1927.
NEW ZEALAND

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(ANNUAL REPORT OF THE).

Laid on the Table of the House of Representatives by Leave.

REPORT OF THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Establishment of the Department.

The Act establishing the Department of Scientific and Industrial Research was passed at the end of last session, following consideration of the report by Sir Frank Heath, presented to the House on the 25th May, 1926. The report contained a scheme along which State organization of research might be developed.

On the 9th October, 1926, the following Advisory Council was appointed, as provided for in section 6 of the Act:—

Mr. George Shirtcliffe, O.B.E. (Chairman), Wellington.
Professor Henry George Denham, M.A., D.Sc., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.
Mr. Quentin Donald, Featherston.
Professor John Malcolm, M.D., Ch.B., Professor of Physiology, University of Otago, Dunedin.
Mr. Theodore Rigg, M.Sc., Agricultural Chemist, Cawthron Institute, Nelson.
Mr. Charles Rhodes, Manager of New Zealand Mines Trust, Auckland.
Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.
Dr. E. Marsden was appointed Permanent Secretary to the Council.

Meetings.

The inaugural meeting of the Advisory Council was held on the 26th and 27th October, 1926, and subsequent meetings have been held on the 14th and 15th December, 1926, 17th and 18th February, 1927, 19th and 20th April, 1927. All meetings have been held in Wellington, but, at the invitation of the Cawthron Institute, a portion of the April meeting was held at Nelson. Members of the Council have paid visits of inspection to the various scientific laboratories in the Dominion.

Departmental Changes involved by the Establishment of the Department.

It was decided to regroup under the Department of Scientific and Industrial Research a number of scientific services previously under the control of a number of the State Departments. The services transferred were:—

(1) Dominion Laboratory—from Internal Affairs Department.
(2) Meteorological Office—from Marine Department.
(3) Geological Survey—from Mines Department.
(4) Dominion Observatory—from Internal Affairs Department.
(5) Stone-testing Laboratory and Geological Advisory Service—from Public Works Department.
(6) Technical Control of the Samoan Observatory—from External Affairs Department.

Survey of Research Work in New Zealand.

A complete survey of the research work in progress and proposed, in the four University colleges, in various Government Departments, at Canterbury Agricultural College, Cawthron Institute, and elsewhere, was made, and some very valuable suggestions were received from representatives of the various bodies approached. This survey indicated that a relatively small amount of research work is actually being done in some of our important primary and secondary industries. In consequence, it served as a useful guide towards directing the incidence of the Council's activities.

In order to increase the value of the services rendered by the Dominion Laboratory to other State Departments and to the manufacturing industries of the Dominion, two additional staff appointments were made—a Technical Research Chemist and a Research Physicist, both New-Zealanders. Arrangements also are in train for the formation of a Technological Bureau of Information attached to the Dominion Laboratory, so that inquiries may be dealt with expeditiously, each of the technical officers of the Laboratory being responsible for a section for which his training renders him most suitable. Further accommodation also is being arranged for at the Dominion Laboratory, so that the state of congestion which has existed there for the last ten years, and which, owing to its having necessitated the dismantling and re-erection of apparatus for each test, has led to considerable waste of time and delay in obtaining results of tests, will be obviated. The Laboratory also will take over for the Labour Department the custody of the ultimate standards of weights and measures, so that the Laboratory's Physicist may collaborate with the Inspectors in comparison with the working standards.

Meteorological Office.

As a result of careful consideration it has been decided to extend the activities of this office so that, each year, information may be published, and, in particular, increased attention directed to the publication of information valuable in connection with public works, agriculture, shipping, and aircraft. In addition, improved arrangements have been made for the wireless transmission of weather data from as many ships as possible voyaging across the Tasman Sea. As the majority of our storms approach New Zealand from the west, this information should increase both the accuracy and the time range of forecasts.

Geological Survey.

The policy laid down with regard to the Geological Survey is the compilation of reports on mineral resources and raw products valuable to industry. At the same time the fundamental work connected with the completion of the geological survey of the Dominion is being actively pursued.

Co-operation with Government Departments and other Institutions.

Much consideration has been given to the question of working out plans of co-ordination to permit of combined attack upon problems requiring investigation. The Department has received every support and encouragement from the heads of other Departments in devising such plans as have been found necessary to overcome unexpected and involved difficulties that have arisen. The Council of Scientific and Industrial Research feels that this co-ordination of effort must necessarily be part of its policy, and, while regarding the control and supervision of all research work as especially within its province, it aims to co-operate, in all its endeavours, with the work done by other Departments.

Investigations and Researches inaugurated.

(1) *Dairy Research.*

As the result of several conferences with representatives of the Department of Agriculture, the Dairy Produce Board, and the New Zealand Agricultural College Council, a scheme for the conduct of dairy research was agreed upon. The Dairy Produce Board has signified its willingness to contribute half the cost of research up to £3,000 annually. The control of the research has been given to a special management committee comprised of—(1) Mr. W. Grounds, (2) Mr. W. Goodfellow, (3) Mr. T. A. Winks, representing New Zealand Dairy Produce Board; (4) Hon. George Fowlds, (5) Mr. A. Morton, nominated by New Zealand Agricultural College Council; (6) Dr. C. J. Reakes, (7) Mr. W. Singleton, representing New Zealand Department of Agriculture; (8) Professor H. G. Denham, (9) Mr. Q. Donald, representing Council of Scientific and Industrial Research. The Hon. George Fowlds was elected chairman of this committee. Professor Riddet has been appointed Director of the research, and applications are being called for the positions of Research Chemist and Research Bacteriologist.

Arrangements have been made to accommodate the research staff at Hawera or at Hamilton pending the establishment of more complete facilities at Palmerston North. A survey of the main problems for investigation has been made, and arrangements are in train for effective linking-up with results of research elsewhere.

(2) *Mammitis and Abortion Diseases.*

Realizing the serious nature of these two diseases, and the severe economic loss they inflict upon the farming industry, the Council is urging the necessity for further research into their nature and control. The Council has recommended that the services of a first-rate bacteriologist be secured to strengthen the present staff at the Wallaceville Laboratory and the deal specifically with these two diseases.

(3) *Seed and Plant Diseases; Plant Breeding and Selection.*

A survey has been made of the losses incurred through plant-diseases, and a special committee has been set up to arrange for the establishment of a special research station in conjunction with the Agricultural College at Palmerston North. Details connected with this investigation have been worked out by the committee, and it is hoped that operations will commence at the new station when the Batchelar property is handed over to the College Council in June. In order to make the work of Empire-wide significance, contact with the Welsh Plant-breeding Station at Aberystwyth is being maintained. Research, breeding, and selection work connected with cereals will be centred at Canterbury Agricultural College, and in other matters connected with this branch of investigation co-ordination of effort will be closely maintained between Palmerston and Lincoln. Where conditions demand it, subsidiary out-stations will be established to facilitate the research done at the main centres.

(4) *Noxious-weed Investigations.*

Research work in this connection has been centred at Cawthron Institute, Nelson, and concentrated upon the control of such weeds as blackberry, ragwort, St. John's wort, foxglove, gorse, pteridium, and piripiri by entomological means. The control of the research is in the hands of a committee comprised of Mr. George Shirtcliffe, Dr. F. W. Hilgendorf, Mr. Q. Donald, Professor H. B. Kirk, Mr. D. Miller, and Mr. A. H. Cockayne. Dr. R. J. Tillyard is directing the actual research work at the Cawthron Institute.

Funds for this research have been secured by means of grants from the Empire Marketing Board and the New Zealand Government. Grants of equipment and services have been made by Cawthron Institute Trust Board. The total grants to date are as follows:—

	Annual Grant.	Capital Grant.
	£	£
Empire Marketing Board	2,000	1,333
New Zealand Government	1,000	667
Cawthron Trust	1,000	200
	£4,000	£2,200

The work at Cawthron Institute has been in active progress since December last, and most promising results have been obtained from *Tyria jacobaeae*, the insect which was imported by Dr. Tillyard to combat ragwort pest. Exhaustive trials on the host range of this insect have been almost completed, but the insect will not be released until the trials are extended to include one or two species of economic plants which have not been available since the parasite was introduced into New Zealand.

Shipments of *Apion ulicis*, the gorse-parasite, have also been received, and are at present undergoing trials in the Cawthron insectaries.

In order to deal satisfactorily with blackberry parasites, *Coroebus rubi* and *Bembecia*, which has been imported, larger insectaries have been deemed essential, and the Empire Marketing Board were approached for additional funds to allow of these being constructed. These funds have been granted, and the insectaries, together with necessary additional laboratories, are in course of construction, so that arrangements should be in readiness for operations on a more comprehensive scale to begin next spring.

At the inauguration of the above-mentioned work, Mr. A. Tonnoir, of the staff of the Canterbury Museum, was attached to the staff of the Cawthron Institute as Field Entomologist and assistant to Dr. Tillyard.

The work conducted at Cawthron Institute has been co-ordinated with investigations proceeding under the direction of Dr. Imms, of Rothamsted Experimental Station, Harpenden, England. Mr. Maldwyn Davies has been placed in charge of the field-work and despatch of insects parasitic to blackberry, gorse, and foxglove. He will conduct trials and investigations at the Rothamsted Station in collaboration with those in progress at Cawthron Institute under Dr. Tillyard's direction.

The first quarterly report upon the noxious-weed-control work both in England and in New Zealand already has been prepared, and indicates that good progress is being made.

Valuable reports upon blackberry and gorse parasitic insects have been prepared by Dr. Tillyard, and Mr. David Miller has submitted a detailed account of the insect control of lantana.

Mr. David Miller also is engaged upon the preparation of a pamphlet on the parasitic insects of New Zealand and their host range.

(5) *Mineral Content of Pastures.*

Negotiations were opened with the Empire Marketing Board in November, 1926, by Dr. Tillyard, in regard to securing funds to enable researches to be undertaken into the nutrient value of New Zealand grasses and fodder plants. The Empire Marketing Board agreed to vote £2,000 to this work, and £1,000 was provided by the New Zealand Government, in addition to the £1,000 already being devoted annually by the Department of Agriculture to the same investigation.

A committee consisting of Professor H. G. Denham, Professor W. Riddet, Mr. Q. Donald, Mr. Bruce Levy, and Mr. S. Fletcher was set up to consider the details of the proposed investigation, Mr. B. C. Aston was appointed to direct the research, and to co-operate with Mr. T. Rigg, of the Cawthron Institute, in regard to co-ordination of effort. Detailed reports have been prepared by officers of the Agricultural Department and of Cawthron Institute, and Messrs. Rigg and Grimmett have proceeded to Rowett Institute, Aberdeen, to ascertain the precise methods of research followed by Dr. Orr. This will enable the research to be given an Empire-wide significance. Definite action in New Zealand has been deferred until reports are to hand from these two officers, or until their return to New Zealand towards the end of 1927.

It is considered that the scope of the investigation as at present outlined is rather limited, and steps are now being taken to enable questions dealing with top-dressing, pasture-management, food values of New Zealand stock-feeds, and similar problems to be included in the research.

(6) *Fuel Research.*

A survey of the whole position is being obtained. In the meantime—

1. The Director of the Geological Survey is making a careful survey of bituminous-coal resources.
2. A liaison officer, a New-Zealander, Mr. H. O. Askew, is working at the Fuel Research Station, Greenwich, and will make a report on the application of the recent work at that station to New Zealand coals and New Zealand conditions.
3. The Dominion Laboratory is investigating various methods of briquetting, and has given advice to various companies on distillation processes.
4. A research grant has been made to a research worker at Canterbury College, to enable him to undertake investigations on low-temperature distillation.
5. The Department is collaborating with the Railway Department and Mines Department on general fuel questions.
6. Arrangements are in train with the coal-owners for the establishment of a bureau of information for fuel utilization and for researches into the suitability of New Zealand coals for various purposes.

(7.) *Forest Products.*

A scheme is under consideration for co-operation in research with the sawmillers and Forestry Department.

(8) *Fisheries.*

A research grant has been made for the purpose of conducting an investigation of the plankton of waters round the New Zealand coast, and of the stomach-contents of fishes. This investigation should be of value in the determination of the fish-food available, and, indirectly, on the fish-carrying capacity of New Zealand waters.

(9) *Vitamin Research.*

A grant has been made to the Otago University to enable an investigation to be undertaken into the vitamin content of various New Zealand foods and foodstuffs, to be conducted under the direction of Professor J. Malcolm. In Dunedin a local committee, consisting of Dr. Inglis, Dr. Hector, Dr. Holloway, Dr. Malcolm, and Mr. Bowman, has been set up to deal with the research, and also a related one concerning food-values. The work in these investigations is at present somewhat limited on account of lack of funds, but it is hoped that ultimately they will be linked up with the wider sphere as contemplated in the nutrient content of pastures investigation.

(10) *Cool Storage.*

The Department has made a survey of the work at present being undertaken by the Department of Agriculture and Cawthron Institute in regard to the cool storage of fruit, and has arranged for the visit of Dr. Franklin Kidd, of the Cambridge Low-temperature Research Station, in September next. Dr. Kidd will report as to the best steps to be taken in New Zealand in regard to investigation of cool-storage problems, and his report will be utilized as a guide to operations to be conducted locally. Investigations into cool-storage problems connected with meat, butter, cheese, fish, and eggs are also being discussed with the various bodies concerned.

(11) *Standardization.*

The question of standardization has two aspects: (1) The elementary standard units of length, volume, weight, electrical energy, &c., on which the industrial and trade operations on a modern scale depend for security. (2) Voluntary determination by industries of standards of size, shape, weight, strength or other qualities, with a view to attaining some measure of uniformity in order to eliminate the waste caused by the multiplication of different patterns, &c., and to secure interchangeability of parts.

With regard to 1: Arrangements have been made with the Labour and other Departments for the Physicist appointed to the Dominion Laboratory to take charge of the ultimate standards and assist in the comparison of these with Inspectors of Weights and Measures, &c.

With regard to 2: Negotiations are at present in progress with the Department of Industries and Commerce and with the Stores Control Board with a view to arrangements for standard specifications which will enable tenderers of New Zealand goods to compete on an effective basis; and already considerable assistance has been rendered by the Dominion Laboratory. Such specifications probably will be based on those of the British Engineering Standards Association, and it is hoped that by defining precisely the nature and quality of the article required simplification in purchase may be effected and thus fresh fields of production opened up. Standard specifications will also render equitable comparison of tenders without undue correspondence and delay. The co-operation of the Stores Control Board in this work is much appreciated.

(12) *Building-stones.*

In order to have information available regarding the properties, extent, and utilization of New Zealand building-stones, Dr. P. Marshall, Government Petrologist, has been engaged to investigate and test all known occurrences of building-stones in the Dominion. An investigation of New Zealand gravels also will be conducted at the same time, and should provide scientific information for all those dealing with road problems, concrete and ferro-concrete manufacture. The information, when available, will be published in book form.

(13) *Research Work for Secondary and Manufacturing Industries.*

The Department has acted in co-operation with the Department of Industries and Commerce, and already a partial survey of the problems concerning the secondary industries has been made. It is proposed to utilize the services of the scientific staff of the Dominion Laboratory to study and investigate the problems of the secondary industries.

(14) *Wool.*

The woollen-mills of the Dominion have also been surveyed, and various manufacturing problems noted for attack by investigation and research. Further action will also be taken to investigate the problem of wool-deterioration, which has been reported frequently during the past few years, and information on that matter is now being secured for the purpose of planning a definite course of research.

(15) *Leather and Allied Products.*

A survey of the processes involved in the manufacture of leather, preparation of hides and pelts for marketing overseas, is being made by the Department's technical chemist, so that scientific guidance will be available for the improvement of the practices adopted in the various sections of the industry. With the aid such scientific knowledge can provide, this important industry should be capable of very considerable development in view of the extensive supplies of raw products available in the Dominion.

(16) *Meat Industry Problems.*

The forthcoming visit of Dr. Franklin Kidd will be availed of for the purpose of considering a number of investigations into the cold storage of meat and the possibility of conducting researches here in co-operation with the Cambridge Low-temperature Research Station. Indications seem to point to the conclusion that much benefit would accrue to the various manufacturing industries of the Dominion through the adoption of co-operative research effort. New Zealand manufacturers are probably unable individually to undertake the considerable expense involved in maintaining research facilities in their own works. In co-operation, however, the expense would be greatly lessened, and similar advantages would be gained.

Research Scholarships.

Research Departments in other countries have always felt their activities and usefulness severely limited by the dearth of trained scientific men capable of conducting research work. In order to provide for the requirements of the Dominion in this respect, four research scholarships, of a value of £180 each per annum, plus £25 additional for books and apparatus, have been established. The first awards of these have been made as follows:—

N. S. Alexander, M.Sc., Auckland University College. Absorption of X rays.
J. C. Andrews, M.Sc., Auckland University College. Mutarotation of sugars.
P. W. Aitken, M.Sc., Otago University. Investigation into flax-gum, and chemical treatment of flax-fibre.
M. N. Rogers, M.Sc., Canterbury College. Helium content of New Zealand natural gases.

New Zealand Institute Research Grants.

These grants have been transferred from the Department of Internal Affairs, and will in future be administered by the Department of Scientific and Industrial Research on lines similar to those of the former Department.

"Journal of Science and Technology."

This scientific publication, hitherto issued by the Board of Science and Art, has been transferred to the Department of Scientific and Industrial Research. The nature of the *Journal* will be somewhat altered in order to include in its pages a wider range of industrial articles. Dr. J. A. Thomson, of the Dominion Museum, will continue as editor of the *Journal*.

Co-operation with Overseas Research Organizations.

The Department has established connections with research institutions in the United Kingdom, the United States of America, Canada, Australia, and other parts of the Empire. Wherever possible—*e.g.*, in fuel research, cold storage, nutrient content of pastures, and noxious-weed investigations—definite co-operation has been arranged, so that the researches are made of Empire-wide significance. The Department has been made the official connecting-link between the Dominion and the Imperial Institute.

Library.

Steps are being taken to build up a library of reference for the research and scientific workers of the Dominion. This library will then serve as a clearing-house for the dissemination of all recent scientific publications.

Bureau of Information.

Numerous inquiries have been received on a wide range of topics of scientific interest, and others having a bearing on industrial problems. Useful assistance had been rendered to many inquirers by this means.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST.

Buildings and Equipment.

The buildings and equipment have been kept in good order, and the storage batteries have been regularly charged. The Observatory grounds are kept in order by the Wellington City Corporation. Four office rooms have been built adjoining the present building and to the west of it. The foundations of the old Garden battery have been used for the new buildings. A separate boiler-house has been built a little to the north of the building, and in this an "Ideal" boiler has been installed. A hot-water heating-system supplying three hot-water radiators in the cellar and five in the offices and passage has also been installed. The additional accommodation allows the staff to work in daylight for the first time, with a consequent reduction in the cost of electric lighting. The rooms have been partly furnished, and one stack of British steel shelving has been fitted. Orders for more steel shelving are in hand. The hot-water heating-system has been satisfactory in heating the cellar and stopping the damage to records and instruments previously experienced by the excessive dampness. The new building has also prevented leakage in the cellar. The out-buildings have been repaired and painted. The south aerial mast was moved some distance to the south-west with the object of improving the reception of long-wave time signals.

Astronomy.

Astronomical Observations.

Observations of the meridian transits of the stars and of the sun have been made for the purpose of controlling the time service. During the year the sun was observed 125 times, and stars 128 times.

Reception of Radio Time Signals at the Observatory.

The following radio time signals were received at the Observatory: Mean-time signals from Honolulu, 135; Malabar, Java, 236; Nauen, 179; Bordeaux, 49; Kavite, 15; and Annapolis, 3. Scientific time signals were also received at the Observatory as follows: Nauen, 116; Bordeaux, 29; Honolulu, 16; Saigon, 8; and Annapolis, 4.

The radio time signals received at the Observatory generally agreed with the Observatory clock within one second of time. Greater differences, however, have been observed in the following cases:—

—	Differences from Observatory Clock.					
	From 1 to 2 secs.	From 2 to 3 secs.	From 3 to 4 secs.	From 4 to 5 secs.	From 5 to 6 secs.	Over 6 secs.
Honolulu (NPM)	19	4	2	..	2	3*
Malabar (PKX)	18	2	1	..	..	..
Nauen (POZ)	17	3	..	..	..	..
Bordeaux (LY)	5	1	1	..	..	..
Annapolis (NSS)	1	..	..	..	..	..
Kavite (NPO)	4	..	..	..	..	..

* NPM 11·67 secs. fast, 28th April, 1926.

The Observatory is indebted to the Bureau Internationale de l'Heure, Paris, and to the U.S. Naval Observatory, Washington, for the corrections to the radio time signals sent out by the French and American observatories.

Beginning with 1st January, 1926, the Saigon time signal, which previously was received at the Observatory at 9.0 a.m., is now sent earlier and reaches Wellington at 6.30 a.m. This early hour makes it impracticable for the Observatory to make any use of the signal.

Time Service.

The time service has been maintained, and the regular signals have been sent out. The signals have been transmitted daily. The total number of time signals sent from the Observatory was 1,621: of these, 457 were sent by wireless telegraph, 672 were sent by special circuit to the Telegraph-office, 227 by the signal lights at the Observatory, 100 by switching off lights on the Harbour Board building at Auckland, 100 by dropping the time-ball at Lyttelton, and 65 by telephone.

No radio time signals were sent on the following dates, owing to—

(1) The Wellington Radio Station (VLW), standing by for distress calls: Sunday, 9th May, 1926; Friday, 18th February, 1927.

(2) Line interruptions between the Wellington Radio Station and the Dominion Observatory: Thursday, 13th May, 1926; Friday, 14th May, 1926; Monday, 21st March, 1927.

The present programme at the Observatory provides for the following time signals, most of which are sent by the Observatory standard clock, which is usually kept accurate to the nearest second of time:—

Automatic Time Signals:—

(1) To the General Post Office, Wellington, by telegraph daily:

(2) To ships and to the general public at Wellington, by electric lights at the Observatory, daily, except Saturdays, Sundays, and Government holidays:

(3) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays:

(4) To the Lyttelton Harbour Board, by dropping the time-ball at Lyttelton, on Tuesdays and Fridays:

(5) To the South Island Telegraph Offices, by telegraph, on Tuesdays and Fridays:

(6) Radio time signals through the Wellington Radio Station (VLW), on Tuesday and Friday evenings:

(7) Radio time signals through the Wellington Radio Station (VLW) every day at 10.30 a.m.

Non-automatic Time Signals:—

(1) To ships and watchmakers in Wellington and to the Public Works Department by telephone, on application to the Observatory.

(2) The Observatory time signals sent to the General Post Office are distributed by telegraphic hand signals to some 2,300 telegraph and telephone offices distributed all over New Zealand at 9 a.m. daily.

(3) Similar hand signals are also sent to all railway offices in New Zealand at 9 a.m. daily by Morse (221) and by telephone (257).

(4) The Wellington Telephone Exchange distributes time signals by telephone to exchange subscribers, generally to the nearest minute of time; the clock in the Exchange is checked by comparing it with the Observatory automatic time signal, but the Observatory is not responsible for the accuracy of these time signals.

Government Buildings Clock.—The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory by direct circuit from the clock, and the adjusting weights on the pendulum are altered from time to time.

Sun-spots.

The regular observation of sun-spots has been discontinued. An enlarging camera for photographing the sun-spots has been obtained, and is fitted for use with the City Council's 9 in. equatorial telescope. The camera is available for any particularly interesting groups of sun-spots.

International Astronomical Union.

By courtesy of the Central Astronomical Bureau, arrangements have been made for this Observatory to receive advice of all important astronomical discoveries. The information is forwarded by the Bureau at Copenhagen to this Observatory through the Melbourne Observatory.

The following information was received in this way during the calendar year 1926:—

(1) Discovery of comet Blathwayt, magnitude 11·0, on 16th January, and observation of comet Blathwayt by Jeffers, 20th January.

(2) Elements and ephemeris of comet Ensor by C. J. Merfield.

(3) Ephemeris of comet van Biesbroeck.

(4) Position of comet Finlay, of magnitude 11·5, 3rd August.

(5) Observation of comet Giacobini by Schwassmann on 16th October, and ephemeris of comet Giacobini.

(6) Discovery of comet Comas Solas, of magnitude 12·0, on 4th November, and ephemeris.

(7) Observation of comet Neujmin on 5th November, by Neujmin.

A number of these objects were observed throughout New Zealand, and reports of the observed positions were sent to the Observatory.

"New Zealand Nautical Almanac."

An article on the Dominion time service arrangements, giving full particulars of all the time signals supplied by the Observatory, was prepared for and published in the "New Zealand Nautical Almanac."

International Longitude Determinations.

At the meeting of the International Astronomical Union held at Cambridge in July, 1925, it was decided, on the initiative of General Ferrie, to carry out a series of longitude determinations in October and November, 1926. About fifty Observatories throughout the world took part. At Wellington, special series of observations for time were made with a small reversible transit which is fitted with a hand-driven self-registering micrometer. Observations with this instrument were procured on seven nights and one morning. In addition, observations for time were also made on the almucantar principle, the instrument used being a survey theodolite with 12-in.-diameter circles, with the telescope 19 in. in focal length and 1·8 in. aperture. With this instrument observations were obtained on eight evenings and one morning.

Radio time signals were received from Nauen, Malabar, Honolulu, Bordeaux, Annapolis, Saigon: and in most cases these signals were received by the method of automatic coincidences. The reduction of the work is in hand.

Auroras.

During the calendar year 1926 the following auroras were observed:—

January 3—Aurora observed from Rotorua.
January 30—Aurora australis observed from Hamilton.
February 19—Aurora australis observed from Dunedin.
February 25—Aurora australis observed from Christchurch.
April 15—Aurora australis observed generally from Wellington, Staveley, Christchurch, Greymouth, Gore, Foxton, Bluff, Ashburton, Auckland.
October 16—Aurora australis observed at Christchurch.
October 25—Auroral display at Lyttelton.
November 5—Aurora australis observed at Dannevirke.

Occulations.

In response to a request from Professor E. W. Brown, F.R.S., for more observations of occulations, the following New Zealand observatories have expressed their willingness to make the necessary observations: Christchurch, Dunedin, Hawera, Nelson, New Plymouth, Wanganui, Wellington. Accurate time signals are sent out from the Dominion Observatory on two evenings a week, and it will be necessary to supply additional time signals to obtain the required accuracy in these observations. In addition to the ordinary occulation observations, a photographic method is in use at the Wellington Observatory by means of which the moon and surrounding stars are photographed on the same plate and the time of the exposure on the moon is recorded on the chronograph. In this way six plates were obtained with the 9 in. telescope.

Mutual Eclipses of Jupiter's Satellites.

Through the courtesy of the British Astronomical Association, predictions of the mutual eclipses of Jupiter's satellites were forwarded to this Observatory, with the result that on two occasions—3rd July and 21st September—two of these eclipses were observed.

Precision Pendulum.

The precision pendulum made by Mr. E. C. Isaac, Wellington, was installed at the Observatory in November. The pendulum is supplied in a metal cylinder, and this will be exhausted to a fairly low vacuum. Electric impulse dials to be used with the pendulum are now on order.

Interferometer.

A research grant from the New Zealand Institute is available for the construction of an interferometer to be used on the 9 in. telescope. An officer of the Public Works Department has been engaged on the plans and specifications of an interferometer, and the four mirrors have been made at the Mount Wilson Observatory, California, and are now in Wellington.

SEISMOLOGY.

The Observatory has three seismographs in use—one Milne and two Milne-Shaws. These are all horizontal component machines, and with them very excellent records are obtained. The records from the twin-boom Milne seismograph at Suva, Fiji, are sent to this Observatory for working up, and are very valuable in supplementing the records obtained at Wellington.

The number of earthquakes recorded on the Milne machine (east–west component) was 116; on the Milne-Shaw (north–south component), 137; and on the Milne-Shaw (east-west component) 120 earthquakes were recorded. Particulars of the numbers of earthquakes registered on the three machines are given in the following table:—

1926.	Machine Milne.	Machine Milne-Shaw (N.–S.).	Machine Milne-Shaw (E.–W.).	Remarks.
January ..	8	10	9	One lost on E.–W. through excessive tilting.
February ..	7	9	4	Excessive tilting accounts for eight losses on E.–W.
March.. ..	12	15	12	
April	9	9	9	
May	2	5	4	One very small shock not traceable on E.–W.
June	10	12	6	Stopping of drum accounts for six losses on E.–W.
July	8	8	7	One lost through defective shutter action.
August ..	13	13	13	
September ..	10	13	13	
October ..	22	24	24	
November ..	6	8	8	
December ..	9	11	11	

Officers of the Post and Telegraph and Marine Departments, and private observers, have given valuable assistance in the reporting of earthquakes felt by them in New Zealand. Eighty-five reports were received from officers of the Post and Telegraph Department, 122 from other observers, and 202 from the newspapers.

The total number of earthquake shocks felt in New Zealand for the year 1926 was 175 ; 131 of these were felt in the North Island and 52 in the South Island. In eight cases the same shock was felt in both Islands. The maximum intensity of the shocks felt in 1926 was 8 on the Rossi-Forel scale. The maximum intensity of shocks felt in 1921 and 1922 was 8, in 1923 was 6, in 1924 was 7, in 1925 and 1926 was 8 on the same scale.

An article on " Earthquakes in New Zealand " was prepared for and published in the New Zealand Year-book. Maps have been prepared showing in considerable detail the distribution and intensity of the earthquake shocks felt in New Zealand ; these are now being made ready for publication.

The work in seismology has increased very considerably since the new Milne-Shaw seismograph has been running, and a further addition to the work has been caused by the installation of the second Milne-Shaw seismograph. In addition to the technical reports on the earthquakes, contact prints are made of all important records, and are sent to other observatories. The old Milne machine has proved its usefulness in a number of cases where the local shocks have been strong enough to throw the Milne-Shaw machines out of action.

During the calendar year 1926 earthquake reports have been received from thirty-one observatories.

Steps are now being taken with a view to obtaining seismographs suitable for recording local earthquakes. By means of these seismographs it is hoped that some precise knowledge of the origins of New Zealand earthquakes may be obtained.

General.

Observatory Committee.

In January, 1927, the Research Council appointed an Observatory Committee for the purpose of reporting to the Council on the programme of work to be submitted by the Director of the Observatory. The members of the Committee are—The Naval Adviser ; the Surveyor-General ; the Engineer-in-Chief, Public Works Department ; and four representatives of the New Zealand Institute. The four members of the New Zealand Institute are Professor C. Coleridge Farr, Christchurch ; Professor D. M. Y. Sommerville, Wellington ; Mr. A. C. Gifford, Wellington ; and Professor P. Burbidge, Auckland. This committee continues the work of the Government Observatory Advisory Board.

The first meeting of the committee was held on the 29th March, 1927, when Professor C. Coleridge Farr was elected Chairman. The committee dealt with the statement by the Government Astronomer on the proposed programme of work for the coming financial year. A number of the matters dealt with by the committee are included in the report.

Publications.

The following Observatory publications have been issued during the year :—

- Bulletin No. 60.—Report of Dominion Observatory, 1925–26.
- Bulletin No. 61.—New Zealand Observations during the Lunar Eclipse, 1921, April 21. Stars occulted during Lunar Eclipse in 1921. By L. J. Comrie. (Reprint from Monthly Notices, R.A.S., March, 1922.)
- Bulletin No. 62.—Site Testing at Nelson. By F. Gibbs and E. L. Morley.
- Bulletin No. 63.—New Zealand Mean Time. (Extract, Transactions of N.Z. Institute, 1902.)
- Earthquake Reports for 1924, April, to 1927, January.

As in past years, the Observatory is again indebted to individuals and to institutions for valuable gifts of publications. Some of these are presented in exchange for the bulletins. In particular, reference should be made to the valuable gifts of cases of books forwarded to this Observatory by Dr. L. J. Comrie ; these include publications from the Nautical Almanac Office, London ; the Royal Astronomical Society, London, and the British Astronomical Association, London, and the Royal Observatory, Greenwich.

During the year forty-six volumes of astronomical and seismological publications were bound.

Meteorological Records, 1926.

The following are the meteorological records for 1926 :—

- Barometer (height above sea-level 415 ft.)—
  - Maximum reading, 30·20—1926, June, 23.
  - Minimum reading, 28·85—1926, June 13.
- Temperature (in transit-room)—
  - Maximum, 71·0° F., recorded 1927, February 12.
  - Minimum, 47·1° F., recorded 1926, August 11.
- Temperature (in cloak-room)—
  - Maximum, 70·2° F., recorded 1927, February 1.
  - Minimum, 47·5° F., recorded 1926, July 4.
- Humidity in new cellar—
  - Maximum reading, 100 per cent.
  - Minimum reading, 77 per cent.

Staff.

Mr. R. C. Hayes, professional cadet, was transferred to Samoa on the 22nd April. Mr. A. G. C. Crust, M.Sc., was appointed to succeed him. The regular staff is now constituted as follows:—A. G. C. Crust, M.Sc., temporary professional assistant; T. S. Wyman, clerical cadet. In addition, Mr. H. O. Belworthy, Internal Affairs Department, has attended to the Sunday duty. Mr. T. W. Preston, Lands and Survey Department, assisted on the longitude determinations from 19th September to 28th November. Mr. R. L. C. Grant, Post and Telegraph Department, was in charge of the radio work during the same period, and Mr. B. L. Elphick, B.Sc., assisted with the seismological work for a total period of sixty-four days.

My thanks are tendered to the staff for efficient and loyal service. The duties at the Observatory are exacting, and are discharged every day of the year, including Sundays and Government holidays. On no occasion has any essential duty ever been neglected.

C. E. Adams,
Dominion Astronomer and Seismologist.

REPORT OF THE DIRECTOR OF THE METEOROLOGICAL BRANCH.

From the 1st April to the 31st August the control of the Meteorological Office rested with the Marine Department, but from then it passed into the new Department of Scientific and Industrial Research. Being a period of transition, there has been little progress to report, although some important initiatory steps have been taken, which I have long advocated and which promise much for future usefulness. They are—

(1) In December an extension of oversea reports was approved, and we now receive brief code messages daily from Sydney, Hobart, Melbourne, Alice Springs, Perth, Brisbane, Norfolk Island, and the Chathams.

(2) Later in the year arrangements were made for certain ships to report ocean weather on the way to and from Australia. These mostly come at the week-end.

(3) Some experiments were made at Sockburn in February and March with pilot balloons, for upper-air investigation.

Weather reports and forecasts are sent out twice daily to all parts of the country, and ocean reports once daily, by radio from Awanui and Wellington. The forecasts are also broadcasted in the evening from the various centres.

Inspections were made of some of the stations on the east coast of the South Island in September last.

Two third-class stations have been raised to the order of climatological stations—viz., Takaka, in the South Island, and Mangamutu (near Pahiatua), in the North Island. Ten new rainfall stations have been established—viz., Opotiki; H.M. Prison Farm, Hauto; H.M. Prison Farm, Rangipo; Tangarakau; Eltham; Flock House, Bull's; Normanby; Waipawa; Hamilton Bay, French Pass; and Little Akaloa.

Notice has been received that the Railway Department requires the Observatory site at Wellington. Another suitable position will have to be decided upon shortly, and this is no easy matter in this city.

D. C. Bates,
Director, Meteorological Office.

DOMINION LABORATORY REPORT.

With the creation during the year of a Department of Scientific and Industrial Research, the Laboratory was transferred from the Department of Internal Affairs, with which it had been associated since 1909, and placed under the control of the new Department. It may be emphasized that the Laboratory already has a good record of achievement in investigational problems dealing with foods, notably milk, with various aspects of coal, with clay, with the kauri-gum industry, and with many minor matters affecting the work of Government Departments. There is a considerable measure of regret in the severance of personal relations with the administrative officers of the Department of Internal Affairs, with whom our relations in the past have been invariably of the happiest. In linking up with the Department of Scientific and Industrial Research it is anticipated that greater facilities will be afforded for research, and more time increasingly devoted to investigational work of an industrial character.

The work during the year has consisted almost entirely of chemical analyses and examinations carried out on behalf of the Government. The number of samples received from various Departments was as follows: Customs, 496; Justice (Police), 34; Main Highways Board, 105; Mines, 467

(Geological Survey 76, Head Office and inspection staff 95, prospectors 296); Post and Telegraph, 161; Public Health, 4,048; Public Works, 35; Railways, 21; other Departments, 48; public bodies, 26; miscellaneous, 39: total, 5,471.

Customs.

The number of samples submitted by the Customs Department was considerably greater than in previous years.

Police.

Ten series of exhibits were examined for poisons at the direction of the Superintendent of Police, and in four cases cyanide, veronal, strychnine, and sodium arsenate were respectively found. Medicine, ointment, naphtha, and various liquors were also analyzed.

Mines.

The Geological Survey submitted eighteen rocks and minerals for superior analysis, and many others for less complete examination. There were also waters from irrigation areas of Central Otago, and natural gas from possible petroleum areas. The Head Office and inspection staff required principally analyses of coal, coal-mine dusts, mine-air, stone for gold and silver, and occasionally other minerals. Prospectors' samples show that attention is being paid again to the molybdenite deposits at Karamea, and to possible tin and wolfram areas in Stewart Island. Manganese of good quality was forwarded from Tikiora, Russell, and from Ruapekapeka.

Health.

Foodstuffs in great variety, and other samples having some direct bearing on health matters were submitted by the Department of Health. The list comprises—Air from workrooms, apples and apple-juice, bacon, barley, beer, biscuit and biscuit-filling, brandy, brawn, bread, bronchial lotion, Burton salts, butter, celery, Cellu-flour, chocolate liquers, cheese, coffee, cordials, cream, cream and custard powder, desiccated coconut, egg-mixture, essences of lemon and vanilla, Fiji remedy, food-flavouring, germoline preservative, germolets, gin, ginger and hop beers, honey, ice-cream, iodine tincture, iodized salt, lard, lemon-cheese, lemon-squash, lime-juice, lime-water, malt-extract, margarine, Marmite, methylated spirit, mineral-water tablets, Moogrol, Oysto-paste, pears, rubber fabric, rum, sausage and sausage-meat, soap, sugar, tomato-sauce, turpentine, trout, vinegar, washing-powder, whisky, whole meal, yeast tablets.

The bread examined included brown bread and special diabetic bread, some of which was decidedly high in starch content. Four of the butter-samples exceeded the standard for water.

Only three lime-waters were examined, but two of these did not comply with the B.P. standard. In view of the widespread use of lime-water, especially for infants, a much larger number of samples should be taken.

The sausage-meat was shown to contain an excess of starchy foods.

The labelling of a few other samples was not in accordance with regulations.

Beer-samples were taken in various parts of New Zealand, and of great variety of brands. The limit for salt in beer has been fixed at 50 grains per gallon, which would seem ample, but one-fourth of the number examined contained more than this. With spirituous liquors such as whisky, brandy, &c., there is an occasional tendency to dilute overmuch with water, but the more usual offence is the substitution of cheap liquor for well-known case brands. Several convictions for this were obtained during the year.

Following on disquieting reports received from Great Britain of dangerous amounts of arsenic in imported apples, attributed to the use of arsenical sprays, a special examination was made of sprayed fruit from orchards in several parts of New Zealand. A safe limit for arsenic was considered to be $\frac{1}{100}$ grain per pound of fruit. Only when patches of dried spray were visible or when the fruit had been sprayed immediately before picking was this limit exceeded, while if the fruit were peeled and the skin discarded the arsenic found was less than $\frac{1}{1000}$ grain per pound.

Milk.

The numbers of samples taken officially during the year are—Wellington City supply, 1,756; country districts controlled by Medical Officer of Health, Wellington, 769; districts controlled by Medical Officer of Health, Dunedin, 795; total, 3,320.

Wellington City.—Comparatively little wilful adulteration of milk was detected during the year. Nine samples were low in fat and had presumably been skimmed, and five had been watered, in two cases to the extent of 30 per cent. One sample was deficient in milk solids, and there were nine minor breaches of the regulations, for which warnings were advised. The use of an ice-chest by the Inspector, in which samples are placed immediately after being taken and so kept until delivery to the Analyst, has permitted some measure of control over the sale of stale milk. Eight prosecutions were recommended for this offence, and fifteen warnings advised. The supply showed decided improvement over that of previous years as regards dirt. The City Inspector must again be commended for the able manner in which he carried out his duties during the year.

Country Districts under Control of the Medical Officer of Health, Wellington.—The results for these districts are summarized in the following table :—

——	Number of Samples.	Deficient in Fat.	Watered.	Slightly below Standard.	Warned for Dirt.
Blenheim	67	..	..	..	..
Carterton	4	..	..	..	..
Dannevirke	44	..	..	1	..
Eastbourne	3	..	..	..	..
Eltham	3	..	..	..	..
Ekatahuna	8	..	..	..	..
Featherston	2	..	..	..	..
Feilding	8	..	1	..	..
Gisborne	57	..	3	..	..
Greytown	15	..	..	2	..
Hastings	47	..	..	..	..
Hawera	59	..	3	1	..
Hutt district	55	1	4	1	..
Levin	14	..	..	..	..
Manaia	2	..	..	..	..
Masterton	23	..	..	..	..
Napier	82	2	1	2	..
Nelson	73	1	7	1	..
New Plymouth	31	..	..	..	..
Pahiatua	9	..	..	..	..
Palmerston North	35	1	..	..	..
Patea	4	1	..	..	..
Picton	33	1	..	..	..
Plimmerton	3	..	..	..	..
Stratford	7	..	1	..	..
Tiretia	1	..	..	..	..
Taihape	5	..	1	..	..
Waipawa	5	..	..	..	..
Waipukurau	7	..	..	..	..
Wairoa	30	1	1	2	..
Wanganui	27	1	1	1	..
Woodville	3	..	..	..	..
Farm samples	3	..	..	..	..
Totals	769	9	23	11	..
Totals 1925	609	7	7	9	22

Country Districts under Control of the Medical Officer of Health, Dunedin.—The samples were forwarded in bottles preservatized with mercuric chloride. The following table gives a summary of the results :—

——	Number of Samples.	Deficient in Fat.	Watered.	Slightly below Standard.	Warned for Dirt.
Dunedin	397	2	5	5	10
Alexandra	8	..	..	..	..
Balclutha	6	..	..	1	..
Clyde	10	..	..	..	..
Cromwell	16	1	..	..	..
Gore..	59	1	..	1	..
Invercargill	80	..	..	..	1
Kaitangata	18	2	..	..	3
Lawrence	16	1	..	..	..
Lumsden	1	1	..	..	..
Mataura	22	2	..	2	..
Milton	16	..	..	..	..
Mosgiel	24	2	..	..	..
Oamaru	38	..	..	..	..
Otatau	6	..	..	..	..
Ohai..	8	..	..	..	..
Queenstown	13	..	..	..	..
Riverton	17	2	1	..	..
Waipiata	33	2	..	..	..
Wyndham	7	..	1	..	..
Totals	795	16	7	9	14
Totals, 1925	349	9	9	5	56

Plunket Society.—Plunket nurses forwarded 250 samples of human milk and humanized milk for analysis during the year.

Post and Telegraph.

Samples examined for the Engineering Branch of the Post and Telegraph Department comprised beeswax, bronze wire, distilled water, iron bolts, jointer's metal, lead sheathing for cables, petroleum jelly, shellac, solder, damaged submarine cable, sulphuric acid, zinc rods.

Public Works.

The principal work undertaken for the Public Works Department was the testing of road-tar, bitumen, and bituminous concrete for the Main Highways Board. Owing to restricted accommodation and shortage of staff, the work fell considerably into arrears as the season advanced. Provision now being made should enable tests to be expedited in future. Other samples analyzed for the Department were coal, boiler-water, paint, roofing-materials, wire.

Railways.

The samples examined for the Railways Department were fuel briquettes, ink, paints and pigments, oleine oil, water.

Stores Control.

The Stores Control Board required careful examination of the following materials: Cleaning preparation, fuel oil, galvanized iron, ink, kerosene, lubricating-oils, metal-polish, motor and aviation spirit. Some assistance was also given in framing certain specifications.

Other Departments.

Samples analyzed for other Departments included creosote and other wood-preservatives, fire-resisting paint, and kauri-gum, for the State Forest Service; copra, for the Department of External Affairs; and soap, for the Navy Office. In addition there have been frequent requests for information or advice on chemical matters by many Government Departments.

Gas Control.

Regular tests of town gas for pressure, purity, and calorific value have been carried out in Auckland, Christchurch, and Wellington. Towards the end of the year two meter-inspectors were appointed in Auckland and Wellington respectively.

AUCKLAND BRANCH.

The number of samples analyzed during the year was as follows: Health Department, 2,243; Justice Department (Police), 49; Public Works Department, 8: total, 2,300.

CHRISTCHURCH BRANCH.

The number of samples received during the year ended 31st December, 1926, was as under: Health Department, 1,192; Justice (Police) Department, 37; other Government Departments, 16; local bodies, 6; general, 1: total, 1,252.

J. S. Maclaurin,
Dominion Analyst.

GEOLOGICAL SURVEY BRANCH.

DIRECTOR'S REPORT.

Control and History of Survey.

On the 1st September, 1926, the Geological Survey, which from the 1st January, 1886, had been attached to the Mines Department, was transferred to the newly organized Department of Scientific and Industrial Research. This change in organization marks a turning-point in the career of the Geological Survey, and therefore a brief account of its history up to the present time is here given.

The Geological Survey of New Zealand was first organized in 1865, when Dr. James Hector, at that time Otago Provincial Geologist, was appointed Director. In 1867 the New Zealand Government passed an Act "to establish an Institute for the Advancement of Science and Art in New Zealand, and to make Provision for the Carrying-out of the Geological Survey of the Colony." The short title of this Act was "The New Zealand Institute Act, 1867."

For many years Dr. (later Sir James) Hector directed not only the Geological Survey, but the Colonial Museum, and there was therefore an intimate bond between these two institutions. Sir James Hector was also Manager of the New Zealand Institute, and ably filled many other positions. Among those connected with the Geological Survey in its early years were William Skey (Chemist), F. W. Hutton, E. H. Davis, S. Herbert Cox, Alexander McKay, and James Park. Julius von Haast (Canterbury Provincial Geologist), F. W. Hutton (who became Otago Provincial Geologist after his retirement from the Geological Survey), and others made examinations and reports for the Survey from time to time.

Until the end of 1885 the Geological Survey was attached to the Colonial Secretary's Department, when, as mentioned above, it was transferred to the Mines Department, a connection that lasted for over forty years. A list of the publications of the Survey from 1866 onwards (not quite complete) is given in the first annual report (1907) of the present series.

In 1903 Sir James Hector retired from the various official positions held by him, and several important changes took place. The New Zealand Institute Act, 1867, was superseded by The New Zealand Institute Act, 1903, and the joint control of the Geological Survey and Museum came to an end. For over a year the Geological Survey was represented only by Alexander McKay, who held the position of Mining Geologist in the Mines Department. Towards the end of 1904 Dr. J. M. Bell, of Canada, was appointed Director of the Geological Survey, and on his arrival in New Zealand in February, 1905, the Survey was reorganized, a permanent field and office staff being appointed. The work done by it since then is stated in its annual reports and other publications.

Summary of Field Operations, 1926–27.

The field season of 1926–27 was a busy one, and detailed topographical and geological surveys were carried out in the following areas:—

(1) Rotorua Subdivision, Auckland, by L. I. Grange, M.Sc., A.O.S.M., F.G.S., Assistant Geologist.
(2) Wairoa Subdivision, northern Hawke's Bay and southern Gisborne, by M. Ongley, M.A., B.Sc., Geologist.
(3) Murchison Subdivision, Nelson, by J. Henderson, M.A., D.Sc., B.E., A.O.S.M., Mining Geologist, and H. E. Fyfe, B.E., A.O.S.M., Assistant Geologist.
(4) Central Otago (in conjunction with soil survey), by H. T. Ferrar, M.A., F.G.S., Geologist.

Visits for various purposes were made by me to Piopio and neighbourhood (Waitomo County), Rotorua district, Te Puke, Waihi, Hastings, Taradale (near Napier), and Gisborne. Dr. J. Marwick, Palæontologist, visited the Mokau and Patea districts in order to collect representative fossils that would assist in correlating the Miocene strata of New Zealand. Mr. L. I. Grange made a special visit to White Island in order to obtain geological data, and to report on its sulphur and gypsum deposits.

Progress of Areal Surveys.

During the twelve months ended 31st May, 1927, approximately 1,370 square miles in the Rotorua, Wairoa, and Murchison districts was examined in detail. In addition Mr. Ferrar and his party, besides making a soil survey of roughly 554 square miles, geologically examined in moderate detail about 860 square miles. It is estimated that since 1905 to date 23,056 square miles (59,712·6 square kilometres) has been geologically surveyed in complete or fairly complete detail.

Dargaville-Rodney Subdivision.

Field-work in this area was completed in the autumn of 1925. Mr. Ferrar's detailed report on it will be prepared for publication during the winter.

Rotorua Subdivision.

For a number of years past the establishment of a vulcanological observatory in the volcanic region of the North Island has been strongly recommended by several scientists of note, and the proposal has received a good deal of support from the general public. No detailed geological survey has ever been made of any part of the volcanic region, and therefore I urged that such a survey was of prime importance, and should precede or accompany systematic vulcanological observations. This view has, I think, been generally accepted, and last October Mr. L. I. Grange, Assistant Geologist, was instructed to begin a detailed geological examination of the Rotorua and adjoining districts, special attention to be given to hot-spring and other volcanic phenomena. From Mr. Grange's summary report on a later page it will be seen that some valuable data have already been obtained or are in sight, and I venture to think that the course adopted will be fully justified by results. Incidentally the geological mapping will assist the soil surveys now being undertaken by the Department of Agriculture. Towards the end of last January I visited Rotorua, and in company with Mr. Grange or alone inspected much of the surrounding country.

Tongaporutu-Ohura Subdivision.

Mr. Grange's detailed report on the Tongaporutu-Ohura Subdivision, and the geological maps that accompany it, are about to be issued. Important coal deposits in the Waitewhena district are described. The occurrence of petroleum in commercial quantity is suggested as not unlikely.

WAIAPU SUBDIVISION.

The detailed report on Waiapu Subdivision was not completely revised last winter, but is now ready for the printer. Portions of this area are being actively prospected for petroleum at the present time.

WAIROA SUBDIVISION.

The Wairoa Subdivision covers a large area of country south of the Gisborne Subdivision, surveyed a few years ago by Dr. J. Henderson and Mr. M. Ongley. (See N.Z. Geol. Surv. Bulletin No. 21.) Mr. Ongley's summary report on the work done by him during the past season is given on a later page. In and near the area examined there are at least two large domal or anticlinal structures favourable to the accumulation of oil and gas. The areas involved have been examined in great detail by the geological staff of Taranaki Oil Fields, Ltd., and that company is now about to start drilling at what is believed to be a very favourable position east of Morere.

MURCHISON SUBDIVISION.

The Murchison Subdivision lies south of the Motueka Subdivision, and on the west adjoins the Buller-Mokihinui and Reefton subdivisions. Its survey was begun last season, partly because it connects areas already surveyed in detail, and partly because active prospecting for petroleum has begun within its boundaries. Dr. Henderson's summary report on the past season's work appears on a later page.

KAITANGATA - GREEN ISLAND SUBDIVISION.

Owing to Mr. Ongley's transference to the Wairoa district, no opportunity of completing the survey of this area as planned has been found. During the winter, however, a detailed account of its geology will be written.

SOIL AND GEOLOGICAL SURVEYS, CENTRAL OTAGO.

On later pages Mr. Ferrar submits a progress report on the soil survey of irrigation areas, Central Otago, and a second report describing the geology of the country examined by him and members of his party. Much of the geological work undertaken by Mr. Ferrar is too closely connected with soil survey to be dissociated from it; nevertheless in great measure it was done by working overtime. From the soil-survey report it would appear that, as stated in my last annual report, the areas where harmful salts accumulate are very small, and can be easily dealt with.

PALÆONTOLOGICAL WORK.

Large numbers of Tertiary and other fossils, both in old and new collections, have been examined and identified by Dr. J. Marwick, palæontologist. Many new species have been observed, and these are being described as opportunity permits. A brief report by Dr. Marwick on his work during the past year appears on page 28.

PUBLICATIONS.

During the year the following official publications were issued:—

- "Twentieth Annual Report (New Series) of the Geological Survey" (parliamentary paper C.-2c, 1926).
- Geological Bulletin No. 28: "The Geology of the Huntly-Kawhia Subdivision, Pirongia Division," by J. Henderson and L. I. Grange.
- Geological Bulletin No. 29: "The Geology of the Egmont Subdivision, Taranaki," by P. G. Morgan and W. Gibson.
- Palæontological Bulletin No. 11: "The Cretaceous and Tertiary Foraminifera of New Zealand, with an Appendix on the Ostracoda," by Frederick Chapman (Melbourne Museum).
- Palæontological Bulletin No. 12: "Contributions to the Palæontology of the New Zealand Trias," by Otto Wilckens (Bonn University).

The palæontological papers by Dr. J. Marwick mentioned in last year's report were published in volume 56 of the "Transactions of the New Zealand Institute," as announced. Volume 56 of the Transactions also contained two short papers by L. I. Grange, one entitled "Geology of the Upper Waitotara Valley, Taranaki." and the other "Significance of Fossils from the Huiroa Oil-bore, Taranaki." An important paper by Dr. Marwick, "The Veneridæ of New Zealand" appeared in volume 57 of the Transactions, published last March, and in the same volume was a brief paper by H. T. Ferrar, "Soil Survey of New Zealand." The paper by Dr. F. R. Cowper Reed, Sedgwick Museum, Cambridge, "New Trilobites from the Ordovician Beds of New Zealand," also published in volume 57 of the Transactions, dealt with fossils collected by this Survey in Nelson. A paper by P. G. Morgan, entitled "The Definition, Classification, and Nomenclature of the Quaternary Periods, with Special Reference to New Zealand," and a paper by Dr. J. Marwick, entitled "Cretaceous Fossils from Waiapu Subdivision," appeared in volume 8 of the *New Zealand Journal of Science and Technology.*

OFFICE-WORK, ETC.

Throughout the winter and early spring of 1926 the various professional members of the Geological Survey staff were engaged in the preparation of detailed reports and in work connected therewith. During the year numerous requests for geological and other information were answered, and many samples of rock, minerals, and fossils were examined and identified. Among the more interesting minerals received were ilmenite from Tangihua Range, North Auckland (said to occur in considerable amount); coal from the more southern of the Poor Knights; vivianite from near Mount Karioi, south-west of Raglan; precious opal from Tokatoka and from Rotorua-Atiamuri road, eleven miles from Rotorua (in small masses only); pilolite (a flexible leather-like clay) from Mr. J. Wall's property, north-west of Paemako, Piopio district.

Many complete analyses of rocks from various parts of New Zealand were made and much other analytical work was done for the Survey in the Dominion Laboratory.

The draughtsman (Mr. G. E. Harris), with a small amount of temporary assistance, drew ten maps, each covering one or more survey districts, for photo-lithographic reproduction; several mineral and prospecting maps; and sixty-three field-maps. In addition he attended to many small matters, including the correction and colouring of map-proofs.

General.

Previous to 1905 the work of the Geological Survey was mainly exploratory. The greater part of New Zealand was covered by reconnaissance surveys, but hardly any detailed mapping was done, and several important aspects of geology were somewhat neglected. During the past twenty-two years on an average over 1,000 square miles per annum has been surveyed in detail, and since 1911 a large amount of palæontological work has been done. It is considered that the detailed geological mapping of a country should be done within a period of, say, thirty to forty years, not only because the completion of the geological map is a prime necessity, but because the advance of science renders the old work partly obsolete in a generation or less, and it then needs revision. Moreover, there are many functions that a Geological Survey can fulfil in addition to its ordinary work of deciphering the geological history of a country and embodying it in maps and resports, but the staff cannot adequately attend to these until a large amount of geological information has been accumulated and facilities for advanced work provided.

At present the Geological Survey is equipped only for the work it has been doing—namely, geological mapping and the partial elucidation of the geological history and structure of the country. Few geological surveys are doing more than this, but more is required. Over three-fourths of the Dominion is as yet geologically unsurveyed in any detail, and therefore an acceleration of the rate of mapping is highly desirable. This, of course, is a matter of increased staff and funds. The progress of science during the past twenty-five years makes new methods of far-reaching importance possible, but all are expensive. More and more exact measurements of all kinds in place of the rough determinations and guesses of the past are called for. Of great importance are geophysical researches, such as gravity determinations, detailed magnetic surveys, and prospecting by means of electrical, seismographic, and gravity methods. In addition there are fundamental researches, such as those being handled in the Carnegie Geophysical Laboratory and elsewhere, which, however, need not be attempted in New Zealand at the present time.

Many minor researches, for which a well-equipped laboratory and more or less elaborate apparatus are required, might be mentioned. Provision of this kind would increase the usefulness of the Geological Survey, and enable it to give a greater degree of practical assistance to mining, engineering, agriculture, and many secondary industries.

SPECIAL REPORTS.

1. MURCHISON SUBDIVISION.

(By J. Henderson and H. E. Fyfe.)

Introduction.

Work in the Murchison Subdivision was begun early in November, 1926, and was continued till the end of May, 1927. The area examined lies immediately south of the Motueka Subdivision, and next season the exploration will be extended to the eastern borders of the Buller-Mokihinui and Reefton subdivisions (described in Bull. Nos. 17 and 18). In all about 670 square miles was examined, including the survey districts of Tainui, Hope, Howard, and Arnaud, and parts of Motupiko, Rotoiti, Maunga, Matiri, Tutaki, and Rotoroa.

Physiography and Structure.

The lowland south-west of the city of Nelson extends south into the Murchison Subdivision, the eastern boundary of which lies in the highlands east of the depression along the watershed of the Motupiko and Buller rivers. The mountains west of the Nelson lowland (which in the Motueka Subdivision form a broad rugged mass of highlands, reaching to the west coast of the island), in the Murchison Subdivision are divided by a structural depression into two groups of ranges, in this report called the central and western highlands.

The mountains along the eastern border of the subdivision belong to two distinct elevated masses, and are separated by a great fault following the Wairau valley. This fracture reaches the edge of the Nelson lowland near Tophouse, and thence extends south-west past the northern end of Lake Rotoiti and the southern end of Lake Rotoroa. The mountains to the south-east are part of the great area of uplift that extends throughout the South Island. That part within the subdivision, which occupies most of Arnaud Survey District and part of Rotoroa Survey District, is traversed by strong north-north-east faults. Along these, streams and glaciers have excavated the valleys of the D'Urville, Sabine, Travers, and upper Wairau rivers. The massive interfracture blocks now form the exceedingly rugged ridges of the Mount Misery, Mount Robert, and Raglan ranges. These mountains are not yet mature, and there are no low passes between the valleys. Since the larger branches of each main stream flow from the west and the watershed of each range is near its western border, the blocks when elevated probably had an eastward tilt. The peaks on each ridge increase in height southward; this increase is gradual over long stretches separated by step-ups where cross-faults occur. Mount Travers (7,666 ft.), on the Mount Robert ridge and near the south-east corner of the subdivision, is the highest point within it.

The mountains north-west of the Wairau fault are separated from the Nelson lowland by a well-marked fracture-zone (the Waimea fault of McKay) that extends from Tophouse to the northern boundary of the subdivision, a distance of ten miles. These highlands form part of the Ben Nevis Range, the highest point within the area examined being Beeby's Knob (4,712 ft.).

The central highlands of the Murchison Subdivision have not yet been completely explored. They form a triangular mass ten miles wide on the northern boundary, with the apex at Mount Murchison, thirteen miles south. The most easterly of the three blocks that make up these highlands forms the Hope Range and Mount Murchison, its continuation south of the Buller. It is a broad plateau-like mass of granite, fourteen miles long and about four miles wide, separated from the Nelson lowland by the well-known Hope fault, and from the adjacent uplifted block and from the Murchison lowland by equally well-marked fractures. The elevated block to the west forms the Look-out Range, which is continued north into the Motueka Subdivision as the high ridge between the Dart and Rolling rivers, branches of the Wangapeka. It is about 1,000 ft. higher than the Hope Range, and when elevated probably had a tilt to the west. The third earth-block of the central highlands is the Mount Owen massif, a dissected plateau of which the southern four miles is within the Murchison Subdivision. It is about three miles wide, and, on the whole, has a gentle westward slope. The highest point, Mount Owen, is 6,155 ft. above sea-level.

No part of the western highlands was explored during the season. They extend along the western border of the subdivision, forming the Lyell Range north of the Buller and the Brunner Range south of that river.

The Nelson depression extends south and south-west through the subdivision, and, so far as explored, maintains an average width of rather more than twelve miles. Southward its floor rises; the step-up to the southern part of the central highlands is small, though that to the south-eastern highlands is still more than 1,000 ft. The northern half is filled with late Tertiary and younger gravels, but in the south the hard rocks flooring it are exposed over large areas.

Only a small part of the eastern edge of the Murchison depression has been explored in detail. It is covered with strata of middle Tertiary age or older, which form ranges up to 4,000 ft. high.

Except for some eighty square miles in the north-east corner of the subdivision, drained by the Motupiko and its branch, Rainy River, the whole of the area examined lies in the basin of the Buller River. This large stream flows from Lake Rotoiti in a general west-north-west direction for twenty-one miles; from the junction of Owen River it is in a straight south-south-west valley for nine miles as far as Longford, whence its course to the boundary of the subdivision, seventeen miles away, though decidedly winding, is in general west.

Rotoiti is a narrow, flat-bottomed lake of about 3·8 square miles in area, with a maximum depth of 269 ft. It occupies about five miles of a moraine-dammed valley extending south-south-west for eighteen miles into the eastern highlands. The Travers River flows through the upper part of this trough, which is characterized by numerous truncated spurs and hanging tributary valleys.

The Buller, in the west-north-west part of its course, is joined from the north by the Hope and Owen rivers, which drain respectively the east and west portions of the central highlands and parts of the adjacent depressions. From the south it receives the Howard and Gowan rivers. The former drains a considerable area of the Nelson lowlands; the latter is a stream larger than the Buller at their junction. The Gowan flows from Lake Rotoroa, which receives its waters from the D'Urville and Sabine rivers, similar in size and environment to the Travers. Lake Rotoroa is 9·2 square miles in area, nine miles long, from 60 to 120 chains wide, and 500 ft. deep. It lies entirely within the Nelson depression, and occupies part of a glacial trough that is continued north for six miles as the Gowan valley.

In the south-south-west part of its course the Buller receives no large tributary, but in the west-ward-flowing part it is joined by the Matiri and Newton rivers from the north, by the Mangles from the east, and by the Matakitaki and Maruia from the south. The Matiri drains most of the Murchison depression north of the Buller, and the Newton part of the western highlands. The Matakitaki and Maruia, streams similar in size to the Gowan, rise far to the south in the eastern highlands, and have about a dozen miles of their lower courses in the Murchison Subdivision. The Mangles forms the natural up-stream continuation of the Buller, which above the Mangles junction abruptly changes its general direction.

General Geology.

The oldest strata examined during the season are the Palæozoic marbles, schists, phyllites, and quartzites of Mount Owen. These are continuous with the rocks of the Mount Arthur Series in the adjoining Motueka Subdivision. Poorly preserved graptolites were observed in pebbles of dark phyllite in the bed of the west branch of Owen River.

The highlands east of the Nelson depression, north of Tophouse, consist of strongly folded and well-consolidated conglomerates, grits, green greywackes, and well-bedded green and purple argillites. Thin lenses of limestone are present in places. These rocks form the Maitai Series, of supposed late Palæozoic age. Conglomerates and greywackes associated with igneous rocks occur in the basin of Rainy River as inconsiderable inliers, surrounded by Moutere Gravels and still later deposits. These are probably Maitai rocks. Possibly also the greywackes and argillites of a small area on the west side of the D'Urville Valley, a mile from the mouth of that stream, are of the same age.

The sediments forming the eastern highlands south of Tophouse are quite distinct from those of the Maitai Series. They consist of conglomerates, grits, greywackes, quartzites, and minor bands of dark argillites. The greywackes, which are the dominant rocks, are fine- or coarse-grained and dark- or light-coloured. The light-coloured and usually coarser-grained rocks are closely related to the quartzites. Many bands of greywacke contain angular and subangular fragments of dark argillite, and where these are numerous the rock becomes a breccia or breccia-conglomerate. Conglomerates consisting of smoothly rounded pebbles of igneous and hard sedimentary rocks also occur. The beds of this series closely resemble those of the Southern Alps in the Otira district. They are provisionally regarded as of Triassic age.

The older Tertiary rocks of the subdivision cover large areas in the Murchison depression, which is as yet almost unexplored. The basal beds, as exposed in the headwater branches of Owen River, consist of arkositic grits and sandstones, with bands of conglomerate, carbonaceous shale, and coal. These beds grade upward into sandstones and argillaceous sandstones, followed by more or less calcareous mudstones. The sections exposed along Sandstone Creek and the lower Owen valley show that the calcareous mudstones are succeeded by alternating bands of sandstone and mudstone, and these by massive sandstones containing plant-fragments. Massive mudstones next appear, and these are overlain by sandstones and conglomerates. Not enough work has yet been done to determine the position in the sequence of the conglomerates, sandstones, shales, carbonaceous shales, and coal-seams exposed between the Owen and Matiri rivers.

Crushed and steeply dipping Tertiary rocks outcrop in a narrow strip along the eastern base of the Hope Range from Glenhope to Mount Murchison. These strata, consisting of sandstone, shales, and carbonaceous shales, are probably of about the same age as those of the Murchison depression.

The younger Tertiary beds of the subdivision occur only in the Nelson depression. Compacted but not strongly cemented conglomerates, grits, sandstones, and shales with lignitic bands outcrop along one or both sides of the Hope Valley from Tadmor Saddle to the Buller River. The conglomerates consist of well-rounded pebbles of igneous rocks derived from the granites of the Hope Range and from the more basic rocks that form the floor of the Nelson depression in this locality. For the most part these strata lie flat, but in places they are steeply tilted. They were not observed in contact with the other Tertiary strata in the Murchison Subdivision, but a few miles north of Tadmor Saddle they overlie them unconformably.

Steeply dipping conglomerates and sandstones in every way similar to those near Glenhope outcrop over a small area on the ridge between the north end of Lake Rotoroa and the Howard River.

Between four and five miles north of Tophouse, conglomerates, sandstones, and shales, in places containing leaves of dicotyledonous plants, are exposed along the bed of Motupiko River for half a mile. The pebbles of the conglomerates are of rocks different from those of the beds near Glenhope, but they are for the most part igneous and derived from near-by sources.

The Moutere Gravels, the youngest Tertiary beds in the subdivision, cover a large area in the northern portion of the Nelson depression. In places they are more than 1,200 ft. thick. They consist of flat-lying, thick-bedded gravels, the pebbles of which are almost entirely siliceous greywacke derived from the eastern highlands south of Tophouse. The matrix is a sandy clay, which also forms inconstant lenses in the lower part of the gravels. The strata are usually weathered yellow, but in a few localities are outcrops showing the original blue-grey colour of the gravels.

All the upland valleys of the south-eastern highlands and many of those of the central highlands are strongly glaciated. The chief glacial deposits, however, are those of the Nelson depression. These had their source in the south-eastern highlands, from the base of which they extend irregularly for ten miles, and were probably laid down by a piedmont glacier. They are now greatly denuded, the main drainage-channels being in places 2,000 ft. below their surface. These deep-cut valleys, though almost certainly excavated by running water, were later occupied by valley glaciers belonging to a period of ice-advance younger than that of the piedmont glaciers. These deposited moraines at many points. Varved clays, in places contorted and overlain by boulder-clay, occur in the Howard basin. Similar clays outcrop in the Matiri Valley near the junction of that stream with the Buller. These are lake deposits, probably nearly contemporaneous with the deltaic fore-set beds exposed in the Matiri a mile from its mouth and the sands forming part of the south bank of the Buller west of Longford.

The chief Recent deposits are the fluviatile gravels of the flood-plains and terraces and the mountain-screes.

Plutonic rocks, ranging from granite through diorite to gabbro, seem to form most of the floor of the southern part of the Nelson depression. This complex is best exposed about Lake Rotoroa and along the Gowan Valley, but even here it is in great part concealed by glacial deposits. In the lower valley of the Hope and at many points in the valleys of the upper Buller and Howard rivers it outcrops beneath younger Tertiary deposits. A small area occurs in the basin of Rainy River. Apparently an irregular land-surface, carved from the plutonic complex, and relatively depressed between the crustal blocks now forming the eastern and central highlands, was later smothered with young Tertiary and Pleistocene deposits.

Flow and fragmental volcanic rocks, intermediate or sub-basic in composition, are exposed in several localities near the south-eastern edge of the Nelson lowland. They outcrop in the upper Motupiko Valley, at the head of Rainy River, about the northern end of Lake Rotoiti, and again in Bull Creek, a small branch entering the D'Urville from the west rather more than a mile from Lake Rotoroa. These volcanic rocks closely resemble those of Brook Street Valley described in Bull. No. 12 (p. 40).

The Hope Range and Mount Murchison are part of the great mass of granite extending along the west side of the Nelson depression to Separation Point, sixty miles north of the subdivision. It is a medium- to coarse-grained rock, in places containing large feldspar crystals. Ben Murray, a peak on the Trent Range, which separates the basins of the Matiri and Owen rivers, is also formed of granite, but the rock is quite distinct from that of the Hope Range.

Economic Geology.

Alluvial gold has been obtained for many years in the Murchison Subdivision. At present the chief diggings are in the basins of Louis Creek, a branch of the Howard, and New Creek, a branch of the Gowan. The gold-bearing gravels have been rewashed from the glacial deposits that here cap the hills. The detrital gold of other streams in this part of the Nelson depression has probably also been derived from the glacial deposits. The chief of these streams are Maggie, Maud, and Gibbs creeks, branches of the Howard, and many branches of Upper Buller, Rainy, and Motupiko rivers. The alluvial gold of the Owen basin was undoubtedly supplied by the auriferous quartz lodes of Mount Owen. These have been known for many years; in the "eighties" a crushing-battery was erected, but the veins could not be worked profitably. Much gold has been won from the beaches and terraces of the Buller, Matakitaki, and Mangles rivers. Dredges worked on the Buller and Matakitaki years ago.

Three seams of coal, from 3½ ft. to 5 ft. thick, occur in the Tertiary beds a mile and a half north-east of Murchison. All have been worked to some extent, and a little coal is mined to supply local needs. The coal is excellent, but at present there is no means of transporting it profitably to a market. A thick coal-seam outcrops in the basin of Frying-pan Creek, a small stream entering the west branch of the Owen near its junction with the east branch, but is vertical and contains many dirt bands.

Inflammable gas in small amount escapes from the Tertiary rocks in the Owen Valley, and at several points in the Buller Valley between Owen junction and Longford. A bore, which at the time of the writers' visit was 2,070 ft. deep, is being drilled near an oil and gas seepage in the Mangles Valley 20 chains up-stream from the Blackwater junction. A little gas and a few "shows" of oil have been obtained.

The igneous rocks of the plutonic complex and of the Hope Range could yield unlimited supplies of building-stone. Marble occurs in large amount in Mount Owen, but its transport would be difficult. A few years ago limestone was being crushed for agricultural lime at a point about a mile west of Murchison, but the plant has now been removed. There is abundant hard rock or gravel for surfacing roads everywhere in the subdivision.

2. SOIL SURVEY, CENTRAL OTAGO.

(By H. T. Ferrar.)

Introduction.

The soil survey of irrigation areas in Central Otago was undertaken at the request of the Hon. the Minister of Public Works, as mentioned in last year's annual report. The area surveyed at the end of May, 1926, was approximately 230 square miles. During the 1926–27 field season, which extended from 16th October, 1926, to 19th May, 1927, the total area mapped was 554 square miles, or 354,560 acres, and covered the Manuherikia Valley from Omakau north-eastward to Tunnel Hill, the Ida Valley from Mount Ida Water-race to Ida Valley Railway-station, and the Maniototo Plain from Mount Ida Water-race southward to Linnburn Homestead and eastward to the Kyeburn. This area includes the following irrigation projects: Ida Valley, Upper Manuherikia, Scandinavian, Hawkdun, and Maniototo, together with some irrigable areas in their vicinity. Next season it is intended to map the areas situated in the Clutha and Arrow River valleys.

Methods of Mapping.

The soil map in course of preparation is based on field-sheets, drawn on a scale of 1 in. to 20 chains, prepared from tracings of the Lands and Survey record maps. By means of prismatic-compass bearings and paced traverses between fixed points additional topographical features are added where changes in the character of the land make such additions necessary. Since water-supply is the factor that has most influence in the productivity of the land in Central Otago, symbols representing different types of land have been used in such a way as to show relief of land rather than textural or lithological differences. That the relief of land (situation of a soil) is a factor of importance has been strikingly exemplified by the results obtained from the soil survey of the Rotorua district which is being carried out by the Department of Agriculture. (See *N.Z. Journal of Agriculture*, vol. 34, No. 5, pp. 289–94, 1927.) Textural and lithologic differences, however, are shown by using differently coloured drawing-inks, and notes are added where exceptional pedological features, such as swampy or arid or salty patches, claim attention. The completed map, together with its descriptive explanation, will form a graphic inventory of the soil resources of the district and can be made the basis for more detailed research work.

Some Consequences of Irrigation.

In all countries where land is brought under irrigation certain deleterious effects, the incidence of which depends upon a variety of circumstances, sooner or later appear. Since this survey was undertaken partly on account of adverse criticism of Central Otago irrigation projects, a few remarks may be made upon some of the visible consequences of irrigation in that region.

Salty Patches.—The most harmful consequence of irrigation in a dry climate is the accumulation of salts in the soil. This effect is most marked in countries where the irrigation-water contains appreciable quantities of salts in solution. In Central Otago the irrigation-water is remarkably pure; salty patches are of small extent, and are more noticeable in unirrigated land than on land under irrigation. The salty patches contain mixtures of the sulphates, chlorides, and carbonates of sodium, potassium, calcium, and magnesium in varying amounts. These salts are derived from the schist rocks that form the mountain-ranges, and are present in the younger sedimentary beds that form the floors of the Central Otago depressions. They tend to accumulate on the surface of the land, but, since these accumulations are transient, the present small rainfall is evidently sufficient to cause their removal.

On unirrigated land, when the present natural water-supply, due to a 15 in. to 20 in. rainfall, is augmented by irrigation water, these salty patches will probably disappear. Conversely, on land under irrigation salty patches may persist on the banks of water-races where seepage and evaporation bring forward saline matter as fast as it is washed away, but on cultivated fields salty patches are either absent or show a tendency to migrate down the slopes as irrigation-water is supplied from above.

On farms where irrigation has been practised for a number of years salty patches are scarce, whilst, on the other hand, where irrigation has been introduced recently incrustations of water-soluble salts are conspicuous. This would indicate that the first effect of irrigation in Central Otago is to bring to the surface the soluble salts naturally present in the soil, and the ultimate effect is their removal. If under present methods of irrigation saline patches should continue to give trouble they could be removed by increasing the amount of water and by attending to the drainage. Heavy applications of water in cool weather would certainly have a beneficial effect in washing the excess of soluble salts out of the soil. The Dip Creek sections near Alexandra, recently supplied with irrigation-water, should be periodically inspected in order to determine what will eventually happen to the saline matter now accumulating there.

Salts in the soil in apparently excessive quantities are not altogether harmful, because, as is well known, animals require mineral matter with their diet, and sheep grazed on salty land are reported to fatten better than they do on irrigated land carrying a heavy stand of fodder.

Bare Patches,—The presence of bare or almost bare patches of land surrounded by healthy crops is due to several causes. When the soils and subsoils are excessively porous a too free movement of water renders the land too dry to support crops, and, contrariwise, where the soils and subsoils are impervious small salinas occur. The aspect of the land also has its influence on soil moisture, hill-slopes facing north-east in Manuherikia Valley and facing north-west on Maniototo Plain being generally rather bare. Irrigation readily obliterates most of these bare patches.

Some bare patches are due to the soil being too hard and too dry to allow grass-seed to germinate and take root, or the young grasses may be asphyxiated owing to the plants being unable to abstract sufficient moisture from the slightly saline soil-water. Here cultivation is the remedy.

Waterlogging.—In places where the soils and subsoils are excessively porous the land is readily saturated by seepage-water coming down from higher ground. The soil in such areas, although not permanently waterlogged, is rendered less productive. In Ida Valley there are a few small bare patches due to this cause, and some orchards in the Molyneux Valley suffer in the same way. Cultivation and perhaps the provision of catch-drains, will provide a partial remedy.

In certain areas where the supply of irrigation-water is liberal there is a strong growth of rushes. This growth is said to be beneficial in that it provides shelter for sheep and makes small quantities of food available when the countryside is snow-covered. Land at lower levels, however, becomes waterlogged and sour, and thus deteriorates in value. There need be no difficulty in adjusting the water-supply to prevent this.

In parts of Ida Valley not supplied with irrigation-water drains have been dug to prevent waterlogging, but in one or two cases these drains have become obstructed and do not function. In contrast to this, in the same localities there are some unirrigated crops that are grown on soils that obtain their moisture by capillary action from the ground-water close beneath. Drains excavated in these areas will lower the water-table and decrease the productivity of strips of land parallel to them. Over large areas care should be taken not to disturb the nice adjustment between upward movement of subsoil water and transpiration of the growing crops.

Uses of a Soil Survey.

A soil survey of a country is a stocktaking of its soil resources with a view to utilizing them to their fullest extent. This is demanded by the natural increase of population. (*Cf.* A. D. Hall, Rep. Brit. Assoc. Adv. Sci., pp. 255–66; 1926.) The resulting soil map seeks to portray various classes of land differentiated according to origin, texture, situation, water-supply, quality, or some other factor that may have a preponderating influence on production. The map thus provides the foundation upon which can be based the future development of the country—that is to say, increased production to meet the needs of increasing population.

Increased production can be brought about in several ways—for instance, by removing unfavourable conditions, such as scarcity or superabundance of water, by substituting good pastures (and breeds of stock) for poor ones, and by supplying mineral deficiencies in the soil. The last method involves the intelligent and economical use of fertilizers both as regards nature of fertilizer and quantity used.

A soil survey is, therefore, not a final investigation, but rather a means of determining the position and extent of soil-types. When these are delineated their cultural value is soon found, and measures can then be taken to increase their productivity in the most economical way.

3. ST. BATHAN'S SUBDIVISION.

(By H. T. Ferrar.)

In conjunction with the soil survey a geological survey of the flat country covered by the Public Works Department's irrigation projects in Central Otago and of adjoining hilly districts was undertaken. The area being geologically examined has not yet been definitely demarcated, but has provisionally been called the St. Bathan's Subdivision. The Alexandra Subdivision (N.Z. Geol. Surv. Bulletin No. 2) adjoins it to the south and west.

Mr. N. H. Taylor, of Auckland University College, who assisted in carrying out the geological mapping of the country adjoining the irrigation areas, covered an area of 306 square miles. In the course of soil-survey work I was able to map the geology of an additional area of 554 square miles, making a total area of 860 square miles. Field-maps of the following survey districts have been completed: St. Bathan's, Lauder, Blackstone, Idaburn, Naseby, Gimmerburn, Maniototo, Upper Taieriside, and Upper Taieri.

Physiography.

The country examined includes parts of the following fault-block mountains—namely, Hawkdun Range, Mount St. Bathan's, Dunstan Range, Blackstone Hill, Rough Ridge, and Rock and Pillar Range, described in some detail by C. A. Cotton ten years ago (" Block Mountains in New Zealand," Amer. Jour. Sci., vol. 44, pp. 249–93; 1917); and three intermontane depressions—the Manuherikia Valley (upper part), Ida Valley (upper part), and Maniototo Plain. The depressions lie at an altitude of 1,000 ft. to 1,500 ft. above sea-level, and the even crests of the block mountains are 4,000 ft. to 5,000 ft. higher.

The chief streams of the district are the Manuherikia and the Taieri. The former drains Manuherikia Valley, Ida Valley, and a small part of Maniototo Plain; the latter drains the remainder of the plain. The numerous consequent streams draining the block mountains flow in narrow but not very deep valleys. Many of these on reaching the intermontane depressions lose themselves in detritus fans of their own making. The larger of them, however, coalesce, meander down broad flood-plains between terraces, and unite with the main streams in the lower parts of the depressions. At Linnburn Bridge the Taieri River emerges from a gorge, meanders first northward, then eastward over a swampy flood-plain to the now insilted Taieri Lake, then makes its way southward into another gorge, and so out of the subdivision. That part which flows through the south-east portion of the subdivision receives a great number of tributaries from all points of the compass.

General Geology.

Previous geological work in this part of the Dominion has been carried out mainly by J. Hector, F. W. Hutton, A. McKay, and J. Park. The district included in the St. Bathan's Subdivision is wholly within the area described in McKay's " Report on the Older Auriferous Drifts of Central Otago," published in 1894 (2nd edition, 1897). This report, with its small-scale map, has been of great assistance. The following tentative table shows the geological column as developed within the area under consideration:—

Approximate Age.	Composition and estimated Thickness.	Name.
Quaternary	Swamp, alluvial and æolian deposits; gravel, detritus fans, moraines; basalt flows and dykes.	
	(Erosion interval.)	
Lower Pliocene or Upper Miocene	Greywacke conglomerates (" Maori bottom " or " sandstone gravels "), 1,000 ft.	
	Soft sandstones and quartz-grits, 500 ft.	St. Bathan's beds.
	Green shaly clays (" paper shales "), fossiliferous, 250 ft. Local lignite deposits (up to 30 ft.)	St. Bathan's beds.
	Quartz-grits and fine quartz conglomerates, silicified in places, 500 ft.	St. Bathan's beds.
	(Unconformity.)	
Lower Miocene (Awamoan)	Fossiliferous glauconitic greensands, 100 ft.	Naseby beds.
	(Unconformity.)	
Oligocene (?)	Green and red schist conglomerates, white-quartz conglomerates, 900 ft.	Kyeburn conglomerate.
	(Great Unconformity.)	
Middle or Lower Palæozoic	Greywackes, grits, sandstones, argillites, phyllites, 5,000 ft. or more	Kakanui Formation.
	Foliated mica, quartz and chlorite schists, 10,000 ft. or more	Maniototo Formation.

The Maniototo and Kakanui schists, phyllites, and greywackes form the fault-block mountains. The schists, a series of highly metamorphosed sediments, have been described in detail by J. Park in N.Z. Geol. Surv. Bulletin No. 2, and need no further mention here. The phyllites mark an intermediate stage of metamorphism between the unaltered greywackes and the schists. The detailed mapping shows that a mile-wide belt of phyllites separates the schists proper from definite greywackes, and that the greywackes and underlying sediments have been progressively metamorphosed as stated by P. Marshall in N.Z. Geol. Surv. Bulletin No. 19. Apart from this metamorphosis, no other evidence as to the age of these rocks has been found in the subdivision.

The Kyeburn conglomerate is an indurated schistose conglomerate of a red or green colour covering a belt of country extending eastward from the head of the Hogburn into Kyeburn Survey District. It is a fluvial deposit which dips southward at high angles beneath the Naseby marine beds and is overlapped by them. On the southern slopes of Mount Buster the conglomerate becomes quartzose, and resembles the St. Bathan's quartz-grits.

The Naseby beds are marine glauconitic greensands which occur in patches (inliers) in Coalpit Gully, Naseby; near the head of the Hogburn; and at Coalpit Gully, Kyeburn Diggings. Fossils are abundant in the feed-water channel from Mount Ida Water-race to the Government dam, Naseby; in the mouth of Coalpit Gully (near Kyeburn Diggings); and farther to the east on the right bank of the Kyeburn, near the footbridge. Fossils were also collected by Hector in 1890 from the deep prospecting-shaft at Naseby (now covered by tailings).

These marine beds are of Lower Miocene (Awamoan) age, and were deposited on the surface of the palæozoic rocks at Quartz-reef Hill, Naseby, but have not been seen west of this point. In Miocene times, therefore, the sea had access to what is now the eastern half of Maniototo Plain.

The St. Bathan's beds (Morgan, N.Z. Jour. Sci. & Tech., vol. 3, p. 29; 1920) are a conformable series of deposits due to a complete cycle of erosion, depression and deposition, elevation and erosion. The lowest beds are quartz-grits or fine conglomerates, with which are associated carbonaceous bands or seams of lignite. They are followed by green shaly clays, the paper-shales, which contain fish-remains and impressions of a fresh-water mussel (*Diplodon* sp.). These clays are therefore truly lacustrine. They pass upward into sands and gravels, which, gradually turning coarser, become the fluvial greywacke conglomerate or Maori bottom.* Quartz-grits occur at several horizons. In places the St. Bathan's quartz-grits contain cobbles of water-worn silicified quartz-grit derived from some older deposit, and in places the greywacke conglomerates become quartzose and resemble the quartz-grits proper.

The St. Bathan's beds cover the floors of the intermontane basins, and remnants of silicified quartz-grit (wether stones) litter the surfaces of the fault-block mountains. They thus formerly had a far greater extension than they now have. Their age is Upper Miocene or Lower Pliocene.

Quaternary Deposits.—Small quantities of morainic material occur along the east side of the Dunstan Range, but elsewhere signs of glacial action are absent. Gravel terraces are usually arranged in flights and carry the geological history forward to Pleistocene and Recent times. About the year 1861 moa-bones in an excellent state of preservation were found in abundance at Puketoi, on the east side of Rough Ridge, and bones are still occasionally found embedded in the soil there and elsewhere. As the bones disappeared rapidly after the arrival of European settlers, it is reasonable to suppose that the moa survived until two or three centuries ago. (*Cf.* W. D. Murison, Trans. N.Z. Inst., vol. 4, pp. 120–24; 1872.)

Igneous Rocks.—Basalt flows and dykes of Pleistocene and Recent age occur in the neighbourhood of Waipiata and Gimmerburn, and two small dykes were located in the Upper Manuherikia valley.

Economic Geology.

Soils.—The soils of the subdivision will be discussed at some length in the detailed report on the soil survey of Central Otago that will be written next year.

Limestone and Greensand.—Except for small quantities of calcareous travertine and a bed or two of marl, agricultural limestone is wanting, but beds of calcareous greensand containing potassium and phosphorus occur at Naseby and at Kyeburn Diggings.

Gold.—For a number of years gold-mining was the chief industry in Central Otago, and it still occupies a few men. In the St. Bathan's Subdivision reef-mining is being spasmodically prosecuted at the old Great Eastern Mine on Rough Ridge, near Oturehua Railway-station. The work done has been of an exploratory nature along a shatter-belt in the mica schists. When visited, the mine was full of water. Since, in the mining sense, the schists are not mineralized, and there are no definite lodes, it is unlikely that a rich find will be made here.

All the known alluvial goldfields within the subdivision were inspected during the past season. These are described in McKay's report, but most of them, though not worked out, are now moribund.

Alluvial gold is unevenly distributed throughout all the fluviatile beds from the Kyeburn conglomerate upwards. The Kyeburn conglomerate or "red bottom" is being sluiced at the head of One-speck Gully, Naseby. The basal white St. Bathan's quartz-grits are locally rich in alluvial gold, and are still being worked at Cambrian (Welshman's Gully), St. Bathan's, and Linnburn, while at Tinker's and Naseby only the weathered portions seem to have been worth sluicing, and are now neglected. The greywacke conglomerate and younger gravels are being sluiced at Cambrian and Naseby, and a dredge to work them is being built four miles to the north-east of Naseby in a tributary of the Little Kyeburn. At Drybread, Kyeburn Diggings, and Patearoa (Sowburn Diggings) beds of the same age as the greywacke conglomerate are being sluiced.

Building-materials.—Unlimited quantities of schist are available for constructional work. This rock readily splits into easily dressed slabs of convenient sizes. The schist is resistant to weathering, and thus forms a valuable stone which is used extensively for building houses and bridge-piers. Thin slabs of schist are sometimes used as roofing-slates. The Waipiata basalt is a durable building-stone, but the Tertiary sandstones disintegrate too readily to be of any value.

* This is not included in the St. Bathan's beds.

Sun-dried bricks made from the clayey soils resist the weather well, especially if shielded from rain. Houses built of these bricks—and there are many such—are eminently suited to temper the vicissitudes of the Central Otago climate.

There is no native timber in the subdivision, but the State pine-plantations near Naseby will meet this deficiency to some extent.

Roadmaking Materials.—An abundant supply of good roadmaking material is obtainable from the outcrops of gravel on the edges of nearly every terrace. Quartz-grits, river-shingle, and tailings are also employed for road-surfacing. In the Ranfurly district basalt is also used.

Lignite.—The small patches of lignite that are found at several places are of value to the settlers for household purposes. The lignite-seams are 15 ft. to 20 ft. thick or more, and pits are kept open at Cambrian, Pegleg, Oturehua, Idaburn, and near the head of the Ida Burn. In addition settlers obtain lignite from small outcrops elsewhere.

Oil-shale.—Oil-shale of fair quality was discovered at Cambrian in 1896 by Osmond Hughes, but the bed was not seen by the present survey. Another bed of poor oil-shale occurs in the Idaburn lignite-pits. These shales may be of value in the future.

Clays and Sands.—Occasional patches of decomposed schist yield a white clay that has good plastic properties and does not crack when air-dried. Coloured clays, in places containing numerous rosettes of gypsum, are abundantly associated with the lignite-beds.

Deposits of white quartz sand occur at several places, some of which are suitable for glassmaking; others might be used as moulding-sands.

4. WAIROA SUBDIVISION.

(By M. Ongley.)

Wairoa Subdivision lies on the east coast of the North Island of New Zealand, between Gisborne and Napier, and during the field season, from November, 1926, to May, 1927, 200 square miles of it was examined, including the survey districts of Nuhaka North, Paritu, Mahanga, and Mahia. This area embraces part of the Raukumara Division, Gisborne Land District, and part of the Napier Division, Hawke's Bay Land District. It adjoins along its northern boundary the Gisborne Subdivision described in N.Z. Geological Survey Bulletin No. 21. On the east it faces the ocean and on the south Hawke Bay; at the south-east corner is Mahia Peninsula, joined to the mainland by an isthmus three miles long, formed of sand-dunes. The subdivision consists of dissected uplands 2,000 ft. high in the north-west and 1,000 ft. in the south-east, lying between the Huiarau Range in the west and the east coast, drained by the Te Arai and Maraehara rivers, flowing north, and the Kopuawhara, Nuhaka, and Wairoa, flowing south. The chief town, Wairoa, on the Wairoa River, is much the largest centre of population between Gisborne and Napier.

The rocks of the subdivision are nearly all Upper Tertiary sediments, mainly sandstones, some of which are tuffaceous, mudstones, and limestones. A few small areas are covered by Cretaceous strata. The Tertiary rocks are folded in wide regular folds; one anticline, the Morere, trends north-east across the subdivision from Nuhaka, on Hawke Bay, to Paritu, on the east coast, and another, the Mangapahi, trends north across the west of Nuhaka North Survey District from Tahaenui Stream to the head of the Mangapoike.

Topography.

Although the subdivision forms part of the east coast of the North Island, the streams do not flow east to the sea, but in the greater part of their courses flow north or south. In the middle of Nuhaka North Survey District the Te Arai flows north into Patutahi Survey District, and, joining the Waipaoa, empties into Poverty Bay. The Maraehara also flows north into Turanganui Survey District, and turns east through a gap in the coast hills into the sea. Rising on the south side of the divide at the head of the Maraehara, the Waiau flows south into Mahanga Survey District, where it is called Kopuawhara Stream. It is turned south-east by the dunes forming Mahia Isthmus, into the shallow tidal lagoon that escapes into the sea at Horaka, north of Mahia Peninsula. Rising a mile south of the head of the Te Arai, Nuhaka River flows south-south-west and south through Nuhaka North and Nuhaka survey districts into the north-east corner of Hawke Bay. In the north-west of the area examined the Mangapoike rises near the head of Te Arai Stream, and, flowing west into Opoiti Survey District beyond the district examined, joins the Wairoa River.

Between the streams flowing north and those flowing south is the divide extending inland from Whareongaonga, where it is 600 ft. high, south-west for three miles to Whareata (1,500 ft. above sea-level), west for a mile to the road-junction (1,700 ft.), north for a mile to Trig. Station 236 (1,906 ft.), north-north-west for two and a half miles to Trig. Station 78 (2,365 ft.), south-west a mile to the inland road (2,000 ft.), north-north-west four miles along the ridge by the road (1,500 ft.), west three miles to Paparitu Trig. Station (2,230 ft.), north four miles to Trig. Station B in Patutahi Survey District (1,989 ft.), west two miles to Parikanapa (2,301 ft.), and north for ten miles to the hills west of Ngatapa.

Depending largely on the topography is the selection of the railway-route between Gisborne and Wairoa. The watershed at Ngatapa was found impassable when the attempt was made to build the line there in 1915. The divide must be crossed between Ngatapa and the coast, or it can be skirted round at the coast. Possible routes run up a river, through the divide, and down the adjacent river. The Maraehara and Kopuawhara valleys, a mile inland, and the Te Arai and Nuhaka valleys, seven miles inland, are in line and could be used; but neither route would be easy. A simpler route follows the Te Arai and Mangapoike valleys, but involves a long tunnel, and the coast route is considered preferable.

The surface of Mahia Peninsula shows a series of wave-cut terraces or benches ranging from a few feet above sea-level to 600 ft. The top of the peninsula, roughly 1,200 ft. to 1,300 ft. in height, also appears to be a wave-planed surface. The very gentle slopes of the various benches may be almost wholly original, in which case there has been practically uniform uplift, or may be due to tilting during uplift. The benches end seaward in almost vertical cliffs, 260 ft. in height or more. At the base of the cliffs is a continuous rock bench, bare at low tide, which in favourable situations extends a quarter of a mile seaward.

General Geology.

The subdivision is covered with Upper Tertiary marine sandstones and mudstones 20,000 ft. thick, with three small areas of Cretaceous rocks exposed through them. The beds found are shown in the following table :—

Series or Beds.	Nature.	Thickness.	Approximate Age or Stage.
	Fluviatile and beach deposits ; dunes ; sand and shingle of raised beaches, &c.	..	Pleistocene and Recent.
	(Unconformity.)		
Petane beds ..	Massive mudstone	1,000 ft.	Nukumaruian (Pliocene).
Ormond beds ..	Limestone ; conglomerate	200 ft.	Waitotaran (Lower Pliocene).
	(Erosion interval.)		
Otunua beds ..	Massive mudstone with large concretions ..	4,000 ft.	"Taranakian" (Upper Miocene).
Mapiri beds ..	Thick tuffaceous sandstone ; mudstone ..	5,000 ft.	
Morere beds ..	Mudstone ; sandstone	700 ft.	
Tutamoe Series	Mudstone ; sandstone with concretions ; conglomerate	7,000 ft.	Awamoan (Miocene).
	(Erosion interval.)		
Ihungia Series..	Mudstone ; sandstone with concretions ..	3,500 ft.	Hutchinsonian (Miocene).
	(Unconformity.)		
Mangatu Series	Argillaceous limestone ; sandstone ; mudstone ..	1,500 ft.	Waiparan (Cretaceous).

Mangatu Series.—The east coast of Mahia Peninsula at four to five miles south of Table Cape and at one to two miles from the south end is formed of light-coloured mudstone, argillaceous limestone, and green-sandstone moved, slickensided, shattered, and brecciated. Similar rocks, not so broken, occupy the Kopuawhara Valley for a mile in the north of Mahanga Survey District, and there in the gas and brine springs three-quarters of a mile to the north and half a mile to the south of the Cretaceous area occur pieces of similar rocks and fragments of *Inoceramus* up to 2 in. long by ½ in. thick. The only other fossil seen was the "Amuri fucoid." The Cretaceous beds appear to be 1,500 ft. thick, and cover altogether less than two square miles. Their presence, however, indicates that they probably underlie the Tertiary rocks round about. Associated with them at all outcrops are gas and brine springs ; and in the southern outcrop on Mahia Peninsula the rocks smell of oil.

Ihungia Series.—As the lowest Tertiary bed with recognizable fossils is a conglomerate containing the same fossils as the conglomerate at the base of the Tutamoe Series in Muddy Creek, Tutamoe Survey District, the beds below are regarded as belonging to the Ihungia Series. They, are, however, quite different from the Ihungia rocks of the type locality ; they contain no igneous conglomerate and no massive mudstone, but consist of coarse concretionary sandstone and thin layers of mudstone darkened with carbonaceous films. Much of the material is comminuted shell, and many of the mudstone layers are eroded to form lenses of edgewise conglomerate. The sandstone beds are up to 20 ft. thick and contain numerous concretions up to 6 ft. long, in many places forming the greater part of the bed. Though the base of the series was not seen, the beds observed are 3,500 ft. thick. They are exposed on the coast of Paritu Survey District for two miles in the core of the anticline between the two outcrops of Tutamoe conglomerate, and extend south-westward along the fold. These rocks cannot be lithologically distinguished from the overlying strata, and fossils have not been found in them ; but they were eroded and yielded pebbles to the overlying conglomerate, and so evidently belong to an older set of beds.

Tutamoe Series.—Overlying the conglomerate with the Tutamoe fossils is a set of thick beds of coarse concretionary sandstone with thin intervening beds of mudstone and rare bands of conglomerate, altogether 7,000 ft. thick. The rocks cannot be distinguished from those below except by their position above the conglomerate ; and the several bands of conglomerate are alike both in the pebbles and in the fossils. The sandstone beds are commonly 6 ft. thick, and may be 30 ft. thick ; the mudstone beds are generally less than 1 ft. thick. In many places the sandstone is marked with worm or gastropod trails, and the mudstone is streaked with carbonaceous films. The beds of conglomerate are usually less than 6 ft. thick, and contain chiefly well-worn pebbles of greywacke less than 1 in. long, with many broken shells, set in a mudstone matrix. Rarely greywacke pebbles 6 in. in diameter and pebbles of white mudstone 4 in. in diameter occur. Generally the upper part of the conglomerate is coarser, and consists not of fine greywacke pebbles but of 6 in. pebbles of dark mudstone and sandstone from the underlying beds. In the conglomerate on the east side of Onepoto Bay, Mahanga Survey District, two exceptionally big boulders of light mudstone are 6 ft. long and 3 ft. wide.

Morere Beds.—The sandstone beds of the Tutamoe Series become more argillaceous towards the top, and grade up into massive mudstone, which crops out typically west of Morere, in Nuhaka North Survey District, and on the east of Paritu Survey District, two to three miles south of Mapiri Point, where it is 600 ft. thick. The same bed can be followed inland from the coast, curving round the north of the Morere anticline to the Te Arai River and into the head of the Mangapoike. On the south side the same bed appears in the north-west of Mahia Peninsula, where it is much lighter-coloured. It also forms part of the north and east coasts of Mahia, the south part of Mahia, and apparently Portland Island as well. In this mudstone occurs a 6 in. to 1 ft. bed of dark crystal tuff, and in the upper part it grades into alternating thin beds of sandstone and mudstone 100 ft. thick.

Mapiri Beds.—The Morere beds continue up to a strong bed of white pumiceous sandstone, Generally the lowest 6 in. of this bed is darker and crystalline, formed of quartz, feldspar, and mica. and grades up through grey into fine white sandstone. It is 6 ft. thick at Mapiri. This pumiceous-sandstone band forms strong dip-slopes, and can be followed inland from Mapiri across the main road and the Maraehara River and up the ridge to the west, forming dip-slopes that trend north-west and north into Turanganui Survey District. Here the outcrop runs round the north of the Morere anticline and turns south-west again into Nuhaka North Survey District. It extends along the west side of Te Arai Valley, and into the Mangapoike watershed. With the beds of pumiceous sandstone occur massive beds of bluish-grey mudstone. North of Mapiri these beds are 3,500 ft. thick; and in the south of Mahia Peninsula, 5,000 ft. thick.

Otunua Beds.—Above the pumiceous bands in the west of Mahia Peninsula, and well exposed in the Turanganui and Otunua streams, occurs mudstone similar to that of the Mapiri beds, but free from pumiceous layers. On Mahia Peninsula it is 4,000 ft. thick, and has been eroded at the top.

Ormond Beds.—Resting on the pumiceous-sandstone beds, and containing boulders of them with a conglomerate 15 ft. thick at its base, is the limestone cap of Moumoukai Hill, 120 ft. thick. On the west side of Mahia Peninsula the same bed, resting on an eroded surface of Otunua mudstone, forms Long Point and Black Reef, and has a conglomerate at the base. There it is 200 ft. thick.

Petane Beds.—On the west-south-west part of Mahia Peninsula, above the limestone at the mouth of Mangatea Stream, is 1,000 ft. of fossiliferous Petane mudstone.

Pleistocene and Recent.—Mahia Isthmus, three miles long and two wide, consists of sand flats and dunes. Sand-beaches form the coast for three miles east of the mouth of the Nuhaka River and for three miles south of the northern boundary of the subdivision. Short boulder-beaches occur at Onepoto Bay, Waikokopu, Opoutama, Takararoa, Tikiwhata, Waikara, Whareongaonga, and south of Mapiri. A shell-beach extends along the north coast of Mahia Peninsula from three miles to four miles and a half west of the Whangawehi Stream. Signal Hill, in the north-west of Mahia, is surrounded by sand-flats a quarter of a mile wide, 20 ft. above sea-level, joining it to the mainland. McKay mentioned that on the north shore of Mahia Peninsula there is a low raised beach 5 ft. to 7 ft. above present high-water mark, and that on the terraced flat lands of the peninsula there are shingle beds, evidently an old beach, at a height of 200 ft. to 300 ft. (Rep. Geol. Explor. during 1886–87, No. 18, pp. 108–9; 1887.)

The Cretaceous Mangatu rocks of the subdivision have been tightly folded, overturned, and crushed; and in the small areas exposed the attitudes of the beds are difficult to interpret. On the east side of Mahia Peninsula they crop out in a semicircle with an overturned fold in the centre, both limbs of which dip south 80°. An anticline extends north-west from the coast across Taiporutu Stream, trending towards the gas-emanations one mile inland. Both limbs are steep, one dipping north 60°, the other south 80°. In the south part of Mahia Peninsula, too, the beds are steep, and a short steep anticline trends north-north-east, dipping 60° to the west and 70° to the east. In Kopuawhara Stream, in Mahanga Survey District, the Mangatu beds strike north, and dip east 40° to 70°.

The Tertiary rocks are gently folded. The Moumoukai syncline, extending north across the subdivision from the coast west of the mouth of Nuhaka River, through Moumoukai Hill, to Te Arai Stream, separates two large anticlines. One, the Morere anticline, trends north-east from the Nuhaka River, past Morere, to the coast of Paritu Survey District, three-quarters of a mile north of Paritu Stream. It has on its north flank a large bulge extending across Nuhaka North Survey District into Patutahi Survey District, east of Te Arai Stream, and a smaller one extending three miles north in Paritu Survey District. This fold covers more than a hundred square miles. West of the Moumoukai syncline another big anticline, the Mangapahi anticline, trends north for ten miles across the west part of Nuhaka North Survey District from the southern boundary to Mangapoike Stream near the northern.

Within the area examined faults are of minor importance in determining the structure as compared with folding; but the folds are modified by faults. The folded Cretaceous rocks on the east side of Mahia Peninsula run against a fault trending north that lets up gas and salt water in three sets of springs. The Morere anticline is cut by several parallel faults near Kopuawhara Stream, close to the boundary between Mahanga and Nuhaka North survey districts, on which occur many gas-emanations. These faults trend south-south-west into Opoutama Stream, and there, too, allow salt water and gas to escape in groups of springs.

Another strong fault trends west-north-west from the coast at Waikara, in Paritu Survey District, across the south of Nuhaka North Survey District, and has been observed as far as Mangapoike Stream.

Small faults break the rocks almost every chain, and are well exposed on the wave-cut platforms of the shore-line, especially on the east coast of Mahia Peninsula.

Economic Geology.

Oil and Gas.—This subdivision being part of the much larger area of the east coast of the North Island in which oil-indications are known, naturally attracts attention as a prospective oilfield. The area examined during the past season contains two big anticlines affording favourable places for oil to accumulate in, and from fractures in these structures hydrocarbon gases are escaping. The underlying Cretaceous rocks exposed in the east part of Mahia Peninsula smell strongly of oil; and similar Cretaceous rocks were found exposed by faults crossing the Morere anticline, so that evidently they underlie this field.

Gas-springs were mapped in several places. In the east part of Mahia are three groups; in Mahanga Survey District, six groups; in Nuhaka North Survey District, two groups. The occurrence of these close to Cretaceous rocks or on faults along which fragments of Cretaceous rocks have been brought up indicates that the gas has its source in the Cretaceous. A gas-spring in Mangapoike Stream and three sets of emanations in the south part of Mahanga Survey District do not, however, show connection with the Cretaceous.

In the Morere anticline hot saline water escapes at Morere Spa at a temperature of 49° C. (120° F.). The water contains 1,899·60 grains of solids to the gallon, or 2·714 per cent.—mainly sodium chloride. The circulation of this water in the anticline and its relation to the gas and the oil-sands are not known. The investigation of these points will be important.

Stone.—As large blocks of hard stone are required for harbour-works on the east coast of the North Island, the location of suitable stone is desirable. During the past season many thick beds of sandstone were observed along the coast and inland, but none both easy of access and handy for water transport. No first-class sandstone was seen. Beds of brown sandstone 10 ft. to 20 ft. thick occur in many places on the coasts of Mahanga and Paritu survey districts, but no sheltered working-place was seen. The most promising place for working appears to be at Onepoto Bay, on the south coast of Mahanga Survey District. Large concretions, up to 6 ft. long, form the hardest parts of these rocks, and as the softer material is worn away the concretions form the boulder-beaches previously mentioned. At Waikokopu they are being used to support the piles of the wharf.

On the east and north sides of Mahia Peninsula and in Paritu Survey District thick beds of white pumiceous sandstone crop out on the coast. This sandstone is described by Hector* as sufficiently indurated to form a good building-stone, and in its colour and fineness of grain not second to any building-stone in the country.

Limestone 100 ft. to 200 ft. thick forms the west coast of Mahia Peninsula from Black Reef to Long Point, and is shedding large blocks into the sea. Suitable stone for harbour-works can be procured there. The same bed of limestone, 100 ft. thick, forms the flat top of Moumoukai Hill, in Nuhaka North Survey District, where it covers over half a square mile, and is being quarried and crushed for road-metal. It could be ground for use as agricultural limestone, or, along with the abundant mudstone which underlies it, could be used to make cement; but there is as yet no local demand of importance for either of these products.

Sand.—On the Mahia Isthmus is a huge deposit of nearly white quartzose sand suitable for the surfacing of bitumen roads. The beach on the north side of Mahia Peninsula from three miles to four miles and a half west of the mouth of Whangawehi Stream is formed of broken shell ready to be used as agricultural limestone.

5. ROTORUA DISTRICT.

(By L. I. Grange.)

Introduction.

In November, 1926, a start was made on the geological survey of the active volcanic belt of the North Island of New Zealand, extending from Ruapehu north-east to Taupo, Rotorua, and White Island, in the Bay of Plenty. By May, 1927, about 500 square miles of the Rotorua district had been examined. A visit was made to White Island at the end of March. The survey of the district has been undertaken (1) as part of the areal geological survey of the Dominion, and (2) to ascertain where it will be advisable to set up an observatory to make continuous observations of the volcanoes and hot springs in order to forecast volcanic eruptions. The results already obtained indicate some of the exact and continuous work that should be undertaken.

General Geology.

Apart from lacustrine and fluviatile deposits of minor importance, the rocks of the Rotorua district are all volcanic, and consist of rhyolitic and andesitic tuffs and flows, ranging in age from late Tertiary to Recent. The spherulitic rhyolites and rhyolitic tuffs that form the higher country appear to be the oldest of these rocks. Spherulitic rhyolite forms Ngongotaha (2,554 ft.), Moerangi (2,440 ft.), Whakapoungakau (2,524 ft.), and the lower part of the Paeroa Range. Rhyolitic tuffs are well developed on Mamaku Plateau, on the Paeroa Range, and in the hilly country east of Lake Rotorua. Though well consolidated, they are so porous that rain-water quickly soaks in, and much of the drainage is underground.

Faulting movements that commenced near the close of the Tertiary and continued to the Recent have tilted, broken, and warped the land-surface. The earliest faults, which are the strongest, mostly strike north-east and east-north-east, and flank wide depressions. The Rotorua–Atiamuri Road lies in a downfaulted area between Paeroa Range and Horahora Cliffs; the Kaingaroa Plains are bounded on the east and west by strong faults. At this time Mamaku Plateau was gently warped. It rises gradually from Rotorua (915 ft.) to Mamaku (1,884 ft.) and falls gently towards Putaruru. Faults striking east and west along the southern shores of the lakes, Rotoiti, Rotoehu, and Rotoma, have a total downthrow to the north of more than 1,000 ft. Rotorua, the largest lake of the district, owes its origin mainly to faulting. Recent faults showing excellent scarps are found near the Rotorua–Waiotapu Road. Their throws range from a foot or so to about 75 ft., and their general direction is parallel to that of the main faults in this locality. Conical holes occur at the foot of several of the scarps. Some of the faults, where they cross dry valley-floors, show small steps of less height than the throw seen along other parts of the faults, thus indicating renewed movement along the same planes. Tarawera-Rotomahana Chasm, formed in 1886, is a series of explosion craters, in places separated by narrow bridges, 9½ miles long. It trends east-north-east, following the strike of some of the faults near it, but no displacement can be detected.

While these earth-movements were taking place, there were many eruptions, most of an explosive nature, but in some lavas were emitted. Probably the first were those that built up Maungaongaonga (2,764 ft.) and Maungakakaramea (2,494 ft.), north of Waiotapu, which are formed of dacite or acid andesite. Deposits of little consolidated rhyolitic tuff and agglomerate, more than 500 ft. thick, and containing many fragments of andesite, underlie the Kaingaroa

* Rep. Geol. Explor. during 1886–87, No. 18, p. xxxviii; 1887.

Plains east of Waiotapu. This material probably diverted the Waikato River from its northerly course to the Bay of Plenty to a westerly course through the Atiamuri Gorge. The next series of eruptions built up the vesicular hornblende rhyolite mountains of Tarawera and Haparangi. Smaller eruptions of this rock formed conical hills similar to those near Mount Egmont in Taranaki.

Succeeding outbreaks have been on a somewhat smaller scale, and only fragmentary material was emitted. The tuffs follow roughly the present contour of the land, and are therefore clearly of Recent age. The earliest of the Recent eruptions were the rhyolitic pumice showers, of which as many as seven can be counted in some sections. In general they average about 4 ft. in thickness, the coarse material of the bottom layers being about 9 in. thick. The fine material has weathered to a brown loam. Most of the showers have come from the Rotorua district; on the western and southern edges there is an overlapping of ash from the Taupo district. Explosion craters now occupied by lakes are the source of some of the showers, a good example being Tikitapu, which was probably the origin of the oldest of the Recent tuffs that occur around Rotorua Township. Preceding the youngest shower of pumice were eruptions of andesitic ash from the explosion craters of Rotokawau and Rotoatua, south of Rotoiti. These were the forerunners of the Tarawera eruption of 1886. On the night of the 10th June of that year ten craters extending the length of Tarawera Mountain were formed, from which a great quantity of andesitic ash similar to that from Rotokawau was blown. A few hours later fourteen vents, prolonging the line of the craters on Tarawera, opened in Rotomahana and at several other points (Fairy, Black, Inferno, Echo, and Southern craters). These, however, with the exception of one crater, probably Echo Crater*, which ejected some andesitic material, erupted only the shattered surface rock—thermally altered rhyolitic tuffs and lavas. After about five hours the violence of the outburst lessened considerably, but for two months there were small shots and much steam from the craters. Black Terrace Crater broke out early in August. Small outbreaks—Waimangu in January, 1900, and Frying-pan Flat in April, 1917—on this chasm indicate that this part is yet to be regarded as a menace.

Hot Springs.

The Rotorua district contains a great number of hot springs. They may be divided into five groups—Whakarewarewa-Ohinemutu, Tikitere, Rotomahana-Waimangu, Waiotapu, and Paeroa Range. Alkaline, acid, and neutral springs may occur within a few feet of one another. In general the alkaline pools are boiling or hot and clear, and have an outflow, whereas the acid seldom reach boiling-point, and are discoloured or muddy. The waters of the alkaline springs deposit silica freely, building up sinter cones round their vents and coating the ground over which they flow. Only five fumaroles of any size occur in the district. Their temperature is 99° C., the boiling-point of water for the altitude, and they form no sublimates. There are in addition many small steam-vents, around which acicular crystals of sulphur are deposited. At Ohinemutu most of the springs are at or close to boiling-point and have an alkaline reaction. On the eastern side of Rotorua Township and at Whakarewarewa there are alkaline, acid, and neutral springs. At the former locality the sulphury slime on the edge of some of the alkaline pools has an acid reaction, probably due to the oxidation of sulphur. Pohutu Geyser, at Whakarewarewa, which was in action during Hochstetter's visit in 1859,† still plays to a height of 50 ft. or 60 ft. for about twenty-five minutes, as a rule, once or twice every twenty-four hours. It is preceded one to four hours by the adjoining Prince of Wales Feathers, which plays almost continuously until Pohutu has finished erupting. It is said that after heavy rain Pohutu is inactive for a day or so. At Tikitere the springs, with only one or two exceptions, are acid, are discoloured by mud, and boil vigorously. The springs at Rotomahana and Waimangu were found to be alkaline or neutral, with the exception of the small hot lakes in Echo (Frying-pan Flat) and Inferno craters. The waters of these lakes are clear. Echo Crater and occasionally Inferno Crater have an overflow of about 18 gallons per second, making notable exceptions to the general character of acid springs. The hot springs along the fault on the Paeroa Range are weakly mineralized, and are alkaline. At Waiotapu are seen acid, alkaline, and neutral springs.

Extensive decomposition of andesites and rhyolites by steam and hot water to kaolin has taken place on Maungakakaramea (Rainbow Mountain), near Waiotapu, and on the scarp of Paeroa Range. At Whakarewarewa, besides alteration to kaolin, there is seen in small areas of collapse a further stage where only silica remains.

Gas rises freely from many of the springs. Samples from Rotorua, Whakarewarewa, and Waiotapu, analysed by the Dominion Analyst, consisted mainly of carbon dioxide with smaller amounts of hydrogen, carburetted hydrogen, sulphuretted hydrogen, nitrogen, and oxygen. The gases from all localities are remarkably alike in composition, and resemble gases from hot springs in volcanic regions in other parts of the world.

Economic Geology.

Although the district abounds in igneous rocks, good roadmaking-material is scarce. The present sources are the Ngongotaha rhyolite, the silicified lake-beds on the eastern side of Rotorua, the vesicular hornblende rhyolite on the Rotorua-Waiotapu Road, and pumiceous deposits. The best deposits of roadmaking-material observed during the field season were the andesite of Maungaongaonga and the rhyolite of Matawhaura, between Rotoiti and Rotoehu, both less than a mile from arterial roads.

A deposit of high-grade white diatomite (kieselguhr), 6 ft. thick, occurs in the Ngongotaha Valley on Mr. Brake's farm, and is quarried for export. Other deposits were found at Ngongotaha Village, Pohirua, on the north shore of Rotorua, and on the western side of Lake Tarawera, but they are not as high grade as that on Mr. Brake's property.

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* Locally this name is given to Inferno Crater.

† F. von Hochstetter: "New Zealand," pp. 427–28; 1867. Waikite Geyser, described by Hochstetter, has erupted only for short periods during recent years.

6. PALÆONTOLOGICAL WORK, 1926–27.

(By J. Marwick.)

During the past year work has been continued chiefly on the Mollusca of the Middle Tertiary of the Gisborne and North Taranaki districts. The collections of the Geological Survey have been greatly augmented by co-operation with the geologists of Taranaki Oil Fields, Ltd. The material is being studied as opportunities offer, and much useful palæontological and stratigraphical knowledge is being gained.

An attempt has been made to correlate the formations of the east coast of the North Island with those of the west coast, but, as yet, we are far from reaching finality. The chief obstacle is the lack of specific agreement between the faunas of different localities, and to surmount this exhaustive collecting is needed. The preliminary examination of the Taranaki and Gisborne fossils suggests the following correlation :—

	Taranaki Area.	Gisborne Area.
Lower Pliocene	Waitotaran	Ormond limestone.
Miocene	Taranakian	Tokomaru Series.
	Mohakatino Series, Mokau Series	Tutamoe Series.
	Mahoenui Series	Ihungia Series.

In February last, a visit was made to the Mokau and Patea districts in order to supplement the collections already gathered by officers of the Geological Survey. The Mokau beds are but poorly fossiliferous, so that only a small number of mollusca were obtained. An afternoon was spent examining the Public Works quarry on the south bank of the Mokau River, three miles above the bridge. The quarry is in a foraminiferal limestone, which is at the top of the Mokau beds, and is underlain, apparently conformably, by a thin layer of carbonaceous clay with occasional shelly lenses. The limestone has a weathered and irregularly eroded upper surface, and is unconformably overlain by the highly tuffaceous Mohakatino beds. At the quarry the limestone is 36 ft. thick, but westward it thins to 12 ft. in a distance of about 10 chains. Three chains east of the quarry the limestone has thinned to nothing, and the Mohakatino tuffs rest directly on the Mokau clays.

Collections from many parts of New Zealand have been examined and classified. Among these were the following: Burnt Hill, Oxford; Chatton Creek, Southland; north end, Mahia Peninsula; Pongaroa, east of Dannevirke; and many localities in the Tutamoe, Uawa, Waikohu, and Waingaromia survey districts.

The palæontological parts of Geological Survey Bulletins Nos. 29, 30, and 31 were revised and corrected, and some time was spent in the proof-reading and indexing of Palæontological Bulletins Nos. 11 and 12. Palæontological Bulletin No. 11, by Frederick Chapman, of Melbourne, deals with the Cretaceous and Tertiary Foraminifera of New Zealand, and supplies a much-needed contribution to our knowledge of New Zealand fossils. Should the present search for oil in this country be successful, a great demand for foraminiferal work will arise. In Palæontological Bulletin No. 12 Dr. Otto Wilckens, of Bonn, Germany, describes Triassic Mollusca from Nelson, Canterbury, and Otago. The bulletin contains excellent figures, and will greatly facilitate the recognition and subdivision of our older Mesozoic rocks.

During the year the following papers were completed :—

(1) The Veneridæ of New Zealand. ("Transactions of the New Zealand Institute," vol. 57.)

(2) Some Cretaceous Fossils from Waiapu Subdivision. (*N.Z. Journal of Science and Technology*, vol. 8, No. 6.)

(3) The Pliocene-Pleistocene Boundary in New Zealand (for the Pan-Pacific Science Congress—in the press).

(4) The Tertiary Mollusca of the Chatham Islands (for "Transactions of the New Zealand Institute"—in the press.)

The foreign and recent molluscan collections so necessary for comparative purposes have been increased by exchanges during the year, and negotiations for further exchanges are being made.

7. SUPPOSED PHOSPHATIC LIMESTONE WEST OF PIOPIO, WAITOMO COUNTY.

(By P. G. Morgan.)

Between 8th and 12th November last I made a visit to some reported occurrences of phosphatic limestone eight to ten miles west of Piopio, on properties belonging to Messrs. J. Wall and Newton King.

The chief locality examined on Mr. Wall's land was about the centre of the section marked on the map as Puketiti No. 3, Maungamangero S.D. Here is a basin-like area surrounded by walls of limestone (of the same age as the Te Kuiti limestone), and drained by a small stream escaping underground on the south-west side near some sheepyards. A somewhat soft, light-coloured band of the limestone, 12 ft. or more thick, overlain and underlain by hard limestone, had been prospected by means of a small cut on the north-east side of the basin. Several pieces of the stone, tested in the field by the ammonium-molybdate spotting test, showed no more than the usual small amount of phosphoric anhydride. A general sample on analysis was found to contain only 0·03 per cent. of P_2O_5. A small piece broken off the limestone at a point several chains to the west seemed to be a little more phosphatic, but analysis showed less than 0·1 per cent. of P_2O_5.

The limestone prospected for phosphate on Mr. Newton King's property ("Puketiti") is about three miles to the north-north-west on the east side of the upper part of Mangaorongo Stream, a tributary of the Awakino. Here, on or near a basin-like area similar to that on Mr.

Well's land, four cuts, numbered 1–4, have been made in what is undoubtedly the same band of limestone as that prospected on Mr. J. Wall's property. Various samples qualitatively tested by me in Wellington all seemed low in phosphate content. The best of these, from cut No. 2, when analysed yielded less than 0·1 per cent. of P_2O_5 (Lab. No. W860).

Analyses of the five main samples taken by me from Messrs. Newton King and Wall's properties were made in the Agricultural Department's Laboratory, and are as follows:—

Field Number.	Analyst's Number.	Calcium Carbonate ($CaCO_3$).	Insoluble (Siliceous Matter).	Phosphoric Anhydride (P_2O_5).	Moisture at 100° C.
1	W/817	98·6	0·18	0·05	0·05
2	W/818	98·3	0·23	0·04	0·04
3	W/819	98·3	0·26	0·03	0·10
4	W/820	98·5	0·31	0·03	0·04
5	W/821	98·3	0·25	0·03	0·02

1–4. From cuts 1–4 on Mr. Newton King's property, "Puketiti."

5. From cut on "Puketiti No. 3," Mr. J. Wall's property.

These results show that the limestone is of no account whatever as a source of phosphate, but that it is of remarkably good quality as an agricultural limestone. Being fairly soft, it can easily be pulverized by a small portable crushing plant, and is therefore of value for local use. Elsewhere the Te Kuiti limestone is usually hard throughout.

A few "spotting" tests with ammonium molybdate were made upon samples of hard limestone obtained near Mr. Wall's homestead and near Piopio. In all cases the tests showed that very little phosphoric anhydride was present.

The soil of the Piopio and adjoining districts is light, but when top-dressed with phosphate in any form becomes wonderfully good pasture-land. Much of the land is broken, and top-dressing is therefore expensive. The soil, except in valley-bottoms, is for the most part a brown loam, derived largely from andesitic erupted ash. A sample of loamy subsoil taken in a cutting on the main road half a mile east of Piopio had the following composition:—

Silica (SiO_2)	41·65
Alumina (Al_2O_3)	22·50
Ferric oxide (Fe_2O_3)	9·32
Magnesia (MgO)	1·06
Lime (CaO)	1·02
Soda (Na_2O)	0·99
Potash (K_2O)	0·83
Titanium dioxide (TiO_2)	1·12
Manganous oxide (MnO)	0·13
Phosphorus pentoxide (P_2O_5)	0·29
Water lost at 105° C.	10·34
Combined water and organic matter	10·98
	100·23

This subsoil seems to be almost all altered andesitic ash. It rests on limestone.

The discovery of phosphate rock or of limestone sufficiently phosphatic to be used as a fertilizer would be of great value to the adjoining district, but of this there seems to be no prospect. The Tertiary limestones that occur over large areas in Waitomo County (including the old Awakino County) are of such a character that little hope of their being associated with workable deposits of phosphate rock can be entertained. The soft band examined by me on Messrs. King and Wall's properties consists mainly of the remains of Bryozoa, organisms that usually contain little more than a trace of phosphoric anhydride.

Of interest is the occurrence of pilolite, a curious leathery clay-like mineral, pointed out to me by Mr. J. Wall in veinlets cutting the loamy subsoil exposed in a track-cutting a little to the west of his homestead ("Waitoru"). I saw traces of the same mineral along the road east of the homestead. Pilolite in New Zealand was first observed by Dr. J. Henderson near Mahoenui (N.Z. Jour. Sci. & Tech., vol. 3, pp. 79–80; 1921), a few miles south-west of Mr. Wall's, and the mode of occurrence is similar.

8. ROTORUA DISTRICT.

(By P. G. Morgan.)

The visit made by me last January and February to the Rotorua district impressed me more vividly than ever before with the great amount of useful geological and geophysical work that can be done in the thermal region of the North Island. Physiographically this region is of great interest. The surface features are determined largely by faulting, a condition that seems to have escaped the attention of most previous observers. The numerous lakes are of complex origin. Mount Tarawera was considered by Hochstetter—who, however, did not climb it—to be part of a high-level plateau, and S. Percy Smith was of a similar opinion. A. P. W. Thomas, on the other hand, describes Tarawera as an old volcano, and his observations have been confirmed by Mr. Grange. Nevertheless, there is much to lead one to think that Tarawera is a mountain of complex history, and that to regard it as merely a volcanic cone coated by lava-flows may be misleading. An important fact connected with the 1886 eruption of Tarawera and adjoining localities is that large quantities of semi-basic lava were emitted from the Tarawera vents as scoria, lapilli, and dust, whereas Tarawera, prior to this eruption, was formed wholly of rhyolitic material. This great change in the composition of the erupted rock is highly significant, and invalidates Hector's conclusion that the Tarawera eruption was (probably) the mere temporary revival of the expiring energies of a recent focus of volcanic origin.* The remarkable, and one might almost say unique, nature of the Tarawera eruption will be fully discussed in the detailed report on the Rotorua Subdivision to be prepared by Mr. Grange next year.

The detailed investigation of the hot-spring waters and of the abundant gases associated with them will help greatly in settling the much-disputed problem of their origin. This work must be done mainly by the chemist. Analyses of the waters and of the sinters, combined with geological studies, will throw light on the mode of formation of the auriferous-quartz lodes of the Hauraki Goldfield and similar areas in other parts of the world.

Probably there are strongly marked variations in the intensity of the force of gravity in the thermal region. If so, exact measurements, whether by the Mendenhall or similar apparatus, or by the Eötvös torsion balance, may be expected to give results that will not only be of outstanding interest, but of value to the projected vulcanological survey. Similarly variations in the direction and intensity of the earth's magnetism may be predicted, and their determination will be equally useful.

As part of the vulcanological survey continuous observations of the temperatures of the hot springs and of the ground at selected spots are necessary, and seismographs will, of course, have to be set up at various places. Exact bench-marks should be established at many points, more especially on the shores of lakes, so that any slow movement of the ground may be speedily detected, and the amount of displacement caused by earthquakes exactly ascertained.

On an earlier page I have stated that geological survey is rightly preceding detailed vulcanological observations, but clearly the geologist needs the assistance of the chemist and of the geophysicist before his work can be completed. The land-surveyor also is a necessary member of the team. On account of the need for numerous and long-continued instrumental observations of a delicate nature, the vulcanological survey will best be conducted by men with first-class training in physics, but the physicist will need help from the geologist in interpreting the instrumental data.

9. ARTESIAN WATER-SUPPLY, HASTINGS AND PAKIPAKI DISTRICTS.

(By P. G. Morgan.)

In consequence of a request received from the Lands and Survey Department for a report by the Geological Survey on the effect that the lowering of Lake Poukawa and the drainage of the neighbouring swamp would have on the artesian water-supplies at Pakipaki and Hastings, on the 21st February last I left for Hastings in order to make the required investigation. On the 22nd I visited Havelock North, Pakipaki, and other places. So far as time allowed, I also made inquiries from well-informed people in Hastings and Pakipaki. On the 23rd I returned to Wellington.

Lake Poukawa is situated east of Te Hauke Railway-station (82 ft. above sea-level and twenty-five miles by rail south-west of Napier). It drains north-east by means of Poukawa Creek to Awanui Stream, which runs into the old channel of the Ngaruroro Stream south of Hastings. The railway-line and the main road from Wellington to Napier follow Poukawa Creek valley. The valley-bottom north-east of Poukawa Railway-station is narrow and swampy. Obviously there is no gravel in this valley or other bed that would allow underground drainage from Lake Poukawa to the Heretaunga Plain at Pakipaki, Hastings, &c. The notion that seems to be held by one or two persons that such drainage takes place may be dismissed as fantastic. Very little water drains into the lake, and, if there were any subterranean drainage, in dry weather the lake would disappear.

On the other hand, the artesian water that can be tapped under the Heretaunga Plain at Pakipaki (39 ft. above sea-level), Hastings (39 ft.), Tomoana (25 ft.), Wakatu (15 ft.), Clive (18 ft.), and Napier clearly enters the gravels and sands of the plain at higher levels near the foot of the Ruahine Mountains and soaks through them seaward. Layers of clay prevent the water in the deeper part of the gravels and associated beds (which are known to have a maximum thickness of over 650 ft.) from rising to the surface of the lower part of the plain, and, except as tapped by bores, it finally reaches the sea far out from the shore. The artesian waters of Christchurch, the Hutt Valley, &c., occur under similar conditions.

There is therefore no reason for supposing that the draining of Lake Poukawa and the surrounding swampy ground will directly affect the artesian water-supplies at Pakipaki and Hastings in any detectable degree. Indirectly, through Poukawa Creek drying up in a period of drought, the artesian pressure at Pakipaki might be lessened slightly—say, to the extent of an inch or two.

The following factors should be borne in mind:—

(1) The Pakipaki and Hastings artesian water is tapped at shallow depths (95 ft., 135 ft.), and, since the overlying strata are not watertight over a wide area, it follows that the pressure at the surface is not great. The head varies from 2 ft. to 6 ft. or 8 ft.—rarely more.

(2) In dry weather the head, and consequently the flow from the artesian bores, lessen considerably. This could be predicted from the shallow depth of the top of the water-bearing stratum, and the nature of the overlying beds.

(3) The cutting of ditches in the country and the establishment of a proper system of drainage in the town of Hastings tend to lower the water-table, and this indirectly lessens the effective artesian pressure, though it does not affect the quantity of artesian water available.

* Rep. Geol. Explor. during 1886–87, No. 18, p. 243; 1887.

(4) The sinking of new bores and the consequent tapping of more and more artesian water must inevitably more or less affect the available artesian pressure.

Reference may be made to the following paper by Mr. Henry Hill: "Water-conservation and Hawke's Bay Artesian Systems," (Trans. N.Z. Inst., vol. 54, pp. 134–47; 1923). On pages 140, 142, and 143 Hill discusses the effect that the draining or lowering of Lake Poukawa would have on artesian water-pressure, &c.

It needs little knowledge of human nature to predict that if the Poukawa Swamp is drained any subsequent falling-away in the artesian water-supplies will be attributed by many persons to the drainage operations, yet the true causes will be those mentioned above.

In conclusion, I can but repeat the opinion expressed above, that the draining of the Poukawa Swamp will not affect the artesian water-supplies of the Heretaunga Plain to any appreciable extent.

10. WHITE ISLAND.

(By L. I. Grange.)

On the 29th March I left Opotiki for White Island, and returned to the mainland on the 9th April. I received assistance from Mr. M. Paul, Inspector of Mines, Waihi, and Messrs. H. Welsh (general manager) and E. Kennedy (engineer), of White Island Products, a company formed in 1926 to develop the mineral resources of the island.

White Island volcano, with an area above sea-level of nearly one square mile, is formed of andesitic tuffs, agglomerates, lava-flows, and dykes, the fragmental rocks predominating. The crater is about 60 chains long, and on an average nearly 20 chains wide. Its eastern end has been breached by the sea at three places. It may be divided into three parts—an eastern flat area (25 acres) rising from sea-level inland to 43 ft. above high tide; a middle area (43 acres), the site of the lake that was infilled in 1914; and a western area (35 acres) of coarse landslip material of irregular surface, the greatest height of which is 260 ft.

Sections exposed on the cliffs below the gannet-rookeries on the south side of the island show that during the latest of the eruptions that were strong enough to throw fragmental material out of the crater andesitic ash was ejected. The two uppermost showers, 6 in. and 2 ft. from the surface, contain fragments of charred wood and thermally altered rocks from the crater-floor. The present vegetation* on the island, consisting mainly of pohutukawa (*Metrosideros tomentosa*), many of which reach a diameter of between 9 in. and 12 in., appears to have established itself after the last of these eruptions.

The landslip of September, 1914, came from the western wall, and, moving over the crater-floor, by blocking blowholes and the vents of the hot lake, caused small eruptions. The material, amounting to several million tons, helped forward by the eruptions, reached the sea at each of the three bays, but chiefly by way of Crater Bay. In the crater sand, mud, and hummocks of partly decomposed andesite were left.

Where cuts have been made on the south-eastern end of the flat the sand and mud is seen to have a minimum thickness of 3 ft. Over the site of the lake, the floor of which was in most parts less than 5 ft. above high tide, the debris reaches from 30 ft. on the seaward end to 65 ft. above high tide on the western end. The hummocks are numerous on the southern half of the crater, being about 15 ft. high on the flat and more than 40 ft. on the lake-site.

At the present time there are eleven fumaroles of considerable size, in addition to many small vents, most of which were formed after the 1914 disaster. The Donald Blowhole, one of the few vents of any size that are some distance from the inner edge of the crater, is the strongest. The vents of this terrific blowhole, which lies at the bottom of a small depression, some 30 ft. deep, emit with a deafening roar clouds of smoke-blue gas, which seems to consist of sulphur dioxide, hydrochloric acid, and only a small amount of steam. Surrounding the vents is an incrustation of hæmatite, with a thin covering of a bright-yellow salt, probably ferric chloride. A weighted thermometer was suspended over one of the vents, but the blast was too strong to allow it to remain in the vent, so that it swung in and out and knocked against the walls. The reading, 173° C., was probably too low; and this appeared to be confirmed by the melting of solder on a tin held 3 ft. above the vent. At a few points in the bottom of the depression are small boiling pools of yellow and green water. One of the samples of water taken from here attacks zinc vigorously. The Little Donald, another dry fumarole on the southern margin of the crater, burst out on the 3rd February, 1926, coating the floor of the crater with a thin layer of ash. The gas appears to be similar to that of the Donald. Occasionally the gas from both blowholes is darkened with ash.

The other fumaroles emit clouds of steam and sulphurous gases under pressure. Some have built beautiful cones of sulphur up to 9 ft. in height. One of the fumaroles in the group north of the Donald Blowhole has a temperature of 102° C. at a depth of 6 ft., and another—the farthest up the slope—a temperature of 200° C. at the lip. An inclined vent a few yards from Lot's Wife (7 chains north-west of Donald Blowhole) has a temperature of 129° C., and contains molten sulphur. A neighbouring fumarole with a cone of sulphur 9 ft. high has a temperature of 118° C., 8 ft. below the rim. Samples of gas were taken from three vents. A rill of hot yellow water close to Lot's Wife is strongly acid; a strip of zinc thrown into it was violently attacked and soon disappeared. There are many other steam-vents and a few boiling pools, most of which are on the margin of the crater.

The work done on the fumaroles and springs on this visit is regarded as preliminary only. Frequent observations, including accurate measurement of temperature of the dry fumaroles, are needed. Undoubtedly the gases of these fumaroles are emitted from liquid or extremely hot rock at no great depth.

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* See W. R. B. Oliver: "The Vegetation of White Island, New Zealand" (Jour. Lin. Soc., Botany, vol. **43**, pp. 41–47; 1915). Oliver found only twelve species of plants on the island.

The sulphur that is in sight is confined to the margin of the crater. High-grade sulphur can be obtained from active and almost extinct fumaroles. The company that was working the deposits in 1914 had a dump of about 1,000 tons of sulphur mined from the foot of Troup Head, but this was lost in the 1914 disaster. The present company has quarried small amounts from the northern edge of the flat.

The White Island Products Company intends boring the flat, and later the lake-site for sulphur. Seams of sulphur are known to exist below the floor of the infilled lake. W. McCandlish* in 1885 had fifteen bores put down on the lake-floor, which was then dry. The bores, which ranged in depth from 3 ft. 11 in. to 18 ft. 3 in., penetrated two seams of sulphur, each 3 ft. thick. Mr. McCandlish estimated that 20,954 tons of high-grade sulphur could be obtained. Blocks of sulphur as much as 6 ft. in greatest length were thrown from the lake bed in 1914 and carried down the crater-floor. Little is known of what sulphur lies below the eastern flat even at shallow depths. A thin seam of sulphur occurs in a shallow pit 6 ft. below the surface at 9 chains north-west of the wharf. The flat seems to be worth testing by shallow bores. The rocks are soft and will give no trouble in drilling, but a high temperature gradient must be expected. In this connection it may be mentioned that when the ground at "The Geysers," California, was bored for compressed steam a temperature of 100° C. was found close to the surface. "As cracks are cut by the drill the steam-flow increases and the temperature rises rapidly 25° C. or more per 100 ft. in the upper strata."† Over the lake-site, where there is a heavy overburden, some modification of the Frasch process, in which the sulphur is melted by superheated steam or water and forced to the surface by compressed air acting on the principle of an airlift, seems to be the only possible means of winning the sulphur. The first cost of the plant required for this process is very great, and therefore it is suitable only where the sulphur deposits are very large.

The best deposit of the sulphur-gypsum fertilizer is situated at the foot of Troup Head, where there is about 10,000 tons. The material appears to contain a fair amount of gypsum, but the sulphur content is high only in hard bands and lenses. The company has been grading up the rock low in sulphur with the high-grade sulphur obtained from the fumaroles. Other deposits apparently high in gypsum, but in general low in sulphur occur on the margin of the flat area and in a few places on the northern cliffs. The average analysis‡ of the sulphur-gypsum fertilizer sold by the company is :—

Sulphur (S)	44·02
Inorganic matter	42·26
Water-soluble salts	9·42
Nitrogen (N)	0·06
Moisture at 104° C.	3·68
Undetermined	0·56
	100·00

The water-soluble salts of the above analysis contain—

Ferrous sulphate ($FeSO_4$)	1·02
Aluminium sulphate ($Al_2 (SO_4)_3$)	0·68
Calcium sulphate ($CaSO_4$)	4·07
Magnesium sulphate ($MgSO_4$)	0·28
Phosphoric anhydride (P_2O_5)	0·02
Potash (K_2O)	0·11
Chlorine (Cl)	Trace
Sulphuric acid (free) (H_2SO_4)	2·88
Carbonates	None
Undetermined	0·36
	9·42

A decomposed andesite coloured red by iron oxide, outcropping high in the cliff above Lot's Wife, is considered by the company to contain sufficient iron to be useful for the "bush sick" country of the Rotorua district. Several thousand tons of the rock have broken away and spread out over the flat in front of Lot's Wife. The analyses of this material for ferrous iron and gypsum are not yet to hand.

On the two southern points and the western point of the island are gannet-rookeries of a total area of about 3 acres. The excrement of the birds is found only to a depth of 3 ft. It rests on ash-beds from 30 ft. to 40 ft. thick on the southern points. From the surface to a depth of 3 ft. the average phosphoric anhydride content is 2·11 per cent.,* and to a depth of 1 ft. from the surface the highest percentage of phosphoric anhydride is 4·42 per cent. The nitrogen content of all samples is less than 0·50 per cent. The material is thus seen to be lower in fertilizing content than one would have expected.

* Information taken from copy of report by Mr. McCandlish in the possession of the company.

† E. T. Allen: "Further Evidence of the Nature of Hot Springs (*Jour. Wash. Acad. Sci.*, p. 74; 4th Feb., 1926). Quoted in "The Volcano Letter," 4th March, 1926.

‡ From pamphlet "Fertilizers" issued by White Island Products, Ltd.

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