beds of the Gondwana series.

Hoshangabad, in the Nerbudda valley, on the alluvium.

These stations are in Long. 78° approximately.

The results of the season's work are given in Table I.

Table I.

Station.	Latitude.	Height above M. S. L.	Observed value of gravity $=g$	g reduced to sea level $=g_0''$	Theoretical value of gravity $=y_0$	$g_0''-y_0$
	° ′ ″	Feet.	Dynes.	Dynes.	Dynes.	Dynes.
Ujjain . . .	23 11 0	1,612	978·677	978·771	978·802	− 0·031
Mhow . . .	22 33 10	1,903	978·620	978·730	978·763	− 0·033
Mukhtiara . .	22 23 40	926	978·664	978·718	978·753	− 0·035
Mortakka . .	22 13 20	576	978·703	978·737	978·743	− 0·006
Khandwa . .	21 49 30	1,014	978·692	978·752	978·714	+ 0·038
Asirgarh . .	21 28 10	2,077	978·584	978·711	978·694	+ 0·017
Jalgaon . . .	21 0 0	760	978·633	978·677	978·665	+ 0·012
Amraoti . .	20 55 50	1,123	978·609	978·675	978·665	+ 0·010
Ellichpur . .	21 18 20	1,314	978·618	978·694	978·685	+ 0·009
Badnur . . .	21 54 10	2,103	978·607	978·730	978·724	+ 0·006
Shahpur . .	22 11 30	1,284	978·663	978·738	978·743	− 0·005
Hoshangabad .	22 45 0	1,002	978·719	978·777	978·773	+ 0·004

The values of g in this table are based on the value of gravity at Dehra Dun, 979·063 dynes.

The last column gives the difference $(g''_0 - y_0)$ between the theoretical value of gravity at sea level and the observed value reduced to the same surface of reference. The reduction of the observed value to sea level is dependent partly on our estimate of the density of the underlying strata. For our present purposes this density has been assumed to be 2·8. The quantities in the last column show by how much the actual force of gravity differs from what it would be were the density of the underlying matter normal, that is 2·8, and we thus have some indication of the variations of actual densities from normal.

The first seven stations lie in approximately Long. 76°, the remainder in Long. 78°.

At the first three stations, Ujjain, Mhow and Mukhtiara, situated in the Vindhyas, gravity is found to be nearly uniformly in defect by about 0·033 dynes. At Mortakka the intensity of the force had increased till it is only slightly in defect. Further still to the south at Khandwa and Asirgarh in the Satpura tracts and at Jalgaon south of the Satpuras, the force of gravity has been found to be in excess, the maximum, so far as the stations visited are concerned, occurring at Khandwa, where the excess is 0·038 dynes.

Generally, then, at stations visited in the Vindhyas gravity is found to be in defect while at those in the Satpuras it is in excess. Before we can, however, apply this generalization to these ranges as a whole, further investigation is required. The coincidence here of the line of demarcation between the areas of excessive and defective gravity with the natural boundary between the Satpuras and the Vindhyas may be only accidental. Of the five stations on the 78° meridian, at Amraoti and Ellichpur in the Berar plains south of the Satpuras, gravity is in excess by about the same amount as at Jalgaon at the same Latitude 2° further west. As we move northwards across the Satpuras to Hoshangabad on the Nerbudda, the force of gravity decreases somewhat. Shahpur exhibits a noticeable anomaly. Here we find gravity slightly in defect, whereas the results obtained at Badnur and Hoshangabad would point to a small excess. When we compare these results with those collected in previous years, we find that up till now excesses of gravity had been found only at low-lying places under 750 feet above sea level. This last season's work has shown stations at altitudes of from 760 feet to 2,100 feet, where gravity is in excess.

The quantities $(g_0'' - y_0)$ are, as has been said, to some extent dependent on the assumed value of normal density. If, however, we

correct the observed value of gravity for height above sea level only and compare this with the theoretical value, we get a series of differences representing the actual effects of the masses standing above sea level without any assumption as to the density.

The comparison is made below :—

Station.	Observed value of gravity corrected for height only $=g_o$.	Theoretical value at sea level $= y_o$.	Effect of masses above sea level.	
			Actual $(g_o - y_o)$.	Calculated with density 2·8.
Ujjain	978·827	978·802	+0·025	+0·056
Mhow	978 797	978·763	+0·034	+0·067
Mukhtiara . . .	978·750	978·753	−0·003	+0·032
Mortakka . . .	978·757	978·743	+0·014	+0·020
Khandwa . . .	978·787	978·714	+0·073	+0·035
Asirgarh . . .	978·778	978·694	+0·084	+0·067
Jalgaon	978·704	978·665	+0·039	+0·027
Amraoti	978 714	978·665	+0·049	+0·039
Ellichpur	978·740	978·685	+0·055	+0·046
Badnur	978·803	978·724	+0 079	+0·073
Shahpur	978 783	978·743	+0·040	+0 045
Hoshangabad . . .	978·812	978·773	+0·039	+0·035

Now by complete compensation is meant that the total amount of matter underlying the station is normal; that the visible mass above sea level is exactly compensated by underlying deficiencies. The combined effect of such visible masses and deficiencies on a pendulum at the station would be *nil*. For such a place $(g_o - y_o)$ would be *nil*. This condition is very nearly attained at Mukhtiara, where the actual effect is only 0·003 dynes. The negative sign indicates that slight overcompensation exists. At Ujjain and Mhow the actual effects are about 50 per cent. of those the visible masses would produce were the density 2·8. Here about half the visible masses may be considered compensated.

Mortakka also shows a somewhat similar degree of compensation. At the remaining stations there appears to be no approach to compensation. At the last few on the list the actual effects are almost the same as those calculated on the assumption of a 2·8 density, showing that the visible masses may be supposed "extra" to the normal amount of matter in the crust. At Khandwa we have the discordance between the actual and calculated effects still more pronounced.

We can represent the differences $(g''_0 - y_0)$ of Table I, as the effects of a disc of matter of a certain thickness and of such density as we may choose to adopt. If we assume that the average crustal density is 2·8 we find that 0·001 dynes would be the effect of a disc of thickness 28·6 feet on a station at its centre.

In the following table the differences $(g''_0 - y_0)$ are converted into thicknesses of the corresponding disc of density 2·8.

Station.	Height above sea level.	$(g''_0 - y_0)$.	Thickness of corresponding disc.	Hypothetical height.
	Feet.	Dynes.	Feet.	Feet.
Ujjain	1,612	—0·031	887	725
Mhow	1,903	—0·033	944	959
Mukhtiara . . .	926	—0·035	1,001	—75
Mortakka . . .	576	—0·006	172	404
Khandwa	1,014	+0·038	1,087	2,101
Asirgarh	2,077	+0·017	486	2,563
Jalgaon	760	+0·012	343	1,103
Amraoti	1,123	+0·010	286	1,409
Ellichpur	1,314	+0·009	257	1,571
Badnur	2,103	+0·006	172	2,275
Shahpur	1,284	—0·005	143	1,141
Hoshangabad . . .	1,002	+0·004	114	1,116

The quantities given as thicknesses of a corresponding disc may be looked at in another way. Take the case of a station where gravity is,

let us say, in excess, Jalgaon for example. Here gravity, being in excess, points to the matter in the crust underlying this place being of more than normal density. If we were to expand this matter, its total amount remaining the same but the volume increasing until the density became normal, we would find that the imaginary surface of the crust, thus derived, was 343 feet above the present level of the station; that the height of Jalgaon, on this hypothesis, was 1,103 instead of 760 feet. In the case of Shahpur, similarly, where gravity is in defect, showing that the density of the underlying matter is less than normal, it would be necessary to compress the existing mass to make its density 2·8. The amount of compression required would correspond to a lowering of the surface at Shahpur by 143 feet, making the hypothetical height of this station 1,141 feet. The last column of the table above gives these hypothetical heights; the height each place would have supposing the underlying matter expanded or compressed until its density became normal.

We see that along the meridian of 76° between Jalgaon and Ujjain the stations to the south of Mortakka on the Nerbudda bank would all be raised by approximately 600 feet on the average, while those to the north of the same place would be lowered by about 750 feet. The height of the Satpuras would be increased while that of the Vindhyas would be decreased. This may, perhaps, indicate a greater thickness of the basalt beds in the Satpuras than in the hills north of the Nerbudda; that a greater amount of matter is present south of this river than to the north. The actual configuration does not reveal this fact. The summits of the Vindhyas to the north are just as high as those of the Satpuras to the south. Indeed, the visible masses to the north and south of the river would rather lead one to suppose there was a preponderance of mass to the north. Latitude observations made at Thikri in the Nerbudda valley showed that this supposition was incorrect and this has now been corroborated by the pendulum operations. The latitude observations, however, only pointed to an excess of matter to the south without giving its definite situation. The pendulum has now located the position of this excess of mass.

BOTANICAL SURVEY.

BY

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Eastern India.—Although botanically the Royal Botanic Garden, Calcutta, is not so much part of India as a microcosm of the tropical and subtropical vegetation of both Hemispheres, its inclusion in a review of botanical survey work in India scarcely requires justification. The main scientific work concerned directly with the garden during the year has been the commencement of a census of the shrubs and trees growing therein. Apart from the convenience to the officers both present and future responsible for the garden a census of its plants ought to be helpful to students of Indian Botany in more ways than one. The making of an accurate census however has involved a considerable amount of preliminary labour. In the first place the garden had to be re-surveyed—in the ordinary sense—as the changes in the *facies* of the garden within the last decade had rendered the existing maps no longer accurate and they were in any case on an inconveniently small scale. Accordingly during 1907 an accurate survey of the garden was begun on the scale of 50 feet to the inch and a large map was prepared and finished in 1908.

The garden was then divided—on the map—into squares of a hundred feet side, the lines of squares running due north and south, and east and west. The squares were co-ordinated by letters and figures and here and there throughout the garden the intersections of the lines forming the imaginary squares were fixed on the ground by permanent marks so arranged as to make it quite a simple matter if required to line out by tape any given square or squares. The next procedure was to number and ticket the trees and shrubs—for the census is restricted to such—and allot them to their proper squares. This was done during the cold season of 1908-09 in the following way: —

A line of squares was selected and Bamboo stakes temporarily driven into the ground at the angles of the squares. Coolies then run coarse tape of proper length from stake to stake so that each square in turn was temporarily lined out on the ground. Then every tree and shrub within the square was provided with a zinc label on which its number was stamped, the numbers going on consecutively and irrespective of

the squares. Simultaneously a provisional list giving the numbers of the trees and shrubs and the provisional identification of each, square by square, was drawn up. In this way the whole garden was gone over thoroughly until a complete rough list comprising over 13,000 trees and shrubs, every one of which can now be referred with ease to its place in the garden, was completed. There now remains the checking of the provisional identifications and the preparation and publication of a numerical list and of a systematic list. This work is now in hand and is being carried out as rapidly as other and necessary official work will permit. The first fascicle of the numerical list comprising about 3,000 numbers is ready for the Press and it is hoped the coming cold weather will see another considerable instalment of the numerical list ready for publication.

Outside the Royal Botanic Garden but within or on the frontiers of Bengal attention has been devoted chiefly to the vegetation of the Himalaya with the view of obtaining enough material with exact enough geographical records to justify the commencement of a systematic account of the Flora of Sikkim and the surrounding districts. For this purpose Mr. W. W. Smith, M.A., Curator of the Calcutta Herbarium and Mr. G. H. Cave, Curator of the Lloyd Botanic Garden, Darjeeling, have been deputed to spend two months in the north-west corner of Sikkim studying the vegetation in the field and making as complete collections as possible, to be worked up forthwith.

At the time of writing Messrs. Smith and Cave are still in the field, so that at present one can say only that their explorations have ranged up the Lachen Valley as far as the Kangra Lama Pass in the extreme north of Sikkim and over practically the whole of the Lhonakh district that fills up the north-west corner of Sikkim lying west of the Lachen Valley and north of the Zemu Valley and the big Kinchinjunga glacier. The collections promise to be of a distinctly interesting character, and an account of the expedition and its results will be published in the Records of the Botanical Survey of India.

Towards the end of 1907, Mr. I. H. Burkill, M.A., F.L.S., Reporter on Economic Products to the Government of India visited Nepal, and while there made botanical observations and as full collections as possible. As botanical material from Nepal is by no means abundant the results of Mr. Burkill's trip are awaited with interest. Mr. Burkill has written an account of his trip and of its botanical results which will also be published in the Records of the Botanical Survey.

In the lower and outer hills of the Darjeeling District itself Mr. W. W. Smith, the Curator of the Calcutta Herbarium, collected largely, while his collections were supplemented by those made under the supervision of the officers of the Bengal Cinchona Department.

Although concerned with a region beyond the Frontiers of Bengal, an account in the Journal of the Linnean Society of the *Caryophyllaceæ* of Tibet by Mr. F. N. Williams, F.L.S., calls for mention here, as most of the material on which the account is based was gathered by collectors of the Calcutta Botanic Garden or by officers attached to the Mission to Lhassa in 1903-04. The result of Mr. Williams' elaboration of the material is to increase the number of species of Tibetan *Caryophyllaceæ* from 11—all previously known—to 43, there being 16 species described for the first time.

During the rainy season of 1908, Mr. W. G. Craib, M.A., Officiating Curator of the Herbarium, was deputed to collect on the hills of the District of North Cachar in Assam, so as to supplement the collections made by the writer in the plains of South Cachar District in the same season several years ago. Mr. Craib brought back quite a good collection that was worked up in the Calcutta Herbarium and will form, it is hoped, a basis for a paper on the Flora of Cachar as a whole.

Later on in the same year Mr. Alfred Meebold collected extensively further to the east and mostly in the State of Manipur. Directly the Botanical Survey is under obligation to Mr. Meebold for the gift of a set of his collections and though indirectly not less so to Colonel J. Shakespear, I.A., C.I.E., D.S.O., Superintendent of the Manipur State, for the generous facilities he afforded to Mr. Meebold. The latter's original intention was to cross from Manipur into Burma, but unforeseen circumstances prevented his complete programme so far as this province was concerned from being accomplished. His collections from Burma are therefore not so complete as those from Assam. The staff of the Botanical Survey is quite inadequate to the task of exploring even one province thoroughly and it is quite impossible when there is nominally even but one officer available for him to explore personally in three different provinces in one year. Consequently in Burma local agency was made use of and under the circumstances it was thought better instead of attempting a general collection to restrict collecting work to bringing together a living collection of the orchids of that province.

The Survey has benefited however by the interest taken by officers of other Departments in the flora of the province. Mr. G. E. S. Cubitt,

Deputy Conservator of Forests, Bhamo Division, has studied the vegetation of the surrounding District and has sent his collections for checking and identification to the Calcutta Herbarium. Mr. Cubitt's lists are accompanied with notes on their habitats and uses. From the Southern Shan States Captain R. W. MacGregor, I.M.S., and from the Ruby mines Mr. A. Rodger, Deputy Conservator of Forests, have contributed many interesting species and their lists should prove very useful when the flora of Burma comes to be worked up.

Western India.—The most important botanical event of the year concerned with this side of India is the completion of the Flora of the Presidency of Bombay by Dr. Theodore Cooke, C.I.E. The first part of this work appeared in July 1901 and the concluding part in December 1908. The Flora covers Sind and Baroda in addition to the Presidency of Bombay proper, and is in two volumes, comprising 1,728 pages of description. The completion of the work affords an opportunity of roughly analysing the constituents of the flora of the area covered by it. The species indexed number 2,653 but 151 of these occur only in cultivation or planted, so that the total of the indigenous and naturalised flowering species is 2,502. The number of natural orders—excluding *Cactaceæ*, *Casuarinaceæ*, *Coniferæ*, *Cycadaceæ* and *Bromeliaceæ* that are merely mentioned—actually described is 142. These orders comprise 999 genera and 2,502 species. The ten most important orders as far as the number of genera represented is concerned are :—

Order.	Genera.	Species.
Leguminosæ	81	274
Gramineæ	72	223
Compositæ	52	103
Euphorbiaceæ	37	101
Acanthaceæ	36	109
Rubiaceæ	34	80
Orchidaceæ	31	74
Scrophularineæ	26	51
Asclepiadeæ	25	51
Labiatæ	21	57

If the orders however be ranked according to the number of species irrespective of genera the last three orders of the list above disappear

and are replaced, though not in the same sequence, by *Malvaceæ*, *Convolvulaceæ* and *Cyperaceæ*, thus :—

Order.	Species.	
Leguminosæ	274	
Gramineæ	223	
Acanthaceæ	109	
Compositæ	103	
Cyperaceæ	102	with 14 genera.
Euphorbiaceæ	101	
Rubiaceæ	80	
Orchidaceæ	74	
Malvaceæ	67	with 16 genera.
Convolvulaceæ	64	„ 18 „

This last list is in substantial agreement with the results of Father Blatter who has given an excellent analytical account of the flora of the Bombay Presidency in the Journal of the Bombay Natural History Society before the completion of Dr. Cooke's Flora. Few of the orders show more than four times as many species as genera, but *Malvaceæ*, *Tiliaceæ*, *Vitaceæ*, *Myrtaceæ*, *Ebenaceæ*, *Lentibularieæ*, *Commelinaceæ* and *Cyperaceæ* exceed this proportion. Twenty-three of the orders are represented each by a single species while 19 are represented by a single genus with more than one species.

In the paper above referred to, the Rev. Father Blatter institutes a comparison of the specific contents of the Bombay flora with those of other natural floristic regions of the Indo-Malayan area. Although the Presidency falls within three different botanical regions, the Indus plain, the Malabar and the Deccan regions respectively, its flora is comparatively poor, being not much more than half as rich as the Eastern and Western Himalayan regions and probably less than half as rich as the Burmese and Malayan regions. Father Blatter computes that there are only 127 species truly endemic to the Presidency. The flora shows a preponderance of perennial plants constituting about three quarters of the whole. The Presidency is poor in aquatics and epiphytics, but has a good representation of climbing plants, nearly one-seventh of the total flora belonging to this last type.

Father Blatter has also made a more detailed study of the Flora of the Province of Cutch. Prefacing his paper with an account of the topography and meteorological conditions of the province, he proceeds to give a detailed list of its plants with their times of flowering and their distribution in and out of India. The indigenous species number 345

belonging to 74 natural orders. The dominant orders are roughly those of Sir Joseph Hooker's Indus Plain Province. No endemic species have been found. In addition to the systematic list Father Blatter gives notes on the ordinary cultivated plants of the province and biological notes on certain of the species that show noteworthy adaptations to their environment. He also devotes some consideration to the explanation of the different aspect of the Pacham Island Flora from that of any other part of Cutch and attributes the difference to the special climatic and edaphic conditions prevailing on the Island. He is unable to find any clue from the flora as to the origin of the Rann of Cutch.

Turning now from the general to the particular, Mr. G. A. Gammie, F.L.S., has continued in the Journal already mentioned his account of the Orchids of the Bombay Presidency. He began his account in August 1905 and since then 8 parts have appeared giving description of and notes regarding 19 genera and 40 species. Coloured figures are given of *Dendrobium chlorops* Lindl., *D. barbatulum* Lindl., *Phajus albus* Lindl., *Eulophia pratensis* Lindl., *Cymbidium bicolor* Lindl., *Cottonia macrostachya* Wight, *Rhynchostylis retusa* Bl., and *Ærides crispum* Lindl.

Work on the higher cryptogams is well represented by Father Blatter's list of the Ferns of the Bombay Presidency, in which he enumerates with their geographical distribution 110 species belonging to 49 genera. His conclusions are that the ferns are very poorly represented in the Bombay Presidency, forming only 4 per cent. of the vascular vegetation. Three-fourths of the species known in the Presidency occur in North Kanara, and no endemic species appears to exist.

During the last two years Messrs. L. J. Sedgwick and R. M. Maxwell have made collections of mosses on the Western Ghats, in Konkan and in Kanara. Those collections have been worked up by Mr. H. N. Dixon, F.L.S., who enumerates 22 species, two of them—*Pterobryopsis Maxwellii* and *P. kanarensis*—being described for the first time.

Official systematic work has necessarily been very restricted as the duties of the Economic Botanist lie in other directions. Different members of the staff of the Economic Botanist collected in the course of their tours through Poona, Thana, Belgaum, Kanara and Sind and over 3,000 sheets were added to the Kirkee Herbarium.

Southern India.—Mr. T. F. Bourdillon, F.L.S., Conservator of Forests, Travancore, has during the year made available to botanists his unique knowledge of the Flora of that State by publishing a systematic account of the Forest trees and more important climbers that occur in

Travancore. The book although intended primarily for Forest officers, is indispensable to all who are interested in the Flora of Southern India, and prominence is for that reason given to it in this section of the Board's Report. Mr. Bourdillon describes 582 species of trees and climbers but estimates that an exhaustive study of the flora would probably bring the trees alone to much over 600 species. A synopsis of the natural orders is given at the beginning of the work and keys to the genera and species are furnished in addition to succinct descriptions. Mr. Bourdillon points out that the Travancore Flora combines that of Malabar and that of Ceylon, while it includes many species of wide distribution and not a few endemic species. There are many species that greatly resemble while yet different from species of the Malayan Peninsula, which has a similar varied climate, and Mr. Bourdillon is of opinion that probably at one time a continuous stretch of forest connected those two now distant regions and that the parents of those similar species flourished somewhere in the area between them.

The excellent collections made by Mr. C. E. C. Fischer, I.F.S., in the Coimbatore District have been elaborated by the Rev. Father Blatter. As in his account of the Cutch Flora so here he prefaces his Coimbatore list with a description of the topographical and climatic conditions of the district. It is not claimed that the list is complete, but its value none the less is indisputable. The area covered by the list is roughly the north-eastern half of the District. As far as genera are concerned the ten dominant orders are the same as those in the Bombay Presidency as a whole, although they do not occur quite in the same sequence. As far as species are concerned the ten dominant orders are also the same as for the Bombay Presidency except that in Coimbatore *Labiatæ* and *Asclepiadaceæ* displace *Cyperaceæ* and *Orchidaceæ*. Altogether the Coimbatore list numbers 1,209 flowering species distributed amongst 119 orders. The flowering times and the elevation of habitat of each species is given.

The district covered is comparable as regards area with Cutch, but there is a marked contrast between the two floras both in regard to actual richness of vegetation and to the dominant orders. In the ten dominant orders in Cutch *Capparidaceæ*, *Cucurbitaceæ*, *Solanaceæ*, *Amarantaceæ*, and *Cyperaceæ* replace *Acanthaceæ*, *Euphorbiaceæ*, *Labiatæ*, *Rubiaceæ* and *Asclepiadaceæ* in the Coimbatore Flora, though not of course in this precise order as far as specific richness is concerned. As far as generic richness is concerned *Rubiaceæ*, *Euphor-*

biaceæ, *Scrophularineæ*, *Labiatæ* and *Orchidaceæ* that appear amongst the ten dominant orders in Coimbatore, yield place in Cutch to *Cucurbitaceæ*, *Malvaceæ*, *Convolvulaceæ*, *Amarantaceæ*, and *Solanaceæ*. In addition to the flowering species 50 species of vascular Cryptogams, mostly ferns, are enumerated.

During the year material for similar work in other districts of Southern India has been collected but still remains to be worked up. In the Anamalais to the South of Coimbatore collections were made by the acting Government Botanist and his assistant. Mr. Meebold—the same gentleman who collected in Assam—also during his journeys last year in Southern India collected largely in Mysore and a set of his collections from this Province has been kindly presented by him to the Calcutta Herbarium.

North-West India.—The Flora of the Upper Gangetic Plain, at present under preparation by Mr. J. F. Duthie, F.L.S., formerly Director of the Botanical Survey of Northern India, covers the United Provinces of Agra and Oudh with their Sub-Himalayan tract, the south-east corner of the Punjab, the south-eastern third of Rajputana, the greater part of Central India and the central projecting fragment of the Central Provinces north of the line of the Nerbudda and Sone rivers. So far only one volume has been published, giving descriptions of the species up to the end of *Campanulaceæ*. During the year the author—whose work has been greatly hampered by long continued illness—has forwarded enough manuscript to enable descriptions of the intervening orders up to *Scrophularineæ* to be put into type, and more is promised within a short time.

The preparation of the Flora of the Punjab Plain, Rajputana and the North-West Frontier Province is understood to be still in the hands of Mr. J. R. Drummond, I.C.S. (retired), but no information is available as to what progress has been made.

Meanwhile Lieut.-Colonel C. J. Bamber, I.M.S., has commenced the publication in the Journal of the Bombay Natural History Society of a descriptive Key to the Flora of the Punjab, North-West Frontier Province and Kashmir. Although the Key being "intended chiefly for the use of inquirers who have very little knowledge of Botany" is primarily a means of identification irrespective of purely scientific considerations and makes no pretence of being a serious floristic work, none the less it fully merits mention here.

Mr. I. H. Burkill, F.L.S., in his working list of the flowering plants of Baluchistan, gives an account of the botanical works of previous investi-

gators in this Province and furnishes notes on the economic and other uses of the many plants in his list. Altogether Mr. Burkill enumerates 1,191 species distributed over 546 genera and 100 orders. The ten most important orders are—

Order.	Genera.	Species.
Leguminosæ	42	133
Compositæ	52	128
Gramineæ	54	125
Cruciferæ	36	62
Labiatæ	23	54
Boraginaceæ	19	52
Chenopodiaceæ	14	36
Umbelliferæ	20	32
Caryophyllaceæ	12	32
Liliaceæ	12	31

Compared with the Bombay Presidency list arranged on the same basis, the same three orders head the list, only in the reverse sequence. Of the remaining seven orders of the Bombay list only *Labiatæ* appear in the Baluchistan list. The latter list agrees with Sir Joseph Hooker's list of dominant orders for British Baluchistan given in the Gazetteer of India with the exception that *Rosaceæ* given in his list is replaced by *Umbelliferæ* in Mr. Burkill's list. *Rosaceæ*, however, would be the next order to be included in the latter.

Mr. Burkill points out that the flora of Baluchistan is Persian in character and very much less northern than that of Afghanistan: but it is northern enough to contain a violet, a primula, the English hawthorn, an anemone, a gentian, a juniper and plants of many genera familiar in North-Western Europe.

In the North-West Himalaya collections have latterly been made in the Kumaon District under the supervision of Mr. N. Gill, F.L.S., Superintendent of the Government Gardens at Naini Tal. The most important contribution during the year to our knowledge of the North-West Himalaya Flora has been made by Mr. Meebold who has so actively botanised in many parts of India. In 1905 Mr. Meebold travelled in Kashmir, traversing the country from Murree to Ladakh. He collected altogether 1,139 species, and has given an account of the botanical results of his journey and a description of the general botanical features of the region traversed in an article entitled "Eine botanische Reise durch Kaschmir" published this year in the Botanische Jahrbucher.

Mr. James Marten, to whom the Botanical Department has been indebted on many occasions in the past, has contributed to our knowledge of the higher Cryptogamic vegetation of the North-West Himalaya in publishing a list of ferns found at and around Mussoorie. In his list 58 species are enumerated belonging to 29 genera.

General.—Although the Malayan Peninsula is not politically part of India, its inclusion in the Flora of British India and its proximity to Burma justify consideration of its flora here. The publication of materials for a Flora of the Peninsula was commenced by the late Sir George King in 1889, and since then the work has made steady progress. An account of the Monocotyledonous orders was completed by Mr. H. N. Ridley, F.R.S., in 1907. The Polypetalæ and Gamopetalæ orders have also now been finished. The last part pertaining to those orders appeared during the present year and contained descriptions of the natural orders *Gesneraceæ* and *Verbenaceæ*, Mr. H. N Ridley being responsible for the former, Mr. J. S. Gamble, F.R.S., C.I.E., for the latter. In the *Gesneraceæ* 131 species belonging to 20 genera are described, one genus and two species being hitherto undescribed. The *Verbenaceæ* comprise 72 species belonging to 15 genera, 16 of the species being new to science.

Turning to the consideration of particular families and genera of plants, the most important work of the year is Signor Beccari's Monograph of the Climbing Palms of the genus Calamus, forming volume XI of the Annals of the Calcutta Botanic Garden. This is one of the finest botanical works that have ever been published and is unique of its kind. The Palms of this genus are confined mainly to the damp forests of tropical and sub-tropical Asia and the Asiatic Archipelagoes, a few only being found in Africa and Australia. Owing to their ferocious spines and their climbing habit they are very difficult both to collect and to study. Signor Beccari's Monograph consists of over 500 pages of descriptive matter, comprising in addition to a learned introductory essay on the morphology and distribution of the genus, detailed descriptions of over 200 species, of which more than twenty are described for the first time. The monograph is illustrated with 230 magnificent double plates, the plates being all from negatives made by Signor Beccari himself. The plates in their clearness and relief admirably illustrate the possibilities of photography in the service of Botany. Another monograph by the same author and on the same lines treating of the allied genus of palms called *Dæmonorops* is now in the Press.

In addition to those especially important contributions to the study

of particular groups of plants, various botanists in Europe have added to our knowledge in different directions, although here scarcely more than an indication of the various contributions can be given. Sir J. D. Hooker, G.C.S.I., O.M., has described a large number of new species of *Impatiens* or Balsams from the Malayan Peninsula and the Indo-China region. Colonel Prain—in conjunction with Mr. I. H. Burkill in India—has described 17 new species of *Dioscorea*,—the Yam genus—occurring in China, Burma and India. Mr. T. S. Sprague has described the prickly-fruited species of *Euonymus*. Mr. J. Hutchinson has re-examined the Indian species of *Sambucus* and given additional diagnoses of them. Colonel Prain, Mr. J. S. Gamble, Dr. O. Stapf, Mr. J. R. Drummond, Mr. J. Hutchinson, and Mr. N. E. Brown have published in the Kew Bulletin diagnoses of a considerable number of new species from India and the Malayan Peninsula.

During the year, as usual, materials were lent to various Botanical Institutions and botanists in Asia and Europe to facilitate special investigations. The material of the genus *Grewia* was sent to Mr. R. S. Hole, Forest Botanist at Dehra Dun; a general collection from Tibet made by Captain F. H. Stewart, I.M.S., to the Royal Botanic Garden, Kew; *Menispermaceæ* to Professor Diels of Warburg; material of the genus *Sparganium* and of several genera of *Acanthaceæ* and *Rubiaceæ* to the Buitenzorg Botanic Garden; material of several genera of *Euphorbiaceæ* to the Imperial Botanic Garden, Berlin; *Crassulaceæ* to M. Raymond Hamet of the Museum D'Histoire Naturelle, Paris; *Primulaceæ* to M. Petitmengin of the University of Nancy, France, etc.

Physiological.—Dr. C. A. Barber, Sc.D., F.L.S., Madras Government Botanist, continues his studies in root parasitism and during the year published an illustrated account of the haustorium of *Cansjera Rheedii* Gmelin. This species is a climbing shrub of the natural order *Olacineæ*, with a distribution extending from the Upper Gangetic Plain to North Australia. Dr. Barber's anatomical researches appear to support the opinion that the genus *Cansjera* should be transferred to the natural order *Santalaceæ* in which its original founder placed it. *Cansjera* appears to be very catholic as regards the plants with which it chooses to become organically connected, for Dr. Barber enumerates at least 42 different species including *Cansjera* itself as being attacked by the parasite. A detailed account is given of the microscopic appearance of the tissues of the parasite and of its effect on the tissues of the host plants, and a comparison between the haustoria of *Cansjera* and of *Olax* and

Santalum is also made. The paper is illustrated with 11 beautifully finished plates drawn by Dr. Barber himself.

Mr. I. H. Burkill has also continued his investigation on the pollination of flowers in India. His last contribution to this branch of study is an account in the Journal of the Asiatic Society of Bengal of observations made in the Autumns of 1904-1906 along the high mountain ridge that separates Nepal from Sikkim in the Eastern Himalaya, and another account of similar observations made in the Spring of 1906 in the North-West Himalaya near Simla. Mr. Burkill describes the floral adaptations in a large number of species for the various modes of pollination by insects or wind or otherwise, and gives analyses of the flora in each case and a list of the insect visitors in the case of insect-pollinated species. Out of 149 species noted in flower in Sikkim, 141 are insect-pollinated. An unusually large percentage (22 per cent.) of the flowers possess pendulous corollas. In the Simla Hills 329 species were noted in flower of which 90·80 per cent. are insect-pollinated. The proportion of flowers with pendulous corollas—8 per cent.—is much smaller than in the Eastern Himalaya, which is probably due to the fact that the flowers in the Eastern Himalaya have to adapt themselves to a much heavier rainfall than in the western part of the range.

A considerable number of papers on the anatomy of plants found in India and adjacent countries have appeared during the year but as their interest is more general than particular to India detailed reference here does not appear to be called for. The more important amongst them are mentioned in the list of publications attached to this report.

Publications.—The results of botanical investigations that have been described in the more important publications of the year have been referred to above, and the subjoined list does not claim to be more than a selection from the total mass of literature with more or less reference to India, issued during the year.

A list of papers on the Botany of India published during 1908-09.

BAMBER, C. J. . . Plants of the Punjab. (*Journ. Bom. Nat. His. Soc. xviii, 4, 835—861, 1908 and xix*, i, *59—86, 1909.*)

BARBER, C. A. . . Studies in root-parasitism. The haustorium of Cansjera Rheedii. (*Mem. Dept. Agri. Ind. Bot. Ser. ii, 5, 37, with 11 plates, 1908.*)

BECCARI, O. . . Asiatic Palms. Lepidocaryeæ. Part I. The Species of Calamus. (*Annals Roy. Bot. Gard. Calc. xi, pp. iii, 518 with 288 plates, Calcutta, 1908.*)

BECKER, W. . . Ein Beitrage zur Veilchenflora Asiens. (*Beih. Bot. Cbl. xx, Abt. 2, 125—127, 1906.*)

BERNARD, CH. . . Sur une anomalie des fruits de Carica Papaya. (*Ann. du Jard. Bot. Buiten. Ser. 2, vii, 56—68, with plates, 1908.*)

BLATTER, E. . . Ferns of the Bombay Presidency. (*Journ. Bom. Nat. His. Soc. xviii, 3, 599—612, 1908.*)

BLATTER, E. . . The Flora of the Bombay Presidency. (Statistico-Biological Notes.) (*Journ. Bom. Nat. His. Soc. xviii, 3, 562—571, 1908.*)

BLATTER, E. . . On the Flora of Cutch. (*Journ. Bom. Nat. His. Soc. xviii, 4, pp. 756—777, 1908, and xix*, i, *157—176, 1909.*)

BONATI, G. . . Scrofularinées nouvelles de l'Indo-Chine. (*Bull. Soc. Bot. France, lv, 509 et 537, 1908.*)

BOURDILLON, T. F. . The Forest Trees of Travancore. (*pp. 456, Trivandrum, 1908.*)

BURKILL, I. H., & FINLOW. The races of Jute. (*Agric. Ledger, 1907-08, 6, 41—137.*)

BURKILL, I. H. . . A working list of the Flowering Plants of Baluchistan. (*pp 136, Calcutta, 1909*).

BURKILL, I. H. . Notes on the pollination of Flowers in India. Nos. 5 & 6. (*Journ. Asiat. Soc. Beng. iv. No. 4, April 1908, pp. 179-231.*)

COMPTON, R. H. . The Morphology and Anatomy of Utricularia brachiata *Oliver*. (*New Phytologist, viii., 4, 117—130.*)

COOKE, T., & STAPF, O. Andropogon (Dichanthium ?) serrafalcoides. (*Kew. Bull. 10, 1908. 450.*)

COOKE, T. . . Flora of the Bombay Presidency. ii, pt. 5, Araceæ to Gramineæ with Index. (*pp. 817—1083, London, 1908.*)

COSTERUS, J. C. . Pistillody of the stamens in Nicotiana. (*Rec. Trav. Bot. Neerland, iv, 221, with plate.*)

DANGUY, P. . . Note sur une collection botanique rapportée du Pamir par le commandant de Lacoste. (*Journ. Bot. xxi, 3, 49—53, 1908.*)

DIXON, H. N. . . Mosses from the Western Ghats. (*Journ. of Bot. xlvii, 1909, pp. 157—164.*)

DODE, L. A. . . Revue des especes du continent asiatique de la section Tetradium et de la section nouvelle Evodioceras du genre Evodia. (*Bull. Soc. Bot. France. 1908, lv, 9, 701—707, 1909.*)

DOP, P. . . . Contribution a l'étude des Malpighiacées d'Indo-Chine. (*Bull. Soc. Bot. France. lv, 427—430, 1908.*)

FINET ET GAGNEPAIN . Additions a la flore de l'Asie Orientale. (*Bull. Soc. Bot. France. liv, 82—90, with plates, 1908.*)

GAGNEPAIN, F. . . Bixacées et Pittosporacées asiatiques (*Bull. Soc. Bot. France, lv, 544, 1908.*)

GAGNEPAIN, F. . . Contribution á la connaissance des Xanthophyllum. (*Journ. de Bot. xxi, 10, 241—253, 1908.*)

GAGNEPAIN, F. . . Essai de classification des Scolopia et Flacourtia asiatiques. (*Journ. de Bot. xxi, 7, 164—173, 1908.*)

GAGNEPAIN, F. . Nouveautés asiatiques de l'herbier du Muséum. (I. Hydrocharitacées, II. Menispermacées, III. Lardizabalées.) (*Bull. Soc. Bot. France. 1908, lv., 34—41, et 43—48.*)

GAGNEPAIN, F. . . Un arbre oleifere d'Indo-Chine. L'huile de Chaulmoogra et le faux Chaulmoogra. (*Journ. de Bot. xxi., 6, 137—144, 1908.*)

GAMBLE, J. S. . . Materials for a Flora of the Malayan Peninsula pt. 21, Verbenaceæ, 1908. (*Journ. Asiat. Soc. Beng. lxxiv., 1909, pp. 729—908.*)

GAMBLE, J. S. . . Acer Osmastoni. *Kew Bull. 10, 1908, 446.*)

GAMBLE, J. S. . . Boschia Mansoni. (*Kew Bull. 10, 1908, 445.*)

GAMBLE, J. S. . . Cynometra Bourdilloni. (*Kew Bull. 10, 1908, 446.*)

GAMBLE, J. S. . . Wrightia sikkimmensis. (*Kew Bull. 10, 1908, 447.*)

GAMMIE, G. A. . . Indigenous trees and shrubs under observation. (*Report of Exp. Work, Ganeshkhind Bot. Stat. 4—15, 1908.*)

GAMMIE, G. A. . . The Orchids of the Bombay Presidency, pts. VI—VIII (*Journ. Bom. Nat. Hist. Soc. xviii, 3, 586—590, 1908, 4, 833—834, 1908; xix*, i, *1909, 139—141.*)

GEHRMANN, K. . . Vorarbeiten zu einer Monographie der Gattung Bridelia (*Engler's Bot. Jahrb. xli, Beibl. 95, 1—42, 1908, with plates.*)

GUEGUEN, F. . . Enations hypophylles du Colocasia esculenta Schott. (*Bull. Soc. Bot. France. lv., 26—32, with plates, 1908.*)

HERTER, W. . . Lycopodium sikkimense. (*Bot. Jahrbuch. xliii., 1909, 42.*)

HILLIER, J. M. . . Lalang grass—Imperata arundinacea Cyrill. (*Kew Bull. 1909, 2, 55—59.*)

HOOKER, J. D. . . On some species of Impatiens. (*Hooker's Icones Plantarum, ix., 3, 2851—2875, 1908.*)

HOOKER, J. D. . . On some species of Impatiens from Indo-China and the Malayan Peninsula. (*Kew Bull.* i., *1909.*)

HUTCHINSON, J. . Notes on the Indian species of *Sambucus*. (*Kew Bull. 4, 1909, 191—193.*)

KUSANO, S. . . Further studies on Æginetia indica. (*Bull. Coll, Agric. Tokyo viii*, i, *59—78, with plates, 1908.*)

LECOMTE, H. . . Sabiacées asiatiques nouvelles de l'herbier du Muséum. (*Bull. Soc. Bot. France. 1907, liv, 671—678.*)

MARTEN, J. . . List of Ferns found at and around Mussoorie, 1908. (*Journ. Bom. Nat. His. Soc. xix.*, i, *1909, 179—183.*)

MASTERS, M. T. . On the distribution of the species of Conifers in China and on the occurrence of the same species in neighbouring countries. (*Journ. Linn. Soc., London, xxxviii., 198—205, 1908.*)

MEEBOLD, A. . . Eine botanische Reise durch Kaschmir (*Bot. Jahrbüch. xliii, iii, pp. 63—90, 1909.*)

NESTLER, A. . . Die hautriezende Wirkung der Primula mollis Hook. und P. Arendsii Pax. (*Ber. deutsch, Bot. Ges., xxvia, 468—475, 1908.*)

PETITMENGIN, M. . Revue critique des Primulacées asiatiques. (*Bull. Acad. Intern. Geogr. Bot., xvii, Nos. 225—226, 334—338, 1908.*)

PRAIN, D. . . A new species of Butea, with notes on the genus. (*Kew Bull. 1908, 9, 381—387.*)

PRAIN, D., & BURKILL, I. H. Dioscorearum novarum descriptiones quædam. (*Journ. and Proc. Asiat. Soc. Bengal, iv., 9. 447—457, Sept. 1908.*)

RENNER, O. . . Beiträge zur Anatomie und Systematik der Artocarpeen und Conocephaleen inbesondere der Gattung Ficus. (*Diss. München, 1906, 129.*)

RIDLEY, H. N. . . Materials for a Flora of the Malayan Peninsula. Gesneraceæ. (*Journ. Asiat. Soc. Beng. lxxiv, Pt. 4, pp. 730—793, 1909.*)

SPRAGUE, T. A. . . The prickly-fruited species of Euonymus. (*Kew Bull.* i, *29—36, 1908.*)

STAPF, O. . . . Arthraxon Meeboldii. (*Kew Bull. 10, 1908. 449.*)

STAPF, O. . . . Mussænda Treulleri. (*Kew Bull. 10, 1908, 449.*)

STAPF, O. . . . Pyrus Pashia var. Kumaoni. (*Bot. Mag. 53, 1909.*)

WILLIAMS, F. N. . The Caryophyllaceæ of Tibet. (*Journ. Linn. Soc., xxxviii., 268, 395—407.*)

WRIGHT, C. H. . . *Alpinia bracteata* Roxb. (*Bot. Mag. 50, 1909.*)

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ECONOMIC BOTANY.

BY

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Wheat.—The most important original contributions to the Economic Botany of India published during the year ending June 30th, 1909, relate to the improvement of the wheat crop. The papers actually published during the year under review as well as those still in the press are the result of the discussion on the best means of developing the wheat production of this country which took place at the second meeting of the Board of Agriculture held at Pusa in 1906. Evans has completed a survey of the wheats of the Central Provinces and Berar based on an examination of ripe ears sent in from the various districts. In this paper a good deal of information is given on the cultivation and uses of the varieties, but the author has not yet worked out by means of pure line cultures the agricultural characters and qualities of the various wheats at present in cultivation in this Province.

The writer, in collaboration with G. L. C. Howard, has published a memoir on the varietal characters of Indian wheats. This paper deals with the influence of external conditions on the various characters of wheat in India and with the principles of classification. It was found that wheats cannot be completely classified from ripe ears only as the botanical varieties are themselves complex and contain types differing in field characters. Among the characters most influenced by environment the consistency of the grain takes the first place. The detailed classification and description of the wheats of the Punjab was included in this paper as an example of the system of classification finally adopted. Several cases of natural crossing, discovered at Lyallpur in 1907, are described, and it is proposed to publish a further paper on this subject. A bulletin has also been issued during the year on the milling and baking qualities of Indian wheats. It was found that some of the wheats grown at Pusa and Lyallpur were harder and higher in nitrogen than the soft whites like Mozaffernagar usually exported to England. While these harder wheats gave decidedly better results in the mill and bake-house than Mozaffernagar white, a Pusa selection, No. 6, gave the best results of all. Contrary to what has often been stated, India can produce

much stronger wheats than those usually exported and this aspect of the subject is being followed up.

A monograph on Indian wheat was completed by the writer, in collaboration with G. L. C. Howard, during the year under review, and is now passing through the press.

Cotton.—Considerable attention is being paid to Indian cotton, and several papers have appeared during the year. Fyson has published his results on the hybridising of Indian cotton, the work on which was commenced in Madras in 1904. Leake at Cawnpore, has issued a second paper on the same subject dealing with buds and branching. This work emphasises the great importance of the study of the growing plant both from the point of view of classification and also of breeding early flowering types of suitable habit for North-West India. Dobbs at Lyallpur, has published some interesting observations on the natural crossing of cottons in the field and the results are best given in the author's own words. He states "By separate sowing on the farm of seed from single known parents evidence has been obtained, conclusive to any one familiar with the common reactions caused by hybridisation, that a very large proportion of the cottons on the farm, particularly those that are most vigorous, are crosses between distinct varieties within each of the above main types, *e.g.*, seedlings grown from a supposed "Khaki" American parent having a light brown lint gave "Khaki", light brown and pure white lint in approximately "Mendelian" proportions. Again "Dharwar" cotton consists, on the farm, of innumerable varieties, early and late, productive and unproductive, of which half do not breed true to type; and it may be inferred that this variation has arisen by hybridisation. In this lie great possibilities of improvement by mere systematic selection as well as the explanation of the extraordinary deterioration noted below of Egyptian cotton grown from unselected seed. It is in fact clear that where a valuable variety grows in close proximity to a worthless one of the same main type, great care, in the following year, in the selection of parents for seed production, is necessary, if the valuable strain is to be kept pure. This agreeing with experience in America where (pages 131 and 132 of the *Year Book of the U. S. A. Agricultural Department*, 1903), it is advised that seed fields of valuable cotton should be located 'half a mile or more from any other cotton,' should be taken into account in seed growing in the future." The published evidence on the frequent existence of natural crossing in cotton in India may be regarded as absolutely conclusive and this circumstance will have to be taken

into serious account in the growth and distribution of pure seed to the cultivators and in the introduction of exotics.

Fibres.—Several papers on fibres have appeared during the year. Burkill and Finlow have written a long paper on the races of Jute, the result of investigations on this crop commenced in 1900. The objects of this work have been to throw light on the question of the alleged deterioration of jute and to discover the most suitable races for cultivation in the various districts. The field notes are given in considerable detail and the authors have provisionally distinguished thirty-three races of *Corchorus capsularis*, round podded jute, and five races of *C. olitorius*, long podded jute. Finlow has given a general survey of the work in progress on fibre plants in India in the *Agricultural Journal of India* in which a reference is made to the report on the investigations (carried out by Messrs. Cross and Bevan) to the Secretary of State for India on the "heart damage" of baled jute. The chief characteristic of this deterioration is an entire loss of tensile strength of the fibre and Messrs. Cross and Bevan, while suggesting treatment with formalin as a method of prevention, are of opinion that further co-operative work is desirable.

The report of the sub-committee appointed by the Board of Agriculture in 1908 to consider the question of the extension of cultivation of fibre plants in India has issued its report which is published as an appendix to the *Proceedings of the Board of Agriculture at Nagpur in 1909*. "The Committee believes that it is possible to extend largely and profitably, in the immediate future, the cultivation of jute, Sann-hemp and *Hibiscus cannabinus*, and that later on, it is possible that a portion of the linseed grown over large areas in various parts of India, may be utilized for the production of fibre as well as seed. A considerable increase of Agave cultivation is possible in Assam and in tracts which have similar physical and climatic conditions. Successful Rhea cultivation must apparently be limited to a comparatively narrow zone where both climate and soil are particularly suitable. The Committee affirms that jute is a very paying crop and believes that it can usually be followed by a food crop in the same year.

"The Committee lays great stress on so arranging the rotation of food and fibre crops that the encouragement of the latter shall not be at the expense of the former. From this point of view, those fibre crops, which occupy the ground for one season only, are preferable to those of a perennial nature.

"The Committee believes that the demand for fibres is bound to increase, as they are essential for nearly all branches of trade, also that it is not likely that prices will fall so low as to render fibre cultivation in India unremunerative."

The flax experiments conducted in Behar have been continued during the year and have been placed on a more permanent footing. It is fortunate that the prompt action taken by the Behar Planters' Association to eradicate the spread of flax dodder has apparently been successful.

Some minor papers on fibre plants include a review of existing information on the use of *Urena lobata* as a possible jute substitute by Abbey-Yates and a paper on the fibre plants of Upper Burma published by Aubert in the *Agricultural Journal of India*. Among the fibre plants utilised by the people, *Hibiscus cannabinus* is the most important. The question of the future utilisation of *Sida* as a fibre plant is the subject of a short note by Finlow.

Fruit.—Although continued attention is being paid to fruit growing in India but few papers have appeared during the year. The second report on the Pusa fruit experiments by the writer is in the press while Woodhouse has published an interesting note on the mangoes of Bhagalpur of which thirty-eight kinds, arranged in three groups, are described.

Miscellaneous.—During the year an important work of reference on the Economic Botany of India has been completed by Watt and published by the Secretary of State for India. An abstract of this author's *Dictionary of Economic Products of India* has long been greatly needed and the compression which has been practised in the preparation of the new *Commercial Products of India* has resulted in a much more useful and workable treatise. It is probable that the new book will remain for many years a standard work of reference on the numerous agricultural products of India.

Gammie has issued a long paper on the field, garden and orchard crops of the Bombay Presidency, the result of eight years' observations on the subject. A more extended illustrated edition is promised shortly. The various economic plants are grouped according to their natural orders, and in some cases, especially among the *Gramineæ*, the cultivated varieties have been partly worked out in detail. The author has also added general agricultural notes to some of more important species.

Barber has published another interesting paper on root parasitism in Southern India. He has studied in detail the anatomy of the

haustorium of *Cansjera Rheedii* which was found to be parasitic on more than 40 other plants. A summary of existing information on the use of dyes from flowers in India has been compiled by Burkill, while Evans has published an account of the varieties of potatoes grown in the Central Provinces. An interesting summary of the tea experiments at Heeleaka, conducted on behalf of the Indian Tea Association by Hutchinson has appeared. The feature of this report is the use of curves in expressing graphically the plot results and the care that has been devoted to the presentation of the subject. Rahar (*Cajanus indicus*) gave the best results among the green manure plants. Hutchinson has also issued a report on the causes of taints in packed teas which are considered to be caused by defects in the box boards, often due to the use of unseasoned timber, and not to faulty methods of manufacture. Papers on cassava have been contributed to the *Agricultural Journal of India* by Booth-Tucker and Pillay. An account of the introduction of two rubber-yielding trees, *Manihot dichotoma* Ule and *M. piauhyensis* Ule, is described by Gage in the *Annual Report of the Calcutta Botanic Garden for 1908-09.*

List of papers on Economic Botany in India published during the year ending June 20th, 1909.

ABBEY-YATES, R. . Urena lobata. (*Agr. Ledger*, No. 4, 1908-09.)

AUBERT, L. . . Some Fibre Plants of Upper Burma. (*Agr. Jour. India, iii, 1908, p. 333.*)

BARBER, C. A. . . Studies in root parasitism. IV. The haustorium of Cansjera Rheedii. (*Mem. Dep. Agr. India, Bot. Ser., ii, No. 5, 1908.*)

BOOTH-TUCKER, F. . Cassava as famine food. (*Agr. Jour. India, iii. 1908, p. 227.*)

BURKILL, I. H. . Dyes from Flowers. (*Agr. Ledger, No. 2, 1908.*)

BURKILL, I. H., & FINLOW, R. S. . The races of Jute. (*Agr. Ledger, No. 6, 1907.*)

DOBBS, A. C. . . (*Annual Report of the Lyallpur Agr. Station, 1907-08*).

EVANS, G. . . Varieties of wheat grown in the Central Provinces and Berar. (*Nagpur, 1908.*)

EVANS, G. . . Varieties of potatoes grown in the Central Provinces. (*Nagpur, 1908.*)

FINLOW, R. S. . . Experimental work on Fibres in India (*Agr. Jour. India, iv, 1909, p. 16.*)

FINLOW, R. S. . . Sida Fibres. (*Agr. Jour. India, iv. 1909, p. 200.*)

FYSON, P. F. . . Some Experiments in the hybridising of Indian cottons. (*Mem. Dept. Agr. India, Bot. Ser., it. No. 6, 1908.*)

GAGE, A. T. . . Annual Report of the Calcutta Bot. Gardens for 1908-09.

GAMMIE, G. A. . . Field Garden and Orchard Crops of the Bombay Presidency. (*Bull. 30, Dept. Agr. Bombay, 1908.*)

HOWARD, A., & HOWARD, G. L. C. . The varietal characters of Indian wheats. (*Mem. Dept. of Agr. India, Bot. Ser. ii. No. 7, 1909.*)

HOWARD, A., & HOWARD, G. L. C. . The milling and baking qualities of Indian wheats. (*Bull. 14, Agr. Research Inst., Pusa, 1908.*)

HOWARD, A. . . On Flax dodder. (*Bull. 11 Agr. Research Inst. Pusa, 1908.*)

HUTCHINSON, C. M. . Report of the Heeleaka Experiment Station, 1905—1908. (*Calcutta, 1908.*)

HUTCHINSON, C. M. . Report on the causes of taints in packed teas. (*Calcutta, 1908*).

LEAKE, H. M. . . Studies in the Experimental Breeding of Indian Cottons; an introductory note. Part 2. On Buds and Branching. (*Jour. Proc. Asiat. Soc. Bengal, v. No. 1, 1909, p. 23.*)

PILLAY, T. P. . . The cultivation of Tapioca in Travancore. (*Agr. Jour. India, iii. 1908, p. 366.*)

WATT, SIR G. . . The Commercial Products of India. (*London, 1908*).

WOODHOUSE, E. J. . The Mangoes of Bhagalpur. (*Quarterly Jour. Dept. Agr., Bengal, ii, 1909, p. 168.*)

PROCEEDINGS of the Board of Agriculture in India held at Nagpur, Calcutta, 1909, p. 54.

MYCOLOGY.

BY

W. McRAE, M.A., B.Sc.,

Offg. Imperial Mycologist.

The campaign against the palm disease of the Godavari Delta is still being continued by means of the special staff sanctioned by the Madras Government. There has been no general recrudescence of the disease in the early months of this year such as occurred last year, and during a tour in January a very small number of newly diseased trees were seen.

During a visit to Kashmir an enquiry was made into the diseases of Mulberrry and of fruit trees. The result of part of this work has been published while the rest is in progress.

The study of the wilt disease of pigeon-pea has been concluded and the disease has been definitely ascertained to be due to *Fusarium udum* Butl. A memoir on the work is now in the press. The cause of the gram wilt has also been definitely determined. Enquiry into cotton, indigo and pigeon-pea wilts was continued.

Renewed investigation to elucidate the methods of infection of red-rot on sugarcane has been undertaken and work is in progress on the life histories of other sugarcane diseases including a new one from Madras.

A disease of ginger is also under investigation and also linseed rust, citrus diseases, papya stem-rot, and a new anthracnose on Val (*Dolichos Lablab*). Some species of the rare genus *Choanephora* and the two maize smuts of India have been studied and a successful attempt has been made to work out the life history of the very obscure paddy smut.

Publications.

BUTLER, E. J. . . The Mulberry disease caused by Coryneum Mori Nomu. in Kashmir with Notes on other Mulberry Diseases. (*Mem. Dep. Agric. India, Bot. Ser., ii, No. 8, April 1909*).

HOWARD, A., & G. L. C. Note on Immune Wheats. (*Journ. Agric. Science, ii, Part 3, Dec. 1907*).

PILLAI, N. K. . . Untersuchungen über den Einfluss der Düngung und anderer Faktoren auf die Tätigkeit der Mikroorganismen des Bodens, February 1908.

FOREST BOTANY.

BY

R. S. HOLE, F.C.H., F.L.S., F.E.S.,

Imperial Forest Botanist.

(I)—Work done at the Imperial Forest Research Institute.

Educational work of Forest Botanist.

1. During the rains from July to October the Forest Botanist delivered the usual course of botanical lectures to the first year students of the Imperial Forest College and in addition gave a course of botanical instruction to the third year students. The Botanist was also in charge of the College students on tour during November-December 1908 and again during May-June 1909 while March was as usual occupied with the Forest College Annual Examinations. The Manual of Botany prepared by the Botanist for the use of the Forest College Students was seen through the press and published during the year.

Facilities for Research work. (a) Herbarium and Collections.

2. The Botanist took charge of the valuable Saharanpur Herbarium at Saharanpur on July 25th, 1908. The collections were forthwith removed to Dehra Dun and suitably housed there. When first taken over they were in considerable disorder, many of the sheets, including all those of *Grewia*, were missing and a large quantity of unnamed material was included which required working up.

Mr. N. Hutchinson, the Curator, has, however, worked hard at arranging and putting the collections in order and this work will be completed early next year. The majority of the missing *Grewia* sheets have fortunately been recovered during the year from the Calcutta Herbarium where they had been misplaced and the remainder together with other missing specimens are expected to be returned shortly from Mr. J. R. Drummond to whom they had been loaned.

In order to economize space the amalgamation of the Saharanpur collections with the Herbarium of the Forest College and Research Institute was commenced in April and the work will be completed early next year.

This amalgamated Herbarium will certainly rank as the most important in India next to the historic collections at Calcutta and will form one of the most valuable assets of the Research Institute not only for research work but also for the purpose of identifying specimens for Forest Officers and others, a work which hitherto could only be undertaken on a very small scale.

In addition to the *Grewia* specimens which were received for research purposes and which will not be finally incorporated until the research is complete 760 sheets were added to the Herbarium during the year. The most important contributions were from Mr. J. H. Lace and Mr. D. O. Witt, the latter sending duplicates of his Berar collections. Mr. A. W. Lushington also contributed an interesting set of specimens of root suckers of various species from Madras.

A valuable set of duplicates was received from the Calcutta Herbarium during the year, and in future it is proposed to extend this system of interchanging duplicates with other Indian herbaria.

Specimens were identified during the year for Forest Officers in Madras, Burma, Central Provinces, Andamans, Bengal and Punjab. The principle adopted in dealing with the Botanical Collections at the Research Institute has been to divorce as far as possible the collections required only for educational purposes from those required for research and reference purposes generally. Apart therefore from the main reference herbarium a small separate herbarium is maintained for the use of the College students and towards the close of the year a commencement was made with the formation of an educational collection of glazed show cases designed to illustrate the botanical course of lectures and to exhibit species of forest importance and types of the chief natural orders and groups of plants.

(b) Botanical Library.

3. When the Botanist took charge of the Saharanpur Herbarium it was found that the valuable library, which was formerly attached to it, had been removed to Cawnpore and placed in charge of the Economic Botanist to the Government of the United Provinces. This naturally discounted the value of the Herbarium considerably. On representations made by the Forest Botanist, however, it was finally agreed that some 400 of the volumes of

special value for the Herbarium should be returned to it. These books are expected early next year and will greatly increase the value of the existing Botanical Library.

During the year several valuable volumes were added to the botanical section of the College Library at an expenditure of Rs. 23. At the close of the year a revised scheme of classification of the botanical books was drawn up and the preparation of a new catalogue commenced.

Shortly after the close of the year the entire botanical section of the library was removed to the Herbarium where it is most conveniently situated for reference.

(c) Accommodation.

4. Want of sufficient accommodation has very seriously hampered all research work up to date. Until quite recently no laboratory, with facilities for microscopic work, and no suitable experimental garden were available. Towards the close of the year, accommodation for the herbarium, botanical office, library, laboratory and experimental garden was secured in the immediate neighbourhood of the Botanist's bungalow. The botanical branch of the Research Institute may therefore now be said to have been for the first time satisfactorily organised and future progress with research work should be rapid and satisfactory.

Research work of Forest Botanist.

5. The following subjects were included in the research programme sanctioned for the year under report:—

(*a*) Study of Teak coppice and reproduction.

(*b*) Study of Forest Grasses, with special reference to the effects of fire upon them.

(*c*) Study of the various species or forms of *Grewia* of economic importance with special reference to the production of a satisfactory classification and description of the same.

6. As regards the first subject some of the notes and observations collected by the Botanist in the Central Provinces during the previous year were worked up and the results sent to the Press for publication in the form of a Pamphlet. The results obtained indicate that, contrary to a widely spread opinion the coppicing of teak towards the close of the period of vegetative activity in September-October is not injurious.

This probably applies also to the case of many other deciduous species and is a matter of considerable importance, for the prohibiting of all fellings during the rainy season has frequently resulted in a considerable loss of revenue.

Another important point noticed, which, however, requires further investigation, is that felling low in the season of vegetative rest is apparently responsible for the frequent death of stools of important deciduous species and that if coppice fellings must be carried out (as they usually are) during the resting period, cutting high appears to be frequently desirable.

The fertility of the seed produced by coppice shoots is another question of great importance which received attention. At the close of last year Mr. McCrie sent the Botanist a sample of undoubted teak coppice seed which he had collected himself from 9-year old coppice shoots in the Saugor Division of the Central Provinces. The seed was sown at the Research Institute in July 1908 and it germinated towards the close of the year under report and produced healthy seedlings. The fact has therefore been proved that teak coppice shoots of only 9 years growth are capable of producing good fertile seed. The age at which coppice shoots produce seed of course depends to a great extent on the age of the mother tree felled and the nature of the stool.

7. The study of the oecology of Forest Grasses was commenced during the year under report, with special reference to the effect of fire upon their distribution and development and the relations existing between them and our important forest trees. During the year under report it was only possible to make a very small beginning with this work. The Botanist made a short tour in the Siwalik Forest Division during the period November 1908 to January 1909, but as he was also in charge of the College students on tour during November-December 1908 very little time was available for research

Attention was mainly confined to 9 important local species which are widely distributed in Sál forests and careful notes were collected in the forest in as many localities as possible regarding the conditions under which the various species grow well in nature, the effect of fire upon them, the power of the different species to improve the soil, and other points.

The information collected has, it is believed, satisfactorily established the following facts of interest among others :—

(*a*) The damage done by fire depends mainly on the character of the soil, the season at which the fire occurs and the species of grass. Firing by no means necessarily kills out delicate and valuable fodder grasses and favours the growth of coarse growing species. Cases have been seen where fire

has had precisely the opposite effect; and species which produce delicate annual culms are often very resistant to fire damage.

(*b*) Some grasses indicate with great accuracy whether a certain soil is, or is not, suitable for the growth of valuable trees like Sál and their appearance in forest blanks tells us whether we can reasonably hope to successfully stock such areas with a particular species or not.

In order that Forest Officers generally may be able to avail themselves of any useful results which are obtained from time to time, it is essential that they should be able to recognize the grasses concerned. In order to facilitate the identification of the species dealt with therefore it is proposed to publish together with the results obtained full descriptions and illustrations of the different species. These illustrations will include dissections of the flowers and illustrations of the glumes on which the identification of the species largely depends and which have hitherto been inadequately dealt with in the published illustrated works on Indian grasses.

All the species at present under study were planted in the Experimental Garden at Dehra Dun during the year in order that their development might be watched and the differences of growth observed which are exhibited by burnt and unburnt plants respectively. It is also obviously advisable that all conclusions based only on observations made in the forest should so far as possible be checked by experimental cultivation.

No publication was possible during the year partly on account of insufficient time being available for the preparation of the detailed descriptions and drawings of the different species and partly owing to the advisability of observing one complete season's growth before publishing.

This study of forest grasses is greatly facilitated by the fine collection of grasses contained in the College Herbarium which was mainly accumulated by Mr. Duthie and largely through the help of Forest Officers.

8. As regards the subject of *Grewias*, although the results are not yet ready for publication, it seems advisable to give here a brief review of the work which has been undertaken and of the lines on which it is proceeding, seeing that this subject of research has been under study now for 2 years, but in considering the progress made the fact must not be

lost sight of that very little time has been actually available for research work during this period.

The study of this genus, the existing classification of which is very unsatisfactory and the synonymy of which is in great confusion involves three distinct classes of work as follows :—

(*a*) The accurate determination of the original types which are the authority for existing names and of the date of their effective publication.

(*b*) The careful study of the various forms in the field in order to determine the extent to which the various types keep constant in nature.

(*c*) The preparation of descriptions and illustrations of the various specific and varietal groups which study in the field, as checked by the careful examination and dissection of herbarium material, shows to be worthy of separate description and definition. This study at present deals with 12 forms each of which has at one time or another received a separate specific name. The united area of distribution of these forms covers practically the whole of India and Burma. To any one acquainted with the confusion at present characteristic of the classification of this genus the magnitude of the work will be apparent, especially as it involves at least a general acquaintance with all the forty odd Indian species of the genus in addition to the detailed study of the forms under special consideration. The non-success also with which Indian botanists have for several years worked at this problem is a sufficient guarantee of its peculiar difficulty.

PART A.—*Determination of Types.*

Of the work defined above this is the portion which offers the greatest difficulty to workers in India owing to the fact that most of the types are stored in European Herbaria and that the publications containing the original descriptions are frequently not available in Indian libraries. In this part of the work therefore the co-operation of European botanists is essential.

The greatest help was received from the authorities at Kew during the year in the shape of authentic drawings and descriptions of type specimens without which this research could not have been successfully carried on.

The writer has also to acknowledge the receipt of several valuable photographs of types most generously sent to him by Mr. H. H. Haines of the Forest Department while he was on leave in England. Thus, although actual access to the types would of course have been desirable, if it had been possible, it is believed that this portion of the work is being satisfactorily dealt with.

PART B.—*Field-work.*

As regards this division of work it is unfortunate that the College educational duties do not permit of extended tours being undertaken for the purpose of studying the various forms in the forest. The opportunities which have been available however have been utilized as far as possible by confining attention mainly to those areas where various types come into contact.

Thus during the year under report the connection between the forms known in Northern India as *Grewia elastica* Royle, *Grewia vestita* Wall, *Grewia leptopetala* Brandis, *Grewia asiatica* Linn. and *Grewia sapida* Roxb. was carefully studied in the Siwalik and Jaunsar Forest Divisions while during the previous year the connection between *Grewia tiliæfolia* Vahl, *Grewia leptopetala* Brandis and *Grewia elastica* Royle was studied on the Satpuras in the Central Provinces.

This field work, limited though it has been, has proved of the utmost value and by giving a correct idea of the variations of certain forms in different localities it has, it is believed, laid a sound basis for the study by analogy of other forms received from localities which it has not been possible to visit. The fact that tours must occasionally be made at unsuitable seasons of the year when satisfactory specimens of flowers and fruit are not available is a drawback, but selected trees have been numbered and marked in different localities in the Jaunsar and Siwalik Divisions and specimens are collected from these marked trees at different seasons of the year.

PART C.—*Herbarium-work.*

In addition to the great advantage of being able to personally study many of the species in the forest in different localities and at different

seasons the Botanist has been able to assemble, largely owing to the help of other Forest Officers, a practically unique collection of herbarium specimens of the species under study. As an indication of the extent of this collection and of the readiness with which Forest Officers in various parts of India and Burma have helped and are helping this research, it is sufficient to note that, in addition to collections made by the Botanist himself, valuable specimens were received during the year from the following localities :—

United Provinces, Central Provinces, Madras, Bombay, Baluchistan, Bengal, Eastern Bengal and Assam and Burma.

When this work is completed the help given by the various officers will be acknowledged individually and at present the Botanist desires to express his thanks to the Chief Conservators and Conservators of the Provinces enumerated above and the District Officers mentioned and especially to Mr. Lace and other Burma Officers for specimens of forms which are at present very imperfectly known and the connection of which with species described from Java requires to be carefully worked out. The majority of the specimens received are of peculiar value, consisting as they do of extensive series of specimens collected at different seasons from the same tree and accompanied as they are by valuable notes. In most cases also specimens of the wood and bark have also been sent, thus enabling the wood of the various species to be accurately described.

In addition to these collections belonging to the Research Institute the Superintendent, Royal Botanic Garden, Calcutta, most kindly sent the Botanist during the year all the sheets of *Grewia* belonging to the General Herbarium of the Botanic Gardens for examination. The greatest help has also been given during the year by Captain Gage, Superintendent, and Mr. W. W. Smith, Curator of the Herbarium, of the Royal Botanic Garden in the way of supplying authentic copies of drawings and descriptions of types and other information asked for. Mr. I. H. Burkill, Reporter on Economic Products to the Government of India, also very kindly sent the Herbarium Collection of *Grewias* belonging to his office during the year for examination.

The final work of preparing the detailed descriptions and illustrations of the various groups which study up to date shows to require separate description and definition was commenced at the close of the year and the entire results of this research will, it is hoped, be published next year.

Tours.

9. The Botanist was on tour in the Siwalik Division from November 19th, 1908, to January 25th, 1909, and in the Jaunsar Division from May 10th to June 26th. During February the Botanist attended a Forest Conference at Lahore.

10. A quantity of seeds and cuttings of forest species was despatched during the year to the Conservator of Forests, Southern Nigeria, Chief Conservator of Forests, Cape Town, Consul-General for Portugal, Bombay, and the Director of Forests and Gardens, Port Louis, Mauritius. The want of a good reference collection of fruits and seeds of forest species has been felt during the year and a commencement has been made with the formation of such a collection. It is obviously of the first importance to insure that seeds despatched in compliance with the various indents should be correctly identified.

II.—Work done elsewhere.

Anatomy.

11. Dr. Barber has continued his study of the anatomy of root parasites. He finds that so far as the structure of the haustorium is concerned *Cansjera Rheedii* agrees rather with *Santalum* than with *Olax* and considers that this evidence supports the proposal previously made on other grounds to transfer *Cansjera* to the *Santalaceæ* in which order it was originally placed.[1] Winifred Smith has studied the anatomy of various Sapotaceous seedlings including those of the species *Bassia latifolia* and *Mimusops Elengi*.[2]

Monographs, Floras.

12. Professor Beccari's valuable monograph of the species of Calamus was issued during the year.[3] Dr. T. Cooke's most useful *Flora of the Presidency of Bombay* was completed during the year. Mr. H. H. Haines continued his work on the *Flora of Chota Nagpur*. Mr. D. O. Witt published a descriptive list of important forest species found in the Berar Circle of the Central Provinces, and Mr. A. E. Lowrie continued work on the list referring to the Southern Circle of the Central Provinces which is we believe to contain photographs of the species dealt with.

[1] *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. II, No. 5.

[2] *Botl. Trans. Linn. Soc. of London*, Vol. VII, p. 189.

[3] *Annals Royal Bot. Garden, Calcutta*, Vol. XI.

New species and change of names.

13. The following important species were published during the year :—[1]

Pogostemon hispidus Prain—a plant of Assam and Burma.[2]

Butea pellita Hook—a plant of local occurrence in the neighbourhood of Naini Tal.[3]

Boschia Mansoni Gamble—a large tree of Burma.[4]

Acer Osmastoni Gamble—a large tree of the Sikkim Himalaya and Darjeeling.[5]

Cynometra Bourdilloni Gamble—a medium sized tree of Travancore.[6]

R. H. Bunting has examined the type of *Rotula aquatica* Lour and identifies it with *Rhabdia lycioides* Mart, so that the former, which is the older, must now stand as the correct name of this well-known plant.[7]

Introduction of Exotics.

14. A considerable amount of somewhat haphazard work has been carried out by local officers in the various provinces in the way of cultivating exotics. A considerable degree of success continues to attend the cultivation of various rubber yielding species in the South Thana Division of Bombay.

Specimens collected.

15. Forest officers in all provinces most generously helped the Forest Botanist with specimens required for his research work as noted in paragraph 8 above. A number of botanical specimens were also collected for the Reporter on Economic Products to the Government of India, for the Hyderabad and Nagpur Industrial Exhibitions, for the Gass Forest Museum, Madras, Balaghat Training School, Imperial Mycologist, Pusa, and others.

Plant distribution.

16. A subject of great interest in India and one which will, it is hoped, be further elaborated has been broached by Professor Paul Brühl in an article dealing with some of the alien plants of Bengal.[8] The number of such aliens which have successfully established themselves over very extensive areas in India is considerable and the study of their extension and distribution is one of the greatest interest and one which increases our knowledge of the conditions necessary for the existence and successful extension of the indigenous

[1] *Kew Bulletin No. 6 of 1908, p. 254.*
[2] *Botl. Trans. Linn. Soc. of London, Vol. VII, p. 189.*
[3] *Kew Bulletin No. 9 „ p. 385.*
[4] *„ No. 10 „ p. 445.*
[5] *„ „ „ p. 446.*
[6] *„ „ „*
[7] *Journal of Botany, XLVII, p. 269.*
[8] *Journal As. Soc. of Bengal, IV, No. 11, p. 603.*

species which are displaced by the foreigners. In Dehra Dun *Asclepias curassavica* has spread rapidly along the canal banks in recent years.

17. The following are among the more important publications of the year concerned with Indian Forest Botany:

BRÜHL, P. . . Recent Plant Immigrants. (*Jour. Asiat. Soc. Beng., iv, No. 11, p. 603*).

HOLE, R. S. . . Manual of Botany for Indian Forest Students.

IYER, V. S. . . Sandbinding Plants (*Ind. For. xxxv, p. 82*).

JACKSON, A. B. . . Rate of Growth of Palmyras. (*Ind. For., xxxv, p. 394*).

LUSHINGTON, A. W. . Some Notes on Palms. (*Ind. For., xxxv, p. 148.*)

MOLL, J. W. & JANESONIUS, H. H. Mikrographie des Holzes der auf Java vorkommenden Baumarten.

SMITH, W. . . The Anatomy of some Sapotaceous Seedlings. (*Trans. Linn. Soc. vii, p. 189*).

WITT, D. O. . . Forest Flora of the Berar Circle.

WITT, D. O. . . Germination and Development of Hardwickia binata, *read at the Nagpur Forest Conference in November 1908.*

SYLVICULTURE.

BY

R. S. TROUP, F.C.H.,

Imperial Sylviculturist and Superintendent of Forest Working Plans.

1. Investigations at the Imperial Forest Research Institute, Dehra Dun.

Investigations of a sylvicultural nature at the Imperial Forest Research Institute during the past year have of necessity been somewhat restricted The post of Sylviculturist was practically held in abeyance till March 1908, when it was amalgamated with that of the Superintendent of Forest Working Plans. Almost the whole of the year under report was accordingly spent in the preliminary work of organising the details necessary for seriously taking up sylvicultural investigations.

In a subject like sylviculture the chief disadvantage under which the investigator labours is the length of time which must usually elapse before any definite results become apparent, this period extending frequently to many decades of years. Accordingly much of the initial work connected with sylvicultural research must consist for some time to come in starting experiments and recording observations which may lead to no definite and reliable results for many years. Work done hitherto in the Sylvicultural and Working Plans branch of the Forest Research Institute has consisted chiefly of investigations into subjects connected with Working Plans; the various items of the past year's work are noted below.

2. Sylvicultural Systems.

Selection System.

The selection system, owing to its simplicity when applied to the irregular forests of India, has hitherto been far more widely in vogue than any other system, the gradual improvement of the forests being effected *pari passu* by means of "improvement fellings".

The selection system as applied to India has recently been the subject of special study by Mr. A. M. F. Caccia, who has published an instructive note on the subject. This note reveals considerable diversity in the various methods of calculating the possibility: *i.e.*, the number of trees or quantity of timber that can properly be removed from a forest, and as local circumstances do not altogether warrant the extent of diversity which exists, and which under present conditions is likely to increase rather than to diminish, measures are desirable for systematising the various methods of calculating the possibility and, if possible, reducing their number.

Coppice Systems.

Next to the selection system, including the execution of improvement fellings—which in themselves can hardly rank as a system—the coppice or coppice-with-standards systems have hitherto received most attention.

System of Successive Regeneration Fellings.

Of recent years it has become more and more apparent to Forest Officers that the almost universal application of the selection system in India is by no means desirable, for though the system, owing to its simplicity, is one which can be readily applied as a temporary measure to the natural forests of India, and in the absence of sufficient Sylvicultural knowledge has in the past been the only system which could reasonably be applied in the majority

of cases, still the opinion is gaining ground that many types of forest in India are more adapted for working under what we may call the "uniform method." This term, although not altogether satisfactory, is perhaps the best general term to employ for the various methods already known or likely to be evolved in future, whereby an even aged naturally regenerated seedling crop is obtained by means of openings in the canopy of a high forest. The closely allied "group system" may here be included with the uniform method for convenience.

It is noteworthy that of 12 forest working-plans issued during the past year 2 prescribe working under the system of successive fellings; these are Mr. F. Trafford's working plan for the Singalila Range forests, Darjeeling, in which the species comprising the growing stock are *Michelia*, oaks, *Castanopsis*, laurels and various other species, and Mr. E. M. Coventry's working-plan for the Shillong pine forests (*Pinus Khasya*).

In Mr. Trafford's plan a rotation of 160 years is adopted, and the area is divided into 5 periodic blocks. Seed-fellings are to be carried out by groups or strips, and where advance growth is plentiful a complete clearing of the overwood is to be made.

In Mr. Coventry's working-plan for the Shillong pine forest a rotation of 60 years is fixed, the corresponding diameter being 2 feet. The rotation is divided into 4 periods of 15 years each. For the execution of regeneration fellings the first periodic block is divided into 5 annual coupes, the block being thus worked over three times during the period.

Proposals have also been put forward for the extension of the system to the *sál* forests of Kumaon in the United Provinces and the Mohnyin teak forests of Katha in Upper Burma, while negotiations are in progress for taking up a small tract of *sál* forest near Dehra Dun for the experimental application of the system under the supervision of the Imperial Forest Sylviculturist.

In the "Indian Forester" of September 1908, Mr. A. L. McIntire has an interesting article on the forests round Darjeeling, which have been regularly worked under the uniform method since 1892.

3. Information by Species.

Sál.

A valuable contribution to the literature on *sál* (*Shorea robusta*) has been furnished by Mr. A. L. McIntire in his "Notes on *Sál* in Bengal". This important

timber tree is receiving special attention at the Forest Research Institute, where investigations are in progress in connection with the elucidation of various sylvicultural problems connected with it.

Hardwickia binata.

In the "Indian Forester" of June 1909 Mr. L. S. Osmaston published some interesting notes on *Hardwickia binata* in the West Khandesh Division of the Bombay Presidency, particularly with regard to the coppicing power of the species. Actual measurements and enumerations show that neither the height at which the coppice is cut, nor the size of the stump, nor the rainfall of the years immediately preceding and succeeding the felling, have any decided effect on the vitality of the stumps.

Himalayan species.

A study of the more important Himalayan species was commenced by the Imperial Sylviculturist, the chief species concerned being deodar, *Pinus longifolia*, *Pinus excelsa*, *Picea Morinda*, *Abies Pindrow*, *Quercus dilatata* and *Quercus semecarpifolia*.

Teak.

The compilation of statistical information in connection with naturally grown teak in Burma has been commenced: this information is based mainly on the results of working-plans enumerations carried out for nearly 30 years past in different types of teak forest in various parts of Burma.

Andaman Padauk.

In *Indian Forest Records, Vol. I, Part III*, Mr. B. B. Osmaston has a useful note on Andaman Padauk (*Pterocarpus dalbergioides* Roxb.), in which he draws attention to the lack of natural reproduction of that species under dense shade, and concludes, from the results of actual observations, that natural reproduction cannot be obtained in any abundance without making heavy clearings in the overwood. Such operations, however, are rendered somewhat difficult and expensive owing to the fact that padauk is not gregarious but scattered in mixed forest, and that most of the associate species are unsaleable.

Mr. Osmaston draws attention to the large proportion of mature and over-mature padauk trees, saplings and young poles as well as trees below 6 feet in girth being very scarce except in the neighbourhood of Port Blair, where clearings have admitted light: he concludes that this remarkable disparity in the age classes can be explained only by assuming that there has been a very recent change in the condition of the vegetation of the Andamans.

4. Yield Tables.

The collection of information for the compilation of yield tables has been commenced with respect to babul (*Acacia arabica*) in Berar, sissu (*Dalbergia Sissoo*) plantations at Changa Manga in the Punjab, eucalyptus plantations at Ootacamund, casuarina plantations in Madras and teak plantations at Nilambur in the Madras Presidency.

5. Information regarding Plantation Work.

A considerable amount of information was collected during the year on the subject of plantation work carried out in India on a large scale, particularly as regards agri-sylvicultural operations and the planting of arid lands and shifting sands. Short visits were paid to some of the more important of these works.

List of Indian Publications, 1908-09.

1. CACCIA, A. M. F. . A Glossary of Technical Terms for Use in Indian Forestry. (*Forest Pamphlet No. 3, 1908*).
2. CACCIA, A. M. F. . The Collection of Statistical Data relating to the Principal Indian Species. (*Forest Pamphlet No. 8, 1909*).
3. CACCIA, A. M. F. . The Selection System in Indian Forests as exemplified in Working-Plans based on this System, with a Short Description of Some Continental Methods. (*Ind. For. Rec., i, Pt. 4*).
4. CHANNER, F. F. R. The Forests of the Terai and Bhaber Government Estates, United Provinces. (*Ind. For., xxxiv, 393*).
5. CLUTTERBUCK, P.H. Revised Working-Plan for the Trans-Sarda Forests, Kheri Division, Eastern Circle, United Provinces.
6. COVENTRY, E. M. . Working-Plan for the Shillong Pine Forests, Eastern Bengal and Assam.
7. DUTT, SUKH LALI. . Light Burning and Natural Reproduction of Sál. (*Ind. For., xxxv, 154*).
8. JEFFERY, G. R. . Working-Plan for the Hintha, Ondok, and Kyauktaung reserves, Ruby Mines Division, Southern Circle, Upper Burma.

9. MARSDEN, R. E. . Working-Plan for the Kale Working Circle, Myittha Forest Division, Northern Circle, Upper Burma.

10. MCINTIRE, A. L. . Notes on Sál in Bengal. (*Forest Pamphlet No. 5, 1909*).

11. MCINTIRE, A. L. . The Regular Method of Treatment as applied to the Forests around Darjeeling. (*Ind. For., xxxiv, 519*).

12. MORGAN, V. G. . Working-Plan for the Motinala Range Forests, Mandla Division, Northern Circle, Central Provinces.

13. OSMASTON, B. B. . *Pterocarpus dalbergioides* Roxb. Andaman Padauk. (*Ind. For. Rec., i, Pt. iii*).

14. OSMASTON, L. S. . Some Plantations in Satara District of the Central Circle of Bombay. (*Ind. For., xxxiv, 533*).

15. OSMASTON, L. S. . Sylvicultural Notes on *Hardwickia binata*. (*Ind. For., xxxv, 377*).

16. PERRÉE, W. F. . Revised Working-Plan for the Goalpara Forest Division, Eastern Bengal and Assam.

17. POCOCK, T. I. . Working-Plan for the Angul Forests, Bengal.

18. ROSS, A. E. . Working-Plan for the Lower Thaungyin Working Circle, Thaungyin Forest Division, Tenasserim Circle, Burma.

19. SOMERS-SMITH, C. Working-Plan for the forests of the Saugor Division, Northern Circle, Central Provinces.

20. TRAFFORD, F. . Working-Plan for the forests of the Singalila Range, Darjeeling Division, Bengal.

21. TULLOCH, J. C. . Revised Working-Plan for the forests of the Bahraich Division, Eastern Circle, United Provinces.

22. WALKER, H. C. . Reproduction of Teak in Burma. (*Ind. For., xxxv, 367*).

23. WALSH, H. L. P. . Working-Plan for the Maingtha, Kunchaung, and Nanme Reserves, Ruby Mines Division, Southern Circle, Upper Burma.

FOREST PRODUCTS.

BY

R. S. PEARSON, F.L.S.,

Imperial Forest Economist.

The Imperial Forest Economist was engaged on investigating a variety of Forest Products of commercial value, his work to a great measure being confined to an enquiry into the uses of the more important Indian timbers. In this connection a large quantity of data was collected and a Forest Memoir published on the subject. Amongst other subjects to which special attention was paid was the possibility of creating a demand for timbers of value, but concerning which little is at present known by the public; the question of creating a demand for certain gums in the European market; the possibility of improving the prospects of the Match Industry in India, on which a treatise will shortly be published, giving information as to woods which have been found suitable for matches, the yield of suitable timber in given localities, possible sites for match factories, and the financial aspect of the business; experiments were commenced with respect to the antiseptic treatment of Indian timbers by different methods, especially with a view of determining the possibility of increasing the durability of inferior woods which are otherwise unsuited for railway sleepers; many minor enquiries were started, generally at the instance of Indian firms, as to the use of certain timbers for such articles as lead pencils, cricket bats, pipes, tea boxes, opium chests and a variety of similar goods.

Strength and Fissibility Tests of Indian Timbers.—Tests as to the tranverse strength of certain timbers were carried out at Sibpur Engineering College, but the progress made was slow. The object of the tests was to determine the strength of the timbers concerning which little is known by the public, but for which it is hoped a demand may in time arise. Another set of tests are being carried out to ascertain the relative strength of plantation and natural grown teak in Burma.

Experiments as to the fissibility of timber when split in a green and seasoned condition, as also when split radially and tangentially, were carried out in the Research workshops. An interesting feature of the results obtained was that whereas the generally accepted theory in Europe is that timber splits more easily radially than tangentially the reverse was found to be the case with most Indian timbers.

Antiseptic Treatment of woods.—The importance of attempting to utilize the softer and more perishable species found in the Indian forests especially with the ever increasing prices of the more valuable timbers, continued to receive attention. Several methods of treating timber have been brought forward in the past and have attained considerable success. They require, for the most part, a considerable initial outlay on the necessary plant, and this has no doubt led to the appearance on the market of certain antiseptic solutions which can be applied externally and without any great initial outlay. Of the more recent preservative methods may be mentioned the Powellizing process. By the courtesy of the Indian Agents for this process Messrs. Killick Nixon & Co., of Bombay, it was possible to procure and lay down a large number of powellized specimens of Indian timbers together with untreated specimens and keep them under observation.

Under antiseptic solutions which are applied like paint, but in a hot state, specimens were treated with four different solutions, and together with untreated specimens laid down and put under observation. Of the four above mentioned solutions, one, namely, "Avenarius Carbolineum," has undergone a severe laboratory test at the National Forest School at Nancy, France, and so favourable were the results obtained that a railway company in France has laid down a large number of sleepers treated with this solution. The whole question of preserving wood, particularly for railway sleepers, is under investigation.

Seasoning of Timber.—Experiments as to the seasoning of timber, both naturally and artificially treated, were carried out, and information collected as to their relative warping propensities when freshly sawn. Species of timber which are known to contract star and cup-shake while seasoning were treated with a solution known on the market as "Ligno," and placed under observation together with untreated logs. It is as yet not possible to state what advantages are derived by such a treatment, but as far as can now be judged the experiment should prove instructive.

Wood and Bamboo Pulp.—The progress made in India, in starting the industry with raw material obtained from forests, has advanced but slowly. Following his investigations into the value of bamboo for paper pulp, Mr. Sindall carried out experiments during the year to ascertain the value of the wood of Himalayan silver and spruce. The results obtained by him were sufficiently encouraging to make it desirable to carry out experiments to ascertain the cost of exploiting the timber from the hills, and Jaunsar Division, in the United Provinces, was selected as

a likely site for the operations. Mr. Billson, the Divisional Forest Officer, supervised the work, but the first attempt has shown the cost to be prohibitive.

Attention is being directed to the possibility of the sulphite process being used with advantage in the manufacture of bamboo pulp, and experiments in this connection are being undertaken. The possibility of starting paper-pulp manufacture in India and Burma is under investigation.

The Match Industry.—This industry has received a considerable amount of attention in India of late years, while the enquiries as to the possibility of starting factories in various parts of India have been numerous. Forty species of Indian timbers were sent to Europe in the previous year, to be tested, and a full report as to their value is now available. A full report on the subject, together with complete estimates for a fully equipped factory estimating the profit and loss on such an undertaking, is now in the press, and should shortly be available to the public.

Oil-seeds.—The question of utilizing the oil expressed from the seeds of forest trees for edible and burning purposes, as also for soap-making and oil-cake, was under investigation. At the instance of Mr. A. G. Lowrie, a forest officer in the Central Provinces, oil expressed from the seed of *Schleichera trijuga* was sent to an Indian firm with a view of utilizing it for soap-making, while the seed of *Prunus eburnea*, on analysis in England, has been classed as a possible substitute for almond oil. The question of utilizing seeds of certain forest trees for oil-cake and manure will be further examined.

Tans and Dyes.—An article entitled "The use of *Terminalia Arjuna* bark for Tanning," by D. O. Witt, I.F.S., brings to notice the use of the "Kohar" bark as a tanning agent, in the Nimar division of the Central Provinces. The process employed locally, in tanning leather with the aid of the bark, is to subject the hide to soaking in water to which some 30 seers of bark are added, and leaving it in the solution for six days. The importance of Mr. Witt's article is not the method of tanning the leather, but the use of the bark of *Terminalia Arjuna*.

Botanical and other specimens.—A large number of botanical specimens as well as specimens of wood, samples of seed and minor forest products, were collected by the Forest Department and supplied to the Reporter on Economic Products, Imperial Forest Research Institute, Agricultural Research Institute, Pusa, America, Chilli, Austria, Phillipines and private firms in India and abroad.

Publications.—Several publications dealing with economic subjects were sent to the press, but have not been published up to date.

Of the publications on forest matters, Economic Branch, the following are the most noteworthy:—

List of Publications.

1. COVENTRY, E. M. . Notes on the Principal Timber Trees of Eastern Bengal and Assam.
2. GUPTA, J. N. . A Monograph on Paper Making and Papier Maché in Eastern Bengal and Assam.
3. HENRY, E. . . Essai en Grand du "Carbolineum Avenarius" (*Revue des Eaux et Forêts No. 7, 1st April 1909*).
4. LOWRIE, A. E. . The Propagation and Collection of Lac.
5. PURAN SINGH . A note on the Manufacture of Pure Shellac, *Ind. For. Mem., i, Chem. Ser. Pt. ii*).
6. TROUP, R. S. . A note on the Present Position and Future Prospects of the Cutch Trade in Burma. (*Ind. For. Rec., i, Pt., iii*).
7. TROUP, R. S. . Note on the Andaman Marble wood or Zebra wood, *Diospyros Kurzii*. (*Forest Pamphlet No. VII, For. Econ. Ser. No. II*).
8. TROUP, R. S. . Indian Woods and their uses. (*Ind. For. Mem. i, Econ. Prod. Ser. No. I*).
9. WITT, D. O. . A note on the use of *Terminalia Arjuna* Bark (*Ind. For., xxxiv, No. x, October 1908*).

INDIAN ZOOLOGY.

October, 1908—September, 1909.

BY

DR. N. ANNANDALE, D.Sc.,

Superintendent, Indian Museum.

This report, as heretofore, consists mainly of an account of the zoological research undertaken in connection with the Natural History

Section of the Indian Museum during the year, but includes also a brief summary of what has been accomplished elsewhere in India and abroad. As only work that directly affects the Indian Empire is dealt with, no further mention need be made of the valuable researches on the zoology of Ceylon undertaken by the Colombo Museum. An account of these researches will be found in the periodical *Spolia Zeylanica* issued by the Colombo Museum.

I.—Work done by the Indian Museum.

(a) **Field Work.**—It is perhaps as well that in this report special stress should be laid on work of direct "practical" importance, and more than a reference may therefore be omitted as regards the collections made of organisms such as sponges, Neuroptera and lizards, although in all these groups they have been considerable. Attention may, however, be invited to what has been done as regards collecting Diptera and fish, as both these groups are of recognized economic importance.

Indian Diptera.

Among the mosquitoes collected last year in various parts of India by the staff of the Museum, Mr. F. Theobald, who has been kind enough to submit a report on the specimens, has found the "types" of twenty-three new species, among which are those of four new genera; while of the allied blood-sucking genus *Phlebotomus* we have acquired specimens of seven Indian species, on which, in collaboration with Mr. F. M. Howlett, Second Imperial Entomologist, I hope shortly to publish a report. One of these species has been proved to transmit a certain type of fever in Southern Europe. The Indian blood-sucking Muscidæ in the collection have now become sufficiently numerous to form the basis of a report by Mr. E. Brunetti which is already almost finished. An interesting new genus is described, as well as several new species. Arrangements have also been made for the publication of a series of monographs on the Oriental representatives of other blood-sucking families of Diptera by specialists to whom our collections have been distributed, and also of one on the Trypetidæ or fruit-flies. That on the Chironomidæ (including the blood-sucking species of the sub-family Ceratopogoninæ) is by Professor Kieffer of Bitsch in Germany and has already been received. It includes descriptions of 35 Indian species of Ceratopogoninæ, all of which are new to science.

Indian Fish.

As regards fish, it has been found that much of the work of the older Indian ichthyologists needs revision, and that to carry out a revision it is necessary to make fresh collections even of the common species. We have therefore made arrangements to obtain specimens from Karachi and elsewhere as well as collecting them ourselves wherever an opportunity has occurred. In this work we have been fortunate in obtaining the assistance of Dr. J. Travis Jenkins, Scientific Adviser on Fisheries to the Government of Bengal. It is much to be regretted from a "practical" as well as a purely scientific point of view that no arrangements have been made officially for ichthyological research in connection with the Government of Bengal's fishery steamer "Golden Crown," but the Museum, with the active co-operation of the Scientific Adviser, has done what was possible to remedy this omission, and latterly our zoological collector has gone out on the vessel to preserve specimens as they are caught. By all these means a large collection of both marine and freshwater species has been accumulated. We hope that, with subsequent additions, it may form the basis of a complete revision of the fish fauna of India.

Research on Terrestrial Zoology.

(b)—Work in the laboratory.—Considering first work as regards terrestrial zoology, I may note the completion and publication of Captain R. E. Lloyd's researches on Indian rats, so far as work of the kind can be completed in a couple of years. The importance of this work was noted in last year's report. Mr. E. Brunetti, in addition to his work on blood-sucking Muscidæ, has finished his revision of the Oriental Leptidæ, Bombylidæ and Sepsinæ, and has already found it necessary, owing to additional collections that have been obtained, to write a supplement on the first two families. He has also made considerable progress on a monograph of the Indian Tipulidæ (crane-flies), the extreme fragility of specimens of which has rendered them very scarce in most collections. They are, however, well represented in that of the Indian Museum, and nearly a hundred new species will have to be described. In collaboration with Dr. Walther Horn of Berlin, or rather compiling information from his work, I have prepared for publication an annotated list of Cicindelinæ (Tiger-beetles) in our collection in the hope that it may form the first part of a catalogue of the Coleoptera of the Indian Museum, a work that would be of use to students of zoogeography.

Research on the Freshwater Fauna of India.

The work of examining and describing the freshwater invertebrats of India and Burma has continued to occupy much of my attention, and I hope shortly to be in a position to publish an account of the Phylactolæmatous and other Polyzoa that occur in stagnant water in the Oriental Region. Mr. B. L. Chaudhuri, Assistant Superintendent in the Museum, besides describing several new species of fish from the "Golden Crown" collection, has commenced a revision of the Indian Cobitidæ or Loaches.

Research on Marine Zoology.

As regards marine zoology progress has been made: Captain F. H. Stewart, Surgeon Naturalist, Indian Marine Survey, has worked in the Museum for some months at the "Investigator" collection of Polychæte worms and has commenced an investigation, which promises to have interesting results, into the morphology and development of the degenerate males of certain barnacles. The barnacles have also formed the basis of a systematic monograph, of which the first part has recently been published in the "Memoirs of the Indian Museum." Marine ichthyology has not been confined to the collection of specimens, for Captain R. E. Lloyd has published an account of the deep-sea fish obtained by the "Investigator" since the publication of Colonel Alcock's monograph in 1899 and has added some interesting observations on variation in one of the genera, while I have myself published an account of the Rays taken by the "Golden Crown." Dr. Jenkins and Mr. Chaudhuri have devoted much time and patience to preliminary work on the other groups in the collection presented by the Commissioner of Fisheries, Bengal.

II.—Work done in India apart from the Museum.

Zoological Research in the Indian Colleges.

The only zoological work issued officially during the year from any of the Indian colleges is the volume on "Indian Insect Life" written by Messrs. Maxwell-Lefroy and Howlett of the Pusa Agricultural College. Major J. Stephenson, of the Government College, Lahore, has published a paper on some Oligochæte worms collected by Captain Stewart in Tibet (*Rec. Ind. Mus., iii*), while Dr. Imms of the Muir College, Allahabad, has described in the *Journ. Linn. Soc. London*, a minute centipede from the Himalayas. Captain R. E. Lloyd, now acting as Professor of Biology in the Medical College, Calcutta, has

written a paper on the relation between normality and fertility in rats which will shortly be published in the *Rec. Ind. Mus.*

Indian Medical Zoology.

Several short notes on medical zoology by doctors in India will be found scattered in medical journals, while Captain W. S. Patton and Capt. R. McCarrison of the Indian Medical Service have published longer papers on Protozoon parasites in English and German periodicals to which full reference will be found in the bibliography attached to this report.

Zoological work of Indian Learned Societies.

The Bombay Natural History Society continues to prove its vigour by the excellence of its publications, while the Asiatic Society of Bengal has published a monograph of the sea-snakes of the world by Major F. Wall, I.M.S. A project is also on foot to issue reproductions of the valuable series of original drawings of Indian fish in the library of the latter Society.

III.—Work in Europe and America.

The work on Indian Zoology undertaken during the year in Europe and America consists, so far as published records indicate, mainly of descriptions of new species based on specimens sent from India. The only comprehensive monographs that deal specifically with the Indian Fauna are the fourth volume of Mr. W. L. Distant's account of the bugs in the "Fauna of British India" series, and Colonel C. Swinhoe's continuation of Moore's *Lepidoptera Indica*.

The "Fauna of British India."

The fact that the former volume consists largely of an appendix on species of which descriptions were not included in the previous three volumes, and that at least one additional volume of a similar nature is to be issued, illustrates the paucity of our actual knowledge of the less conspicuous elements in the fauna of India and the rate at which this knowledge is expanding.

List of the papers and books having a special reference to Indian Zoology recently published.

Memoirs published in India.

In the *Memoirs of the Indian Museum.* The Oligochæta of India, Nepal, Ceylon, Burma and the Andaman Islands. By Dr. W. Michælsen. Vol. i, 1909, p. 103.

The Anatomy of some aquatic Oligochæta from the Punjab. By Major J. Stephenson, I.M.S. *Ibid.*, p. 255.

Investigator sicarius, a Gephyrean worm hitherto undescribed, the type of a new order. By Captain F. H. Stewart, M.A., D.Sc., M.B., I.M.S. *Ibid.*, p. 283.

Report on the fishes taken by the Bengal Fisheries steamer "Golden Crown." Part i—Batoidei. By N. Annandale, D.Sc. Vol. ii, 1909, p. 1.

An account of the Indian Cirripedia Pedunculata. Part i—Family Lepadidæ (*sensu stricto*). By N. Annandale, D.Sc. *Ibid.*, p. 61.

A Description of the Deep-Sea Fish caught by the R.I.M.S. ship "Investigator" since the year 1900, with supposed evidence of mutation in *Malthopsis*. By Captain R. E. Lloyd, M.B., D.Sc., I.M.S. *Ibid.*, p. 139.

In the *Records of the Indian Museum*. Report on a collection of Aquatic Animals made in Tibet by Captain F. H. Stewart, I.M.S., during the year 1907. Part i—Introduction, Cœlenterates, Nematomorpha, Rotifers and Gastrotricha, Entomostraca, Arachnids, Fish (Systematic) and Batrachia. By Captain F. H. Stewart, M.A., D.Sc., N. Annandale, D.Sc., Dr. J. G. deMan, L. Camerano, E. von Daday, Captain R. E. Lloyd, M.B., D.Sc., I.M.S. Vol. ii, 1908-1909, p. 309.

Notes on Aculeate Hymenoptera in the Indian Museum. By Colonel C. T. Bingham. *Ibid.*, p. 347.

Indian Psychodidæ. By E. Brunetti. *Ibid.*, p. 369.

Description of a new species of mouse from the Madura District, Madras. By T. Bentham. *Ibid.*, p. 385.

Some Cleridæ of the Indian Museum. By S. Schenkling. *Ibid*, p. 387.

Description of a new species of Polychæte worm of the Genus *Spio*. By A. Willey, D.Sc., F.R.S. *Ibid.*, p. 389.

Description of a new species of saw-fish captured off the Burma Coast by the Government of Bengal's Steam Trawler "Golden Crown." By B. L. Chaudhuri. *Ibid.*, p. 391.

A new Sting Ray of the Genus *Trygon* from the Bay of Bengal. By N. Annandale, D.Sc. *Ibid.*, p. 393.

New Micro-Lepidoptera from India and Burma. By E. Meyrick, B.A., F.R.S. *Ibid.*, p. 395.

Notes on some Chrysomelid Beetles in the collection of the Indian Museum. By C. A. Paiva. *Ibid.*, p. 401.

Six new Cicindelinæ from the Oriental Region. By Dr. Walther Horn. *Ibid.*, p. 409.

Description of an *Agriolimax* from Gyantse, Tibet, collected by Captain F. H. Stewart, I.M.S., with details of its anatomy. By Lieut.-Col. H. H. Godwin-Austen, F.R.S., F.Z.S. *Ibid.*, p. 413.

Revision of the Oriental Leptidæ. By E. Brunetti. *Ibid.*, p. 417.

Revised and Annotated Catalogue of Oriental Bombylidæ with descriptions of new species. By E. Brunetti. *Ibid.*, p. 437.

The Races of Indian Rats. By Captain R. E. Lloyd, M.B., D.Sc., I.M.S. Vol. iii, 1909, p. 1.

Notes on Freshwater Sponges, No. 10. Report on a small collection from Travancore. By N. Annandale, D.Sc. *Ibid.*, p. 101.

Report on a collection of aquatic animals made in Tibet by Captain F. H. Stewart, I.M.S., during the year 1907. Part. ii. Oligochæte worms, Mollusca and Fish (Geographical). By Major J. Stephenson, I.M.S., H. B. Preston, L. Germain and Captain F. H. Stewart. *Ibid.*, p. 105.

Note on some Amphibious Cockroaches. By R. Shelford, M.A., F.L.S. *Ibid.*, p. 125.

Description de quelques nouvelles Cécidomyies des Indes. By Professor J. J. Kieffer. *Ibid.*, p. 129.

Description of new land and marine shells from Ceylon and S. India. By H. B. Preston, F.Z.S. *Ibid.*, p. 133.

Description of two new species of *Caranx* from the Bay of Bengal. By B. L. Chaudhuri, B.Sc. *Ibid.*, p. 141.

Remarks on some little known Indian Ophidia. By Major F. Wall, I.M.S., C.M.Z.S. *Ibid.*, p. 145.

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NOTE.—In addition to the papers referred to in the above list many short miscellaneous notes on Indian zoology will be found in the *Records of the Indian Museum* and the *Journal of the Bombay Natural History Society*. Papers referring solely to Ceylon are not noticed, but several that have a more or less direct bearing on the zoology of India will be found in *Spolia Zeylanica*, the organ of the Colombo Museum.

AGRICULTURAL ENTOMOLOGY.

BY

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Imperial Entomologist.

The study of the insect pests of crops was continued at the Pusa Research Institute and by the assistants in Provincial Agricultural Departments. The detailed study of the more important species was carried on in the insectory, on the Pusa experimental farm, and in the field. The work against potato-moth (*Phthorimæa operculella*) was extended into

Bengal, the Central Provinces and Bombay, and larger trials are being made of methods of storage. Further study was made of the ground-nut leaf-miner (*Anacampsis nerteria*) and rice stem-borer (*Schœnobius bipunctifer*) in Madras. In Bombay the work of checking the Rice Grass-hopper (*Hieroglyphus furcifer*) has been successful and work is being undertaken against the Deccan grass-hopper, a wingless species new to science which has lately come into prominence. In the United Provinces, work has been done in checking the Rice Grass-hopper (*Hieroglyphus furcifer*) attacking sugarcane. For a very large number of pests, further information has been accumulated, specially with regard to their seasonal occurrence and to the peculiarities of their distribution in the various agricultural areas of India.

The work of testing insecticides has been concluded for the moment; a new insecticide, to replace arsenicals, has been found and is being put on sale and generally rendered available. The attempt to find good commercial insecticides that could be sold by makers has been abandoned and arrangements have been made to render available a small number of standard preparations to meet all needs. In particular, the attempt to find any contact poison superior to Crude Oil Emulsion, introduced into India in 1903 by the Agricultural Department, has failed and this insecticide is now established.

A feature of the year has been the attention paid to the eri silk industry, which is being very largely tried at the present time. Practically all experimental work in this has ceased and at Pusa the work is confined to carrying on the industry with a view to training those who wish to embark upon it as an industry. The possibilities of mulberry silk are being investigated, as also of tasar and other wild silks. In these cases it is the commercial possibilities rather than the scientific aspects that are being considered and the purely practical work of the section at Pusa has increased so much that purely scientific enquiry must take a minor place. The Supernumerary Entomologist, Mr. C. W. Mason, has continued his enquiry on the food of birds and has also been in charge of an inquiry to determine how far dessication of wheat protects it from weevil.

Lac cultivation has been continued at Pusa to afford a training in it rather than to apply scientific research, but this work has brought out forcibly the need there is of a scientific enquiry, carried on over a long time, into the races of the lac insect, of which very little is known at all.

The number of enquiries received at Pusa from all parts of India has been very large and the minor inquiries they give rise to are consider-

able. An investigation into the deterioration of Army mobilisation clothing by *Anthrenus vorax* was made by the Supernumerary Entomologist, Mr. C. W. Mason.

The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., has continued his investigations into *Diptera* which attack fruit and crops and those which attack cattle. The life histories of flies that cause damage to crops have been worked out and the very difficult question of fruit flies and their parasites enquired into.

In South India, Mr. R. D. Anstead, Scientific Officer of the U. P., A. S. I., has taken up the question of the scale insects attacking coffee (*Lecanium hesperidum* and *L. hemisphæricum*).

Mr. C. B. Antram, Entomologist to the Indian Tea Association, has confined his attention to the investigation of the Tea Mosquito (*Helopeltis theivora*) and the Tea Green Fly (*Chlorita flavescens*); in connection with the former, extensive experiments are being carried out on gardens throughout the tea districts. Experiments in spraying for checking the Thrips on Tea in Darjeeling, were made by the Imperial Entomologist at Lebong.

An advanced course of teaching in agricultural entomology is now given at Pusa to graduates from Agricultural Colleges, the course occupying one year; to the students taking the course in general agriculture at Pusa, a shorter course of instruction in practical entomology is given. In connection with the former the publication of Indian Insect Life, which took place in August, deserves mention; this volume of 780 pages is a manual of the insects of the plains of India, based upon the lectures given to students of Agricultural Entomology at Pusa and intended for them, as for entomologists in general. Indian Insect Pests has been translated into Bengali and the translation is being published.

The scope of this report is confined to Agricultural Entomology and all reference to the purely scientific work of the Pusa Institute, a necessary corollary of teaching, is omitted. The record of advance is smaller than in previous years and there is especially little to record in publications; but, in this subject, the scientific work of previous years is bearing fruit in greatly increased applied work, and, failing an adequate increase of workers to do the practical work, those doing scientific enquiry must abandon it.

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VOL. IV, NO. 3, H. MAXWELL-LEFROY . Lac as an Agricultural Industry.

Thrips on Tea in Darjeeling.

FOREST ZOOLOGY.

BY

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Imperial Forest Zoologist.

General.

Investigations carried out during the year in the Sál (*Shorea robusta*) belt of the Central Provinces have resulted in some interesting discoveries with reference to the distribution or absence of the most serious of the insect pests infesting this tree in the three areas it occupies in the country. The three sál belts may be taken as comprising the United Provinces Terai and Oudh Sál belt, the Central Provinces and Chota Nagpur extending down into Ganjam sál belt and the Eastern Bengal and Assam Sál area.

The longicorn pest *Hoplocerambyx spinicornis*, Newn. is common to the Central Provinces and Assam Sál areas but is replaced in the United

Provinces area by the longicorn *Æolesthes holosericea*. This year has resulted in the discovery of a bark-borer pest, a species of *Sphærotrypes*, which differs from the species of this genus present in the United Provinces and again from that present in Assam.

In all three areas the shoots of the tree are subject to the attacks of a shoot-borer (a species of *Arbela*) but the insect is different in all the areas. Coming now to the defoliators whereas *Boarmia selenaria* is the worst defoliating pest in the United Provinces areas followed during the rains by *Ingura subapicalis* Walker, in the Central Provinces the *lasiocampid Trabala Vishnu* is the chief defoliator, whilst in Assam and Eastern Bengal several species of Lymantria and a Dasychira commit the chief damage.

The determination of the pests infesting the seed is still under investigation, but sufficient progress has been made to emphasize the fact that the insects infesting it in the three belts differ from one another.

In the determination of the chief defoliators of the sál in the Central Provinces considerable aid was received from Mr. A. P. Percival, I.F.S., who inaugurated a series of most successful investigations during the year.

The work of combating the bark-boring beetle attack in the Simla Catchment area deodar forests was carried on throughout the year by the Divisional Officer and his Assistants and the measures introduced have resulted in stamping out the attack or reducing it to negligible proportions. By means of the method of felling green trees to serve as 'trap' trees to entice the beetles to oviposit in them the complete life histories of the buprestid beetle *Amorphosoma* sp. and the longicorn beetle *Trinophylum cribratum*, previously entirely unknown, have been completely worked out. This is a most valuable piece of investigation work which reflects great credit on the Punjab Forest officers.

During a tour in Chamba State a serious bark beetle attack in the Bré and neighbouring forests was investigated.

The investigations into the life-history of *Chermes himalayensis* Steb. (C. abietis-piceæ Steb.) commenced in 1901 were carried on during the year and have reached an advanced stage. The results arrived at have been incorporated in a Memoir illustrated by coloured plates drawn in the forest.

THE CHIEF ECONOMIC RESULTS OF THE YEAR.

(*a*) By the Imperial Forest Zoologist.

The Simla Catchment Area Bark-boring beetle attack.

The measures initiated in May 1908 (alluded to on page 138 of the Report for last year) and continued throughout the year and up to the burst of the monsoon of the present year appear to have proved successful in stamping out or reducing the attack of bark-borer beetles *Scolytus major* Steb. and *Polygraphus major* Steb. which made their appearance in the deodar areas of the Simla Catchment area forests in February 1908. The method employed was to fell a succession of 'trap' trees (*i.e.*, green deodar trees) at intervals throughout the period and to bark these and burn the bark as soon as the grubs, hatched from the eggs laid in them by the beetles, had nearly reached full growth. During these operations it was noted in August 1908 that a number of the trap trees (felled in May) contained young buprestid and longicorn larvæ obviously hatched from eggs laid since the trees were felled. Trees so attacked were kept under observation throughout the period and nymphs and mature beetles were obtained from them in May and June of the present year. The life-histories so worked out were, as mentioned last year, previously unknown, the buprestid proving a species of *Amorphosoma* at present unidentified, whilst the longicorn is *Trinophylum cribratum* not previously reported from the locality or known to live in the deodar.

The Central Provinces Sal Pests.

Hoplocerambyx spinicornis (The Singbhum Sál Borer).—This longicorn is now well known as one of the worst of the insect pests of the sál tree in the Central Provinces and Eastern Bengal and Assam sál areas. It does not occur in the United Provinces sál areas, it being replaced in this locality by the longicorn *Æolesthes holosericea*. *Sphærotrypes* sp. (Sál bark-borer).—A species of *Sphærotrypes* which may prove identical with Blandford's *S. globulus* was discovered abundantly in the bast layer of newly felled sál trees in Mandla in April. The insect attacks the tree in a similar manner to the other two species of the genus, *siwalikensis* Steb. and *assamensis* Steb. of the United Provinces Terai and Assam sál belts respectively.

Trabala Vishnu and Thosea ? sp. (Sál defoliators).—One of the most important defoliating pests of the sál tree in the Central Provinces is the larva of the Lasiocampid moth *Trabala Vishnu*. With the help of the local forest officers the first two generations of the life-history (between January and May) of the year were worked out during the period under report.

Arbela ? sp.—A species of this bark-eating family of caterpillars was discovered killing the young shoots and leaders of sál saplings. It differs in size from the similar pests of the other two belts being intermediate between them.

Other Sal pests.—Observations were carried out on several other defoliators and on some of the seed destroying pests of the tree. These latter pests, the larvæ of minute moths mostly, differ apparently from the insects infesting the seed in Assam and the United Provinces.

Coniferous Pests of the Western Himalayas.

Chermes himalayensis, Steb. (C. abietis-piceæ Steb.)—The intricate life-history of this Chermes which passes through alternate generations on the Spruce and Silver fir in this region has occupied the attention of the writer since 1901. Two preliminary papers on some points in the life-history were read before the Asiatic Society of Bengal in 1903.* Observations carried out since that year have resulted in it being possible to compile a Memoir on the life-history of this exceedingly interesting insect.

Bark-boring beetle pests in Chamba State.—During a tour in Chamba State an inspection was carried out of an area of deodar and blue pine forest (the Bré and neighbouring forests) situated at elevations between 7,500 and 9,500 feet. A considerable number of the trees had died during the past two years either singly or in patches and strips running up the precipitous mountain slopes. At the higher elevations where the spruce replaced the deodar this tree had also been killed out in some numbers. The mortality of the trees was of serious importance since they clothed the catchment areas of important streams.

An examination of the trees showed that the death of the trees was almost without exception due to bad bark-boring beetle attacks.

The Deodar trees had been killed by *Scolytus major* Steb. and *Scolytus minor* Steb. and *Polygraphus major* Steb. Traces of the buprestid

* Jour. As. Soc. Bengal, LXXII, Pt. II, 57, 252.

beetle *Amorphosoma* sp. and the longicorn *Trinophylum cribratum* were also present. The blue pine had been killed by *Tomicus Ribbentropi* Steb. and *Polygraphus major*, these two beetles being responsible for the death of the spruce trees at the higher level.

The little coniferous bark beetle pest *Pityogenes conifer*æ Steb. was present, or its galleries were present, in all the trees.

The inspection showed that there could be little doubt that had the cause of the attack been correctly gauged at its commencement and methods to combat it been inaugurated numbers of trees now dead could have been saved.

This attack taken in conjunction with the attack of the same beetles in the Simla Catchment area during 1908-09 forms a striking demonstration of the danger of allowing these bark beetles to get the upper hand in the Himalayan Coniferous forests and of the importance of the forest officers making themselves thoroughly acquainted with the appearance and life-histories of these minute pests. The attack in the Simla Catchment area was taken in time and the measures promptly instituted to combat it have resulted in the beetles being stamped out. There is no reason for supposing that the Chamba attack could not have been treated in a similar manner.

Other Coniferous Pests.—A large number of other bark, wood, defoliating, shoot-eating, and cone and seed-boring pests received attention during the year. The life-histories of a number of the commoner forms have made such progress that they are being incorporated in a Memoir the first parts of which have been submitted for publication.

(*b*) By other Departmental Observers.

Tomicus Ribbentropi, Steb. in Rawalpindi.—A sudden attack of this bark-borer was reported in blue pine in the Rawalpindi Division. About eighty infested trees were cut out, the bark stripped off and burnt and the attack stamped out.

Scolytus major Steb. and Polygraphus major Steb. in Kulu.—The Divisional Forest Officer reported that these two bark-borers were infesting deodar and blue pine respectively in Kulu.

Melolonthid and Elaterid grubs killing deodar seedlings in Jaunsar.—Mr. H. G. Billson reported a serious attack of these grubs in deodar nurseries in the Jaunsar Division. A considerable number of seedlings were killed, the tap roots being cut through by the grubs. Later in the year a third grub, that of a Noctuid moth, made its appear-

ance and proved an even worst pest, the caterpillars ringing the main root just below the surface of the soil and killing numbers of young plants. Remedies were suggested for dealing with the grubs.

Cœlosterna scabrata in Acacia arabica at Kalpi.—This pest has been alluded to in previous years as having proved a serious pest in Berar plantations. During the year it appeared at the Kalpi plantations in the United Provinces and destroyed a number of young trees.

Pinus longifolia shoot borer.—The caterpillar of a small Pyralid moth appeared in large numbers throughout the *Pinus longifolia* areas in the Western Himalayas and caused the terminal shoots of the trees to drop off by tunnelling up them and killing them.

Bombay Pests.—The wood-borers *Sinoxylon crassum* and *Sinoxylon anale* were reported as infesting firewood at Sukkur and a wood-boring caterpillar to be tunnelling into *Chloroxylon Swietenia* and *Albizzia amara*. The teak branch gall (*Cecidomyia* sp.) was plentiful in Surat.

Mango Pests.—The serious attack of the longicorn grub *Batocera* sp. in the Ganjam plantations continued to be investigated during the year whilst the mango Jassid pests *Idocerus clypealis*, *niveolus* and *Atkinsonii* were reported from mango gardens in the Miani Forests near Hyderabad, Bombay.

Longicorn wood-borers in the Southern Shan States.—Mr. A. W. Watson, I.F.S., has commenced a series of highly interesting and important investigations into the Cerambycid wood-borers in some of the forest trees in the Southern Shan States.

(*c*) By Other Observers.

The Bark-boring beetle Attack in Zhob.—A further report on the steps being taken to stamp out the attack of the Chilgoza bark-borers *Polygraphus Trenchi* Steb. and *Phlœosinus Zhobi* Steb. in Zhob was submitted by Captain James, I.A., Assistant Political Agent. The attack has now been practically suppressed.

Pests of the Ziarat Juniper Forests.—Investigations are being carried out into some longicorn and Scolytid pests of this tree in the forests near Ziarat in Baluchistan.

Oak Wood-borers in the Naini Tal Brewery.—A further report on the subject of some longicorn grubs boring into the oak timber used by this brewery was received during the year.

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Chief Scientific Results of the year.

Perhaps the most important scientific result of the year is connected with the observations made on the life-history of *Chermes himalayensis* Steb. illustrated by a series of coloured plates of the various stages drawn out in the forest. The life-history shows important points of difference from that of the European *Chermes viridis* Linn.—differences which are accentuated by the prevalence in India of a monsoon from July to September.

The discovery of the *Sphærotrypes* in the Central Provinces sál belt and the working out of the complete life-histories of the deodar buprestid beetle *Amorphosoma* sp. and the longicorn *Trinophylum cribratum* are also results of considerable scientific importance.

List of Publications.

1. MAITLAND-KIRWAN, J. D. — The Cultivation of Lac in the Forests of Sind. (*Ind. For., xxxiv, 537*).
2. STEBBING, E. P., & JAMES, CAPTAIN E. H. S. — A Further Note on the Chilgoza Bark-boring beetles of Zhob. (*Ind. For. Rec. I, Pt. III, p. 245*).
3. STEBBING, E. P. — A Manual of Forest Zoology for India.
4. Ditto — The Terai Sál bark-borer (Sphærotrypes siwalikensis). (*Leaf. No. 1, For. Zool. ser.*)
5. Ditto — The Teak Leaf Defoliator (Hyblœapuera). (*Leaflet No. 2, For. Zool. ser.*)
6. Ditto — The Teak Leaf Skeletonizer. (Pyrausta machœralis). (*Leaflet No. 3, For. Zool. ser.*)
7. Ditto — On some Undescribed Scolytidæ of Economic Importance from the Indian Region I. (*Ind. For. Mem., 1, For. Zool. ser.*)
8. Ditto — On some Insect Pests of the Himalayan Oaks (Quercus dilatata and incana). (*Ind. For. Rec., ii, Pt. i, 1.*
9. Ditto — On some Undescribed Scolytidæ of Economic Importance from the Indian Region II. (*Ind. For. Mem., I, Pt. II, For. Zool. ser.*)
10. Ditto — The Deodar Bark-borer (Scolytus major). (*Leaflet No. 4, For. Zool. ser.*)
11. Ditto — The blue pine Polygraphus bark-borer. (*Leaflet No. 5, For. Zool. ser.*)

12. STEBBING, E. P. The blue pine Tomicus bark-borer. (*Leaflet No. 6, For. Zool. ser.*)
13. AVASIA, D. N. Lac and Lac Cultivation. (*Forest Pamphlet No. 4, For. Econ. ser. No. 1.*

VETERINARY SCIENCE.

BY

COLONEL H. T. PEASE, C.I.E., I.C.V.D.,

Inspector-General, Civil Veterinary Department in India.

The output and issue of the various products prepared at the Imperial Bacteriological Laboratory at Muktesar is shown in the accompanying table.

NAME.	Quantity prepared. Doses of 5 C. C.	Quantity issued. Doses of 5 C. C.	INCREASE.
Anti-rinderpest	5,45,974	6,27,349	63,141
Anti-anthrax	29,786	30,933	13,695
Hæmorrhagic Septicæmia Vaccine.	5,140	3,500	On trial.
Charbon Symptomatique pillules .	1,860	1,310	1,560
Mallein	9,238	9,052	5,485
Tuberculine	306	144	272

Rinderpest.—We have arrived at the limit of our capabilities for the output of anti-rinderpest serum, the most important product at the laboratory, and as we are working at high pressure a break-down may occur at any time. Some investigations have been carried out in the laboratory regarding the period of immunity which could be expected from the serum alone method and also regarding the nature of the immunity conferred by a simultaneous inoculation of serum and virulent blood where no clinical symptoms of rinderpest are produced and to determine the effect of double doses of serum followed by immediate exposure to natural infection. These experiments have been published in Memoir No. 1.

Investigations are also being made in regard to the practicability of using peritoneal washings in the preparation of serum, as this method

has given very good results in the Philippines, producing serum possessing greater power and reducing the cost of preparation by half.

Hæmorrhagic Septicæmia.—Investigations into the nature of this disease, as it occurs in India, have been commenced by Mr. Gaiger at the Punjab Veterinary College and his interesting preliminary report is being published in the Journal of Tropical Veterinary Science No. 4, Volume IV.

Investigations into methods of immunization against the disease have been continued at the Muktesar laboratory and have led to the production of a serum which is capable of conferring immunity for a period of six weeks, and of a dead vaccine which gives immunity for a period of two or three months against the inoculated disease. The serum is not likely to be of much use in the field but as the disease is more or less seasonal, an inoculation with the vaccine would be likely to carry animals in villages where the disease is enzootic through the dangerous season, *i.e.*, the rains. If it will do this, it will render considerable service. It is at present being tried in the field. A description of the method is published in Memoir No. 1.

Anthrax.—As our knowledge of this disease increases it appears to be dwindling in importance. There is reason to suppose that it is neither so widespread nor important as we have been led to suppose. It does, however, exist in certain tracts. The investigations into the practical value of the known methods of immunization, with experiments to obtain a serum or vaccine suitable to the conditions of the country are still incomplete.

Surra.—A considerable amount of research work has been carried out both in laboratories and in the field regarding this most important disease of horses and camels.

Method of spread.—Mr. Leese was engaged from the 27th April to the 24th September in a Surra area at Mohand in the Siwalik range, on experiments and observations in connection with the rôle of biting flies in the transmission of the disease. He endeavoured to settle, if possible, whether biting flies are chiefly responsible for the spread of Surra under natural conditions, it being now well established that in laboratory experiments Tabanus is capable of conveying the trypanosomes from an infected animal to a healthy one if both animals are bitten within a short interval of time. Also to ascertain what kinds of biting flies are to be found in a Surra zone, both in and out of the Surra season; to note their habits as regards biting of domesticated animals; to carry out transmis-

sion experiments with those varieties of flies which the above observations would indicate to be possibly involved in natural transmission, it being known from an investigation of a natural outbreak of Surra in Kathgodam that the disease can continue to spread amongst horses in the absence of Tabanus. His experiments prove that Tabanus, Hæmatopota and Stomoxys are all capable of carrying the trypanosome from a diseased to a healthy animal. The Tabanus is the most important, the Hæmatopota next, and the Stomoxys only an occasional danger. This more or less agrees with observations which have been made in other parts of the world with other trypanosomes. It was impossible for Mr. Leese to carry out experiments regarding delayed transmission with Tabanus owing to the difficulty which was experienced in keeping the fly alive in captivity. The second Imperial Entomologist who is collaborating with Mr. Leese on the subject, states that he has never kept Tabanids alive for more than a week. Further experiments will be made in this direction next surra season.

Much valuable information regarding the incidence and habits of biting flies at Mohand in the Surra zone was collected. The flies, many of which appear to be new species, have been sent to the British Museum to be named and described. Mr. Leese's report has been published in No. 2, Volume IV, of the Journal of Tropical Veterinary Science.

Much information regarding Surra and Surra-free zones has been collected. That regarding camels has been published in the second annual report of the Veterinary Officer investigating camel diseases for the year ending 31st March 1909, which also contains many general recommendations which have been made in addition to the special measures already advised against Surra in camels in particular localities.

Curative treatment.—A considerable number of experiments have been conducted during the year by both Mr. Leese and Mr. Gaiger with a view to ascertaining whether any of the drugs which have been found efficacious in horse trypanosomiasis would be of any practical use in the treatment of camel surra. Mr. Leese's experiments are still incomplete and unpublished but they do not promise well. Mr. Gaiger's experiments with atoxyl and orpiment were negative. These experiments are being published.

Captain Holmes has at present 32 horses, ponies and mules under observation, which have been treated by various arsenical derivatives such as atoxyl and commercial orpiment and orpiment alone as well as a combination of atoxyl, sodium arsenite and arsenious acid. He has also used soamin, arsacetin, etc. The results of these various methods

vary, but some are very good indeed, several of the animals having been free from trypanosomasis for periods varying from 6 to 15 months after the cessation of treatment. None have shown a return of trypanosomes in the blood. Guiger also succeeded in curing two cases by atoxyl and orpiment but his percentage was not good owing to the variation in the commercial orpiment, which appears to owe its action to the free arsenious oxide it contains. The commercial varieties were used in India and it was found to be much more poisonous than the drug used by Thiroux and Teppaz which was apparently precipitated orpiment which Capt. Holmes finds has little effect in Surra. The results achieved, however, are most encouraging and it really seems as though we have at last in view a satisfactory method of treating this fatal disease. When the details are more accurately worked out we shall try treatment in the field where the disease is very prevalent.

Streptotrichosis.—As reported last year, Captain Holmes made an investigation into a form of lymphangitis occurring amongst cattle in Calcutta and locally known as Calcutta sore. He considered that the causal agent was a Streptothrix. Colonel Raymond has been working at this disease for the last two years and has issued a report in which he attributes the disease to a bacillus, bringing it into line with a similar disease in cattle reported from Sumatra by Vryburg.

Piroplasma bovis.—The Imperial Bacteriologist has published some notes on the flagellate forms of *Piroplasma bovis*, in his Memoir.

Tetanus.—New methods of preparing an antitoxin or vaccine are being investigated.

Parasites and parasitic diseases.—A considerable amount of work has been done in this subject. A check list of parasites of the domesticated animals has been prepared by Mr. Gaiger who has also drawn attention to the great prevalence of *Linguatula tenioides* and has recorded the occurrence of *Filaria osleri* in that animal.

Mr. Leese has reported the discovery of two new worms in the Camel, i.e. *Hæmonchus longistipes* and *Ostertagia mentulata*.

Evans and Rennie in Burma have published articles on the parasites of the ox and the elephant in Burma. In the latter animal they have recorded *Fasciola jacksoni* and given a description of the disease to which it gives rise. In the latter they found a new genus not described so far. Also the occurrence of *Gastrodiscus secundus, Eurytrema cœlomaticum, Paramphistomum bathycole, P. scoliocœlium, P. cotylophorum* and P. nearly related to *streptocœlium* has been recorded.

A good collection of type specimens is being made at the Punjab Veterinary College.

Biting-flies and ticks.—Under the orders of the Government of India collections of ticks and biting flies are made in India by this Department and forwarded to the Imperial Agricultural Entomologist at Pusa. I have this year informed this officer of the wants of the Department in regard to these insects and it is understood that he will describe and illustrate the Tabanidae, collect type specimens for all our teaching institutions and publish life histories of the various genera in our journal.

A great number of flies and ticks have already been collected, and it is understood that they have been sent to England to be identified or named and described, but we have so far received no information on the subject. We are unable to prosecute enquiries regarding their connection with disease owing to lack of staff. The connection between *R. sanguineus* and biliary fever in the dog has, however, been described by Christophers and investigations into the rôle played by biting flies in the transmission of Surra have been commenced by Leese.

A List of Publications contributed during 1908-09.

HOLMES, J. D. E. . Veterinary Memoir No. I.
Containing :—

PART I . Surra Investigation of an Outbreak of Horse Surra with methods of Treatment with Atoxyl, Tartar Emetic, Mercury and other Drugs.

PART II . Immunization against Charbon Symptomatique by means of a single vaccine.

PART III . Immunization against Hæmorrhagic Septicæmia of Bovines, by means of serum, sterile vaccine and Toxin.

PART IV . Rinderpest—Duration of immunity from (1) Serum alone and (2) Simultaneous methods following a single, double, treble, quadruple and quintuple doses.

PART V. . . A peculiar form of Streptotrichosis among cattle.

PART VI . Flagellate forms of Piroplasma Bovis.

PART VII . Note on a Giant Polynuclear cell.

HOLMES, J. D. E. . Treatment of Surra by Atoxyl and Orpiment (*Jour. Tro. Vety. Sci. Vol. III, No. 4, p. 434.*)

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HOLMES, J. D. E.	Treatment of Surra by Atoxyl and Orpiment (*Jour. Tro. Vety. Sci. Vol. III, No. 4, p. 434.*)

HOLMES, J. D. E. . Immunization against Charbon Symptomatique by means of a Single Vaccine. (*Jour. Tro. Vety. Sci. Vol. IV, No. 1, p. 8.*)

A List of Papers published during 1908-09.

BURTON CLELAND, J. . Streptococcal Granuloma of lung of a Camel. (*Jour. Tro. Vety. Sci. IV, No. 2, p. 133.*)

CUILLE, M. I. . . Acute experimental Ankylostomiasis in the Dog. (*Jour. Tro. Vety. Sci., No. 2, p. 169.*)

DE GRASCA, V., & DI. DONNA, A. Experiments regarding Immunization against Hæmorrhagic Septicæmia (Barbone) of the Buffalo. (*Jour. Tro. Vety. Sci., III, No. 3, p. 330.*)

EVANS, G. H., & RENNIE, T. Notes on some parasites in Burma, II. (*Jour. Tro. Vety. Sci., IV, No. 2, p. 134.*)

GAIGER, S. H. . . Natural Canine Surra. (*Jour. Tro. Vety. Sci., III, No. 4, p. 443*).

GAIGER, S. H. . . The influence of Atoxyl and other Chemicals on the course of a few cases of Surra. (*Jour. Tro. Vety. Sci., III, No. 4, p. 452*).

LEESE, A. S. . . Two diseases of young camels. (*Jour. Tro. Vety. Sci. IV, No. 1, p. 3*).

LEESE, A. S. . . Experiments regarding the natural transmission of surra carried out at Mohand in 1908. (*Jour. Tro. Vety. Sci., IV, No. 2, p. 107*).

LEESE, A. S. . . Annual Report of the officer investigating Camel disease.

LEESE, A. S. . Prophylaxis of surra in the Camel.

LEESE, A. S. . A note on surra in camels.

LOWE, W. CECIL Anthrax. (*Jour. Tro. Vety. Sci., IV, No. 1, p. 53*).

MITTER, S. N. Observations on some staining peculiarities of Anthrax Bacilli.

MONTGOMERY, R. EUSTACE. On the Prophylaxis of Trypanosomiasis, with particular reference to the influence of the Camel in India. (*Jour. Tro. Vety. Sci., III, No. 3, p. 301*).

NEUMANN, L. G. A new Indian Tick, Ornithodorus lahorensis. (*Jour. Tro. Vety. Sci., III, No. 4, p. 462*).

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PROGRAMMES OF WORK FOR 1909-10.

PROGRAMMES OF WORK OF THE VARIOUS SCIENTIFIC DEPARTMENTS FOR THE YEAR 1909-10, AS APPROVED BY THE BOARD ON THE 10th MAY 1909.

1.—Imperial Institute, London, and the Department of Economic Products, Calcutta.

(PART 1).—*Reporter on Economic Products.*

Investigations as follows, which have been declared already in earlier programmes, will be continued, on :—

(1) the nature and origin of the various kinds of Myrrh, Frankincense, Byssabol, and allied fragrant gums ;
(2) the use of *Baccaurea sapida* as a dye stuff or dyeing auxiliary :
(3) the classification of the races of juar ;
(4) the classification and uses of Indian Yams (*Dioscorea*) conjointly with the Director, Royal Botanic Gardens, Kew ;
(5) the species and races of lemon grass in India and their oils ;
(6) a survey of the physical and chemical constants of Indian oils ;
(7) the variability of crude lac and on the exact value of mixing resin in manufacture ;
(8) the botanic races of *Lathyrus sativus.*

Other investigations to be prosecuted, which have not been mentioned in earlier programmes, will be on :—

(9) the identification of Burmese pulses (conjointly with the Director of Agriculture, Burma) ;
(10) the value of certain indigenous drugs (through the Indigenous Drugs Committee) ;
(11) the drug, *Coptis Teeta*—its forms and chemistry ;
(12) the origin and composition of Sarcocolla gum.

(PART 2).—*Imperial Institute.*

Programme of Investigations, chiefly chemical, to be continued or to be undertaken for the Government of India at the Imperial Institute during 1909-10.

The following are the more important investigations which it is proposed to undertake at the Imperial Institute :—

Drugs.

The investigation of the characteristic alkaloids present in the roots of the following Indian aconites will be continued :—*Aconitum palmatum,*

A. heterophylloides, *A. soongaricum*, *A. laciniatum*, and the hybrid *A. laciniatum spicatum*.

Specimens of *Datura Stramonium*, *D. fastuosa* and *Hyoscyamus reticulatus* have been received and the amount of "total alkaloids" present in each case has been determined. Some progress has been made with the identification of the alkaloids in each plant, and it is hoped to complete this work shortly.

Work on the constituents of *Strychnos potatorum* and *Thalictrum foliolosum* will be continued.

Turpentines.

A preliminary report on Indian turpentine oil and colophony is in preparation, and work on the constituents of the oil and resin will be continued during the year, using for this purpose the oleo-resins of *Pinus longifolia* and *P. excelsa* already supplied. This work will be extended to the oleo-resins of other Indian pines as soon as samples of these a received from India.

Oils and Oil-Seeds.

A report on Bassia seeds has been despatched to India, and two further samples are under investigation. As increased attention is being given in commerce to the fats derived from these seeds, and it seems possible that their use may be extended in various ways, it is proposed to investigate their constituents more thoroughly, and for that purpose further samples of the fats of *Bassia latifolia* and *B. longifolia* have been asked for.

Correspondence is in progress with the Director-General of Commercial Intelligence in India with reference to a suggestion made by him that it might be worth while to investigate the possible utilisation of cotton seed oil as a source of edible fat to be used as a substitute for "ghi." Work on this subject may be undertaken during the year.

The examination of the non-oleaginous constituents of the seeds of *Schleichera trijuga* will be continued.

Fibres and Cotton.

Samples of the following fibres, of which supplies are stated to be available in the "Report and Programme for 1907" have been asked for, and will be examined—*Debregeasia hypoleuca*, *Desmodium tiliæfolium*, *Clematis montana*, *Sterculia urens* and *Maoutia Puya*. A sample of

the fibre of *Agave sisalana* is advised for examination and will be dealt with as soon as it arrives.

It is also suggested that if any samples of cottons of types new to India, or grown in new districts in India are available, specimens should be sent to the Imperial Institute for examination and afterwards for inclusion in the permanent reference collection of cottons now maintained in the Public Exhibition Galleries of the Imperial Institute.

Rubber.

Samples of Ceara, Castilloa and Para Rubbers forwarded by the Agri-Horticultural Society of Madras will be examined.

Volatile Oil.

The oil of *Mentha arvensis*, a supply of which is stated to be available in the "Annual Report and Programme for 1907," will be examined, as it seems worth while to ascertain how the Indian Oil compares with the Japanese Oil of commerce.

2.—Meteorological Department.

METEOROLOGY.

1. *Sounding Balloons.*—The preliminary work of this nature indicated in last year's programme having proved successful, considerable attention will be paid in the present year to its continuation and application to Indian Meteorological problems. It is believed also that India is now in a position to undertake on its own lines a share in the International work with sounding balloons, which has in recent years proved fruitful in results. It is proposed therefore to make the necessary preparations for a series of balloon flights in December next, the month chosen by the International Commission in Europe and America for simultaneous experiments on the conditions of the upper air.

2. **Kites.**—It is possible that in addition to the work with balloons some opportunity may occur for resuming the use of kites, which with their more open scale registering instruments, are particularly useful for work on the lowest two miles of the atmosphere.

3. **Atmospheric electricity.**—Continued observations will be made of the chief factors of atmospheric electricity, *viz.*, the potential gradient, ionization conductivity and radio-activity of the air, and oft he quantity of electricity carried down by rain and snow.

Experiments are being made with the object of determining the origin of the permanent negative charge on the earth's surface.

4. **Winds.**—It is proposed to continue the publication of the series of memoirs on the winds of India upon which Sir John Eliot was engaged at the time of his death.

5. **Seasonal variations.**—It has not yet been found possible to make a systematic study of the data collected from the logs of ships in the Indian Ocean with a view to finding relations between abnormal conditions there and abnormal seasons. It is hoped that progress may be made this year.

Astronomy.

6. **Variations in the quantity of radiation emitted by the sun.**—An attempt will be made to develop a method of finding the ratio of the brightness of the full moon to that of certain stars under conditions which ill eliminate the effect of changes in the atmospheric absorption. Variations in this ratio may be taken as indicating changes in the solar constant.

7. **Photographing the sun in monochromatic light.**—The routine work with the spectroheliograph will be continued, and on the arrival of a new grating it is hoped that photographs will be made with the second slit set for the line H.

8. **Spectra of sunspots.**—Co-operation with the International Solar Union will be maintained. A study is also proposed of :—

(*a*) movements in the line of sight ;
(*b*) pressure shifts ;
(*c*) comparison with limb spectra.

It is further proposed to examine :—

9. **Rotation velocities** near the sun's equator as derived from measures of the H and K lines at the limbs.

10. **Rotation velocities of quiet prominences** as measured in H and K.

11. **The shift to the red** of lines at the limb, determined in different parts of the spectrum and by comparison with telluric lines.

12. **Pressure shifts** at the limb and centre of the disc as obtained by measurements of the relative displacements of lines subject to large and small pressure shifts.

Terrestrial Magnetism.

13. The routine measurements of absolute and variation instruments at Alibag will be continued. It is hoped that the publication of the sixty years' records at Colaba will be completed during the current year.

Seismography.

14. Three Omori seismographs are now registering continuously, two at Simla in the directions north-south and east-west, and one at Bombay. The Milne seismographs at Calcutta, Kodaikanal and Bombay will remain in use during the year.

3.—Survey of India (Scientific Research work).

Gravimetric Survey.—Pendulum operations across the Aravalli and Vindhya hills.

Magnetic Survey.—Colaba Observatory under the Director-General of Observatories, and the four observatories under the Surveyor-General will continue to work. Observations will be taken at 24 Repeat Stations, and detailed surveys of disturbed areas will be commenced.

Solar Photographs.—Photographs of the sun will be taken daily at 10 A.M. and 4 P.M., at Dehra Dun, as has been done since 1879 in conjunction with Greenwich.

4.—Geological Survey.

PART A.—*Subjects undertaken during previous years to be continued.*

(1) Survey of the Tertiary oil-bearing area in Upper Burma.
(2) Extension of geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana.
(3) Chemical work on brines from Rajputana and salt samples from the Salt Range, Punjab.
(4) Revision of the geological map of the Raniganj coalfield in conjunction with a committee appointed by the Mining and Geological Institute of India.
(5) Mapping of unsurveyed areas in the Central Provinces.
(6) Palæontology of (*a*) Liassic beds of Baluchistan, (*b*) Lower Tertiary marine beds of Baluchistan, (*c*) Ordovician, Silurian and Devonian rocks of Spiti, (*d*) Cretaceous and Tertiary Systems of Tibet.

PART B.—*New Questions.*

(7) Survey of the Dhalbhum Estate, Singhbhum.
(8) Survey of the Idar State [continuation of (2)].
(9) Survey of the Karana Hills in the Chaj Doab, Punjab.
(10) Examination of the fossils from Kangra, Jammu and the Island of Perim off Kathiawar.
(11) Survey of the coalfields and oil-bearing regions of North-East Assam.
(12) Palæontology of (*a*) Carboniferous rocks of the Shan States, (*b*) Jurassic Brachiopods from the Northern Shan States, (*c*) Siwalik Vertebrates, (*d*) Indian Tertiary Mollusca.

5.—Botanical Survey.

I.—Country under the Superintendent of the Royal Botanic Garden, Calcutta :—

(*a*) **Bengal.**—The chief work during the year will be the making of an accurate census of the non-herbaceous plants cultivated in the Royal Botanic Garden, Calcutta, preparations for which have been completed during the past year. In addition to this the Curator of the Herbarium will be deputed—for as long as he can be spared—to study *in the field* the Flora of the Eastern Himalaya with a view to writing up materials for a Flora of that region.

(*b*) **Assam and Burma.**—An endeavour will be made to write up the Flora of the district of Cachar in Assam and to work up material for the Flora of Tenasserim in Burma.

It is unlikely that it will be possible to carry out this programme in its entirety, and considering the very limited staff available it will probably be found more profitable for work to be concentrated upon one thing at a time rather than distributed over several things simultaneously. It is, however, impossible at this stage to state definitely which of the particular subjects after the first one mentioned will be investigated.

II. Survey of Bombay Presidency.—No programme has been submitted.

III.—Survey of Southern India.—Government Botanist, Madras, states that he will be unable personally to do any systematic touring. Tours, however, will be made by his assistants during April and May in the Nilgiris, during July and August in the Nallamalis, and during December

to March in the Travancore hills. This programme has received the approval of the Board of Revenue, Madras.

IV.—Survey of Northern India.—No programme has been submitted.

6.—Agricultural Department.

The scientific work of the Institute for the coming year is indicated under the programmes of the different sections.

The College has been opened, and students are now being admitted. Although it is the intention that only distinguished students from the Provincial Agricultural Colleges should be sent to Pusa for a two years' course in specialising, students are also being admitted for lower courses until the Provinces are able to undertake this work themselves.

A provisional prospectus sanctioned by the Government of India has been communicated to the Provincial Governments, and their replies are awaited.

I.—Agricultural Chemistry.

1. *Soils.*—The work on the availability of plant food in soils, and the nature of the dark colour of black cotton soil will be continued.

2. *Soil moisture and water requirements of plants.*—The investigations into (*a*) the destiny of rain water, including as it does, records of drainage through soils, losses by evaporation, and surface flow; and (*b*) the water requirements of crops, will be continued.

3. *The effect of soil or manure on the composition of certain seeds* is an investigation which has been in progress tentatively and will be extended if considered desirable.

4. *The prevention of weevil attacks on wheat* is an investigation which is being conducted in collaboration with the Imperial Entomologist.

5. *Training.*—Instruction will be given to students on the lines indicated in the Pusa syllabus.

II.—Economic Botany.

1. *Training.*—The teaching work of the section will be continued on the lines laid down in the prospectus of the Institute.

2. *Plant breeding and plant improvement.*—During 1909, the following crops will be studied:—Wheat, tobacco, barley, oil-seeds and fibre plants.

(*a*) *Wheat.*—The botanical and agricultural survey of the wheats of Bengal will be completed on the lines adopted in the investi-

gations on the Punjab wheats. The production of improved varieties by selection and hybridisation will be continued as well as the investigation of the factors influencing the quality of the grain.

(*b*) *Tobacco.*—The botanical survey of the Indian tobaccos will be completed.

(*c*) *Oil-seeds.*—The study of the oil-seeds of India which has been carried on on a small scale during the past year will be extended on lines similar to those adopted in the investigations on wheat.

(*d*) *Barley.*—The work on this crop will be continued.

(*e*) *Fibres.*—The collection and investigation of fibre-yielding plants will be continued.

3. *Fruit experiments.*—The permanent experiments on the culture of Indian fruits will be continued on the lines laid down in the first report.

4. *Minor investigations.*—The economic importance of the male plant in ganja cultivation and the problem of the inheritance of sex. The study of cassava as a famine food (with Dr. Leather).

III.—Mycology.

1. *Training.*—The training of students in Mycology will be continued. Those at present under training are probationers for posts of Mycological Assistants in Provincial Departments of Agriculture. Assistance will be given to Provincial Colleges in providing notes and material for Mycological instruction.

2. *Plant disease investigations.*—Work on sugarcane diseases will be continued. A further paper on red-rot will be published. The study of a new sugarcane disease has been commenced. The supernumerary Mycologist is investigating the life history of sugarcane smut.

Assistance will continue to be given in the operations to check bud-rot disease of palms in Godaveri.

The work on pigeon-pea wilt will be published. That on the wilt of indigo is being continued. Arrangements will be made, if possible, for a local study of cotton wilt. Gram and other wilts will be further studied if opportunity arises.

The chief diseases of mulberry and fruit trees in Kashmir will be reported on.

The supernumerary Mycologist is engaged in an investigation of a ginger disease prevalent in Bengal and Bombay.

The study of some anthracnoses of leguminous crops will be taken up.

3. *General.*—The survey of Indian parasitic fungi will be continued. It is hoped to complete the text of the book on Indian plant diseases.

IV.—Entomology.

1. *Research and experimental work.*—The work of the past year in studying and advising on crop pests will be continued. Assistance will be given, where desired, in directing the work of Provincial assistants and in coping with any outbreaks of pests that may occur. The issue of coloured plates of injurious and beneficial insects will be continued. Inquiries in progress on insecticides, on potato moth, on fumigating plant-imports, on the treatment of grain by fumigation will be continued as time permits. Further work on lac cultivation will be done, both in Bihar and other parts of India, in the cultivated areas: the cultivation of *eri* silk will be continued on a small scale at Pusa, and assistance will be given to those carrying on the cultivation in new localities; the work in progress on spinning, weaving and dyeing will be continued. The cultivation of mulberry and *tassur* silk on a very small scale as a demonstration to students will be begun.

2. *Training.*—The teaching of advanced Entomology, commenced in August 1908, will be continued and must form a large part of the work of the section. The publication of the "Manual of Indian Entomology" should be completed by July, and it is proposed to publish revisions in vernacular of "Indian Insect Pests." All necessary assistance will be rendered in carrying out the course of training for students at Pusa during the year.

3. *Investigation.*—More members of the Veterinary Department will, it is hoped, be sent for short courses on the methods of observing insects parasitic on, or otherwise harmful to, cattle, horses and other stock; work on these insects, on blood-sucking Diptera and on Dipterous crop pests, will be continued.

4. *Publication work.*—The work of the artists' staff of the Journal and Institute, at present under my control, will continue to be directed and supervised as hitherto.

V.—Agricultural Bacteriology.

Some of the following problems will be attacked as opportunity offers and time permits :—

I.—The chief bacteria characteristic of Indian soils particularly those taking part in—

(*a*) The fixation of nitrogen.
(*b*) The rotting of organic material.
(*c*) Nitrification.

II.—The characteristic organisms growing in association with leguminous crops in India, with particular regard to the inoculation of the soils growing them.

III.—The bacteria taking part in the rotting of stored organic material under Indian conditions and the bearing of the knowledge gained on the conservation of cattle-manure in India.

IV.—The fermentation processes accompanying the manufacture of silage in India.

V.—The fermentation processes taking place during the manufacture of tobacco.

VI.—The fermentation processes taking place during the manufacture of indigo.

VII.—Any bacterial diseases of important Indian crops.

VI.—Agriculture.

1. *Permanent experiments.*—The permanent manurial and rotation experiments and the permanent pasture experiments will be continued.

2. *Flax and other fibres.*—Experimental work on a field scale on these crops will be continued.

3. *Sugarcane.*—Work on sugarcane as described in last year's programme will be continued.

4. *Tobacco.*—Experimental work on curing in the curing house will be taken up, provided an expert can be obtained.

5. *Varieties.*—Wheat, barley, maize, rice and castor varieties will be tested.

6. *Threshing trials.*—Wheat threshing trials will be continued under the direct charge of a threshing expert who will be sent out by an English firm.

7. *Breeding.*—Breeding work will be considerably extended. The Montgomery herd now numbers over forty cows and will be further increased. Milk records are kept for each cow, and by breeding from the best cows it is hoped that the milking powers of the herd will be substantially increased. The local herd of the cows will probably be transferred to the Bengal Agricultural Department. Ewes from Bikanir and from Gorakhpur district will be crossed with Dumba rams on a fairly large scale. Seven new breeds of fowls have been received from England. There are now nineteen breeding pens in addition to ducks, geese and turkeys.

8. The general improvement of the estate will be continued. One hundred and fifty acres will be added to the present arable area.

9. *Training* of students from the Provinces will be continued.

The Programme of the Imperial Cotton Specialist.

To visit and advise in any Province when he is requested to do so.

2. To make special investigations into the distribution of Indian cottons in the field throughout the country, more especially for the purpose of ascertaining exactly where the most valuable forms of each variety are grown and to discover, if possible, the natural causes which favour these.

3. To arrange for trial with superior varieties already discovered, such as (1) with *Karkheli* cotton in the Central Provinces, Kathiawar, Berar, Khandesh and the Deccan, where inferior varieties of the same type are already grown; (2) with Navasari cotton (the most valuable form of Broach) in Gujarat, Southern Maratha country and the northern parts of Madras; (3) with *Bourbon* cotton in the heavier rainfall tracts of the West Coast.

Provincial Departments of Agriculture.

The programmes for 1909-10 generally follow those described in 1908-09. The following are, however, important additions :—

Bengal.—The College Farm at Sabour will be laid out for general comparative work and special investigations. The principal crops selected for experiments in this Province are paddy, jute and sugarcane. At Kalimpong it is proposed to collect information on the crops and the agricultural practices of the Darjeeling Hills. Well-boring experiments will be undertaken this year in Bihar. The classification of the different types of sugarcane will be begun to determine (*a*) the dates of ripening

in the different varieties, and (*b*) the glucose content and their chemical characters. The nitrifying power of different typical soils of Bengal will be studied.

United Provinces.—Two more experimental stations—one at Atarra and the other at Benares—will be opened during the year. The former is situated in the Bundelkhand and is designed to pioneer agricultural improvements rendered possible by the introduction of irrigation. A horticultural station has been established in the Kumaon Hills for the development of fruit and vegetable growing. The Rampore State is taking up the supply of high grade poultry for breeding. At Cawnpore the outturns of certain pure strains of wheat are being compared with reference to their milling qualities. The amount of loss at different stages of Mr. Hadi's process of sugar manufacturing will be determined by the Agricultural Chemist to ascertain whether any further improvement is possible. The reclamation of a portion of bad land (locally known as "Rakar") by enclosing and heavy manuring with poudrette is being attempted. Experiments with soil moisture which are in progress at Cawnpore have been extended to investigate (*a*) losses of soil moisture by cropped land under different crops with and without manures, and (*b*) losses of soil moisture from land irrigated with an accurately measured quantity of water, (*i*) bare fallow, (*ii*) grass and weeds, (*iii*) wheat.

Punjab.—It is proposed to open an agricultural station at Jullunder for the study of sugarcane, of well problems and other questions connected with that important agricultural tract. The question of sub-soil ploughing in case of worn-out soils will also be taken up at this station. At Lyalpur tests will be instituted to ascertain the amount of water required by wheat and cotton under irrigation. Depôts for agricultural machinery will be started. An area of ground will be set down to grow local and foreign fruit trees of economic value. Experimental cultivation of Cassava will be tried to determine whether it can be introduced as a cheap food crop. Experiments will be made to ascertain whether flax and jute can be profitably introduced as farm crops of the Province. A well-survey of certain districts will be made with a view to extend well-irrigation where possible. The Department will undertake to make experiments at typical places for the revival of sericulture.

Bombay.—Several foreign and indigenous varieties of wheat are being tried at a number of the stations. Individual selection is being made to increase (*a*) rust-resistant qualities, (*b*) yield, and (*c*) quality.

The Department will test in the Ahmedabad district the relative advantage of Broach cotton over the local variety. Efforts will be made to push the cultivation of Broach cotton in the Southern Maratha country where it is found to grow successfully. The operations of cane growing, crushing, boiling and *Gul* manufacture are under study at Manjri. The factors which determine the value and keeping qualities of *Gul* are being investigated. The Hadi process of sugar manufacture will be compared with the native process of *Gul* manufacture under Poona conditions as regards profits. On the Nadiad farm the growth of foreign tobaccos under shade is being inv stigated. It is proposed to establish a seed-testing station in connection with the Poona Agricultural College. Experiments in dry farming have been begun at Rahuri in Ahmednagar district. Well-boring experiments have been started in Gujarat. In the Deccan large sized oil-engines will be tried for economy in pumping water from rivers and crushing sugarcane grown under irrigation. A workshop is to be attached to the College for the improvement and experimental manufacture of iron ploughs, chain pumps, chaff-cutters and other agricultural implements.

Madras.—The District Board Farm at Bezwada has been taken over by Government. Preliminary investigations into the paddy cultivation of Kistna and Cavari deltas have been set on foot. The amount of water required to raise a full crop of paddy will be tested at Coimbatore and Samalkota. Experiments will be made in the use as manure of fish scrap for paddy, especially on the West Coast where it is available. The introduced Mauritius sugarcanes having ousted the local canes in the Godavari delta, it is proposed to test the suitability of other new varieties. A Hadi boiling plant will be erected at Coimbatore and Samalkota for the improvement of the local manufacture of jaggery. The use of the drill for sowing cotton as a pure crop in the Trichinopoly district will be extended. The cultivation of groundnut as a rain-fed crop will be introduced into the Malabar Coast districts. Natural pasture grasses are being studied under cultivation at Taliparamba where fodder for cattle in dry weather is a great want. Cassava and ginger largely grown on the dry lands of Malabar will be taken up for study.

Central Provinces.—Manurial and varietal experiments will be started with sugarcane on the Raipur Farm, as this crop is likely to become important in Chattisgarh with the extension of flow irrigation. Interesting experiments are in progress on the Akola Farm to test the value of gram and certain other legumes as soil renovators when grown in alter-

nate lines with cotton. The effects of different forms of tillage and cultivation in relation to water content and movement on black cotton soil will be examined.

Burma.—Manurial experiments with paddy are proposed to be undertaken at Mandalay. Special efforts are to be made to popularise bone-meal. The indigenous varieties of wheat will be classified, and some introduced varieties are to be grown. Selection and crossing of indigenous varieties of cotton are to be attempted. A scheme for the utilization for agricultural purposes of the sewage and nightsoil of towns is under preparation in consultation with the Sanitary Commissioner. Fruit experiments will be started at Katha, Hmawabi and Mandalay. Experiments are in progress to ascertain (1) the relative yield of various varieties of groundnut, (2) the percentage of oil, and (3) the power of resistance to disease. The correct time of planting Egyptian cotton in Burma will be ascertained.

Eastern Bengal and Assam.—At Rajshahi and Jorhat sugarcane experiments will be started with a view to find out the cane most suitable under the manurial treatment in vogue in those districts. Jute refuse is being tried for its value as organic manure. It is proposed to take up a general investigation of the varieties of rice with a view to selection and breeding experiments. The Sumatra and the local *Bhengi* varieties of tobaco will be grown, each on an acre for special experiments in regard to after-treatment. The object is to produce tobacco suitable respectively for cigars and cigarettes. The work in sericulture will be directed towards (1) making available an adequate supply of seed cocoons guaranteed as practically free from disease, and (2) giving a sound practical training to the sons of silkworm rearers. Investigations into the possibility of introducing simple machines with the object of (*a*) lessening the large amount of labour, and (*b*) reducing the large volume of water required at present for the retting of jute and similar fibres will be undertaken by the fibre expert. The sources of material for paper making are being studied by Mr. Finlow as opportunities arise.

7.—Forest Department.

The following are some of the various investigations which will be made by officers of the Imperial Forest Research Institute, Dehra Dun, with the assistance of other officers of the Department.

I.—WORKING-PLANS.

1. The compilation from selected Working-Plans of data regarding the rate of growth of different species (ring countings, sample plots) and generally the tabulating, in convenient form, of statistics and information regarding different species, methods of working, etc., now scattered throughout the plans. A statement showing sanctioned Working-Plans, with area of forest, period of plan, method of treatment and principal species has already been compiled as a basis of this and other investigations.

2. With regard to normal stock, selected areas containing what appears to be a full stock of I, II, III and other classes will be counted out, and the average of each class taken as an approximate normal, as a preliminary to the more accurate investigation of this subject. The following species will be first taken in hand—Sâl, Teak, Deodar, *Pinus longifolia*, *Pinus excelsa*, and other species now being worked under Working-Plans as soon as possible.

3. A careful study of the selection system will be made. The following points merit attention in this regard in order to discover the best means of working by compartments so as most nearly to approach the ideal method of working over the entire area annually for the removal of mature trees, *e.g.*—

(*i*) By making the annual coupes as large as possible so that the area may be worked over at as frequent intervals as possible.

(*ii*) By fixing such an exploitable girth that the loss of interest due to leaving mature trees standing for an excessive period is reduced.

(*iii*) By allotting gradually decreasing areas for the annual coupes.

4. The examination of control forms in order to ascertain the average outturn by different methods of working in force, and generally to collect and collate the statistics of the results of forest management throughout India which are included in past control forms will be continued.

5. Preparation for teak of a paper setting forth all that is known regarding habits, methods of treatment, etc., such as has already been prepared for the sâl.

6. Preparation of yield tables (as far as data are available):—

(*i*) Sissoo Plantations at Changa-Manga.

(*ii*) Eucalyptus plantation at Ootacamund.

(*iii*) Casuarina plantations in Madras.

(*iv*) Teak plantations at Nilambur.

7. Preparation of tables of outturn :—

(*i*) Some selected high forests in the United Provinces (or elsewhere) under the selection system, in which enumerations have been carried out.

(*ii*) Some selected sâl coppice forest in the United Provinces.

(*iii*) Teak forest in Burma.

8. Preparation of a note on the application of the *uniform method* with special reference to India and with examples from Indian working plans.

9. Upkeep of Registers of sample plots and publication of any data available.

10. Opening of ledger files relating to definite subjects under investiga ion or to be hereafter brought under investigation.

II.—Sylviculture.

11. Study of the effects of fire conservancy on different species in various conditions of climate and growth, more especially on sâl and teak, will be continued.

12. An examination into the conditions favourable to the replacement of the selection method by the regular method will be continued.

13. Investigation into the effects of soil composition and underlying rock on the distribution and growth of different species will be continued.

14. Enquiry into the effects of the continuance of a given species (*e.g.*, sâl, teak) as regards the soil fertility for that species will be continued.

15. Collection of information regarding plantation work carried out on a large scale, specially Agri-Sylvicultural operations and the planting of arid lands and shifting sands; and the publication of pamphlets dealing with these subjects.

16. The study of teak reproduction in conjunction with the Imperial Forest Botanist and the Imperial Forest Chemist.

17. The study of sâl reproduction in conjunction with the Imperial Forest Botanist and the Imperial Forest Chemist.

18. Putting in order the Kaunli garden for sylvicultural research purposes in conjunction with the Imperial Forest Botanist.

19. Subjects to be investigated on the initiation of Conservators by them in conjunction and in correspondence with the Sylvicultural branch of the Research Institute.

III.—Forest Zoology.

20. Investigation (in the United Provinces) into the distribution and life histories of the *Monophlebus* scale insect, *Spærotrypes siwalikensis*, and the sâl defoliators in the sub-montane sâl areas of the Ganges, Garhwal, Kumaun and Naini Tal divisions and into the Pinus longifolia *Cryptorrhynchid* weevil, *Tomicus* and *Polygraphus* bark-borers and *Platypus* wood borer in the *chir* areas of Garhwal, Kumaun and Naini Tal divisions will be continued.

21. Investigation (in the Punjab) into the distribution and life histories of the following insects in the hill coniferous forest of the Kangra division :—

The *Scolytus* pests of the deodar and the *Polygraphus*, *Pityepenes*, *Platypodæ* and cone-borers and defoliators of the *Pinus excelsa*, Spruce and Silver fir: also the defoliating and wood-boring pests of the hill oaks and pests of *Pinus longifolia* will be continued.

22. Investigation into the autumn generations of the life histories of the insect pests of Deodar, Silver fir, Spruce, Blue Pine, and *Pinus longifolia* will be continued.

23. Investigation into the insect pests of the sâl tree in Oudh.

24. Investigation into the life history of the *Padauk* weevil pest and the *Padauk Scolytid* wood-borer.

25. Investigation into an important *Scolytid* wood-borer of the "sundri," a defoliating pest of this tree and other pests of the mangrove forests.

26. Boring molluscs of bamboos in tidal waters in Burma.

27. Destruction of babul plantations in Berar by rats and a longicorn beetle.

28. Predaceous and parasitic pests of the lac insect.

IV.—Forest Economy.

29. The enquiry into the utilization of the less valuable kinds of timber as railway sleepers will be continued, and a practical experiment is being made with sleepers obtained from Dipterocarpus sp. from Burma and the Andamans.

30. Enquiry will continue into the subject of :—

(*a*) Woods suitable for the manufacture of matches.

(*b*) Cultivation of lac.

(*c*) Antiseptic treatment of timber, particularly for railway sleepers.
(*d*) Utilization of various oil seeds from forest trees.
(*e*) Utilization of *Xylia dolabriformis* waste for paving blocks.
(*f*) Woods likely to be useful for minor industries.
(*g*) Woods for tea boxes.
(*h*) Camphor (Lævo-Borneol) from *Blumea balsamifera*.
(*i*) Cultivation of *Podophyllum Emodi*.
(*j*) Cutch.
(*k*) Destructive distillation of wood in conjunction with the Imperial Forest Chemist.

31. Investigations will be made into the following subjects:—

(*a*) Actual process and prospects of the manufacture of matches as a commercial enterprise; best sites for the establishment of match factories and available supply of timber suitable for the manufacture of matches.
(*b*) Wood-pulp industry.
(*c*) Wood suitable for the manufacture of casks, packing cases and opium chests.
(*d*) Powellizing inferior woods.
(*e*) Padauk wood from the Andamans. Cause of falling off in demand, and possible measures for stimulating it.
(*f*) Investigation into the physical properties and seasoning powers of various woods.
(*g*) Utilization of gum resins.

V.—Forest Botany.

32. Enquiry into the following subjects will continue:—

(*a*) Study of the coppicing of teak, its effect on the normal health and development of the tree.
(*b*) The grasses of the Savannah tracts will be examined with special reference to their difference in burnt and unburnt areas.
(*c*) A practical examination will be continued into the effects of fire on grazing areas in order to ascertain:—
(i) Whether the grass on areas burned over annually decreases in quantity and quality:

(ii) whether this result or the reverse happens in the case of areas protected from fire, and especially whether protection from fire encourages the growth of coarser grasses or leads to the replacement of coarse grasses by others more suitable for fodder.

(*d*) A study will be made of the timber of different species of *tun* and *Grewia* to ascertain which yield the most valuable wood.

(*e*) Investigation (in the Madras Presidency) into the subject of the rising of marks on tree stems, used to indicate fixed levels of measurement in sample trees or plots.

33. The following subjects will receive attention :—

(*a*) Study of Teak reproduction.

(*b*) Study of Sâl reproduction.

(*c*) Rearrangement and putting in order of Saharanpur Herbarium (located at Dehra Dun).

(*d*) Putting in order the Kaunli garden for research purposes in conjunction with the Sylviculturist.

VI.—Forest Chemistry.

34. Further examination of tannin extracts will be made, specially the tannin extracted from mangrove at the Rangoon works with a view to its decolourization.

35. The collection and analysis of the latices of rubber-producing species will be continued.

36. The following subjects will continue to be worked at :—

(*a*) The estimation of the amount of oil from seeds of forest trees, and the utilization of the cake.

(*b*) Experiments with the newly designed camphor-still and the distillation of camphor (Lævo-Borneol) from *Blumea balsamifera* of Burma.

(*c*) Investigation (in Burma) into the various species of *Compositæ* as to their suitability for the production of camphor or any other valuable essential oil.

(*d*) Investigation into Catechu with a view to prepare Catechin-free Cutch on a commercial scale will be continued.

(*e*) Investigation into the manurial value of the various leaves, twigs and shrubs indigenous in the Madras Presidency, in

order to ascertain the proportion of nitrogen and phosphoric acid, etc., which they contain.

37. Enquiry will be made into the following subjects :—

(*a*) Investigation into the destructive distillation of wood in conjunction with the Imperial Forest Economist.

(*b*) The improvement of the processes of distillation of Rhusa grass oils.

(*c*) Calorific power of different Indian timbers.

VII.—GENERAL.

38. Pamphlets, circulars, as well as the Memoirs and Records of the Forest Department setting forth the results of investigations into various subjects affecting the progress of Indian Forestry, will be published from time to time.

8.—Natural History Section, Indian Museum.

In view of the fact that certain changes in the staff have recently been sanctioned, it is possible to submit a purely provisional programme only.

The Superintendent will continue his work on the invertebrate fauna of stagnant water in India and, in collaboration with the Assistant Superintendent, will commence a revision of certain families of fresh water fish.

The Surgeon Naturalist, Indian Marine Survey, will conduct investigations in the Museum on the degenerate males of cirripedes.

The Scientific Adviser on Fisheries to the Government of Bengal in conjunction with the officers of the Museum, will study the fishes taken by the fishery steamer.

Mr. E. Brunetti will continue his work on Indian Diptera devoting special attention to the *Tipulidæ*, *Empidæ* and *Phoridæ*.

Captain R. E. Lloyd, I.M.S., will complete his survey of the races of Indian rats.

9.—Civil Veterinary Department.

By the Imperial Bacteriologist—

(1) **Anthrax.**—To continue the investigations laid in the programme of the previous year.

(2) **Charbon Symptomatique.**—The preparation of an Antiserum.
(3) **Surra.**—Methods of treatment.
(4) Further tests of vaccines prepared during the past year against Hæmorrhagic septicæmia and Charbon symptomatique.

By the Officer investigating Camel diseases—

(1) Investigations into surra in the field.
(2) The study of Filariasis in the Camel.
(3) Treatment of surra in the Camel.

By the Provincial Staff—Punjab Veterinary College Laboratory—

(1) Treatment of surra.
(2) Study of Hæmorrhagic septicæmia.

Provincial Superintendents—

Collection of information and the mapping out, as opportunity occurs, of the incidence of Surra, Piroplasmosis, Hæmorrhagic septicæmia and Anthrax.

APPENDIX.

APPENDIX.

ECONOMIC INVESTIGATIONS CONDUCTED FOR THE GOVERNMENT OF INDIA AT THE IMPERIAL INSTITUTE DURING THE YEAR ENDING 30th SEPTEMBER 1909.

BY

W. R. DUNSTAN, M.A., LL.D., F.R.S.,

Director of the Imperial Institute.

The scientific investigations which have been in progress at the Imperial Institute for the Government of India are :—

1. An examination of a number of Solanaceous plants, species of *Hyoscyamus* and *Datura*, involving the separation and identification of their principal constituents. This work has been completed and generally reported on, with the exception of one species of *Datura* which is still under investigation.

2. The examination of the constituents of several species of Indian aconites. This work has made considerable progress, but is not yet completed.

3. The examination of the constituents of the chief varieties of Indian opium collected in the various opium districts of India in continuation of a previous enquiry. This work is in progress.

4. An examination of the constituents of Indian turpentines from *Pinus longifolia*, *P. excelsa* and *P. Gerardiana*. A first report on this work has been made.

In addition to these scientific investigations which have been conducted at the Imperial Institute, several similar enquiries have been undertaken in co-operation with the Imperial Institute by well-known authorities on special subjects. Certain of these will be completed at an early date.

A large number of Indian economic products received from the Reporter on Economic Products and other Indian officials have been technically examined and commercially valued, and in some instances also submitted to manufacturing trials. These include fibres, oil seeds, volatile oils, tobaccos, cereals and various minerals. Information has been supplied to various Indian merchants and firms respecting the commercial value of many Indian materials, and information respecting Indian materials has been also furnished to commercial firms in this country.

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