1933.

NEW ZEALAND.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

(SEVENTH ANNUAL REPORT OF THE).

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

CONTENTS.

The Right Hon. G. W. FORBES, Minister of Scientific and Industrial Research,—

I have the honour to submit herewith the annual report of the Department for the year 1932-33.

E. MARSDEN.

SECRETARY'S REPORT.

The Research Council has held three meetings during the year, at which there have been full attendances, and, in addition, there have been numerous committee meetings.

The personnel of the Council is as follows:—

Mr. George Shirtcliffe, O.B.E. (Chairman).

Professor Henry George Denham, D.Sc., M.A., Ph.D., Professor of Chemistry, Canterbury College, Christchurch.

Professor John Malcolm, M.B., Ch.B., Professor of Physiology, University of Otago, Dunedin.

Mr. Theodore Rigg, M.Sc., Assistant Director, Cawthron Institute, Nelson.

Mr. Hugh Vickerman, D.S.O., O.B.E., M.Sc., M.Inst.C.E., Wellington.

Mr. George A. Pascoe, Chairman, Development of Industries Committee.

Mr. Alfred H. Cockayne, Assistant Director-General of Agriculture.

Dr. Ernest Marsden, M.C., D.Sc., F.N.Z.Inst. (Secretary).

The Development of Industries Committee held six meetings during the year. Its membership was altered by the resignation of the Chairman, Mr. J. Pearce Luke, whose place was taken by Mr. G. A. Pascoe.

The expenditure of the Department during the year was as follows:—

Permanent services—	£
Dominion Laboratory (with branches)	11,306
Geological Survey	4,895
Meteorological Office	7,314
Apia Observatory	2,475
Dominion Observatory	1,534
Magnetic Observatory	1,817
Lincoln College	3,402
Research investigations (including contributions)	34,983
Head Office, publications, Research Scholarships, and miscellaneous	7,233

The grants made by the Empire Marketing Board and industries in support of research investigations amounted to a total of £10,762 for the year.

The continuance of the economic depression has meant the continuation of the uncertainty of finance which had to be faced in the previous year. Nevertheless, although this occasioned considerable anxiety, it was permitted to exert little restrictive influence upon the activities of the Department. Both in the regular services and in the research activities the amount of work covered was in excess of that done in previous years. This indicates that in times of depression scientific services are called upon in order to assist industries in the increasing difficulties which they experience in maintaining production and endeavouring to provide an output at reduced costs commensurate with the lessened spending-power of the community. There was every evidence that all those who were engaged upon scientific activities of the Department during the year felt the sense of their responsibilities in the circumstances of the depression, and were induced thereby to put forth additional zeal and effort into their work.

In order to effect as much relief as possible to various industries, the Department has investigated a very large range of proposed projects and assessed the likelihood of their success from the scientific point of view, and consequently has been able to render a good deal of valuable guidance in this respect.

DOMINION LABORATORY.

The primary function of the Laboratory is to make chemical examinations of materials for all Departments, except that of Agriculture. The work is extremely varied in character, and, while much is of a routine nature, a considerable amount of research work is carried out. In addition to these activities, various members of the staff are frequently consulted regarding subjects of which they have special knowledge.

As a result of encouragement giving to prospecting by the Unemployment Board, a greatly increased number of mineral samples from prospectors were examined during the year.

One of the most useful branches of work has been the examination of materials for Government Purchasing Departments.

A number of important investigations was carried out for the Police Department, one of these involving the recovery of veronal from bodies that were exhumed after burial for several months. This, though difficult, was successfully carried out.

In addition to the ordinary work for the Department of Health, an investigation was made regarding the significance of nitrites as affecting the purity of Hawke's Bay artesian waters.

Following on two fatalities from sulphuretted hydrogen in the Millerton Mine, a research was undertaken at the request of the Mines Department into methods for detecting and estimating this gas underground. A convenient form of detector has been evolved, and laboratory experiments with it are in progress prior to trials underground.

The chemical work on the subject of iodine in relation to the incidence of goitre is now completed and will be published at an early date (in conjunction with the Department of Health).

Research for the Plant Research Station on the chemical composition of spraying-materials for fruit-trees has given valuable results, and is being continued.

The comparative values of New Zealand and imported hydrated lime for industrial use were investigated.

Laboratory research in connection with the extraction and refining of kauri-gum was advanced sufficiently to justify the working-out of conditions on a commercial scale. An extraction plant that lay idle in Auckland was modified in some details and operated for several weeks extracting swamp gum. The results were up to expectations. A considerable quantity of refined gum was produced, parcels of which were sent to numerous manufacturers abroad. Their comment is being awaited with interest.

Owing to withdrawal of the financial support of the Coal-mine Owners' Association, the Fuel Research Association was disbanded during the year. This is a matter for great regret, as a large amount of useful work was being accomplished. The last bulletin published by the association dealt with briquetting, and, as a consequence, the briquetting of slack coal will soon be in commercial operation in the Dominion.

GEOLOGICAL SURVEY.

The field-work of the Geological Survey was restricted this year by the shortage of funds. In two districts the geologists boarded where and how they could, and in a third, Naseby, where population is sparse, a camp of minimum size was maintained. In all, about 1,000 square miles of country was mapped.

Geological investigation was continued in the Eketahuna Subdivision, and another season's work should complete the mapping of this district. There are indications of oil at many points along the eastern slopes of the North Island, and the whole of the northern half of this petroliferous region has now been examined, but the Eketahuna Subdivision is the first district of the southern half to be explored in detail.

Work was resumed in the Amuri Subdivision. In this area important limestone deposits occur and some bands of phosphatic pebbles, which may have future value. In this treeless region of low rainfall the effects of recent earth-movements are as well preserved as in any part of New Zealand, and the study of these may help to a better understanding of the relative frequency and severity of earthquakes.

Owing to the greatly increased value of gold, alluvial fields till recently regarded as practically worked out have regained economic importance, and are being tried by a new generation of prospectors. Partly on this account the geological exploration of the Naseby Subdivision was begun last season. Good progress has been made in the mapping of the district, which covers most of the basin of the upper Taieri and contains several famous alluvial goldfields, a number of auriferous quartz veins, thick deposits of lignite, as well as beds of light-burning clays, diatomaceous earth, and fine high-grade quartz sands.

The examination of alluvial diggings begun last year was continued, one officer spending the whole of the season on this work in Otago and another a few months on the West Coast. In Otago several areas of river-flat were examined to determine if the geological conditions indicated the presence of buried stream-channels the position of which could then be fixed by geophysical methods. In the same region structure studies in the Manuherikia Valley indicate that mountain-building pressure has raised a low fold of Tertiary strata in front of the Dunstan Range. The quartz conglomerates at the base of the Tertiary sequence are richly auriferous at several points where upturned at the foot of the mountains, and this fold may bring portions of the same beds now covered with younger deposits within mining depth.

The success attending the use of geophysical methods of prospecting for minerals in other parts of the world has directed attention to the possibility of using this means of increasing the output of gold. The geophysical work so far has been confined to attempts to locate deposits of detrital gold. The methods depend on the use of delicate instruments to detect differences in the physical properties of material buried beneath the surface. Gold occurs in such small proportions even in high-grade wash that its physical properties cannot be made use of in this work. But since streams tend to concentrate other heavy materials present in the gravels in far greater amount than gold along with that metal, geophysically detectable deposits of these heavy minerals are of interest to the gold-miner if they occur in gold-bearing country. In effect, all that geophysical investigations can do is to direct the miner to the most likely places to prospect. The cost of such prospecting is thus reduced, but prospecting is by no means rendered unnecessary; and the public, for their own protection, should take care that the value and amount of the wash of the claim in which they are investing has been adequately determined by boring, shafting, driving, or other well-proved methods.

During the year the two officers engaged on soil survey carried out a reconnaissance survey of the soils of 650 square miles of Taranaki and mapped in detail the soil of 80 square miles of closely settled farm lands in Waipa County.

METEOROLOGICAL OFFICE.

The principal duties of the Meteorological Office are the collection and publication of data on the climate and weather of the Dominion and the issue of weather forecasts.

The practical value of the former is indicated concisely by the report of a committee set up by the American Society of Civil Engineers to "give thought as to how the United States Weather Bureau could be made of greater service to engineers." This report stresses the importance (*a*) of maintaining a close network of regularly distributed stations with instruments exposed under standard conditions, near the ground, in open level spaces, (*b*) of avoiding changes of location or height above ground, which make continuous records of stations unreliable as indices of climatic phenomena and their variation, and (*c*) of inspection of the stations. It is also stated that meteorological data "are essential in the economical planning, construction, and operation of many types of public and private enterprises and improvements, in which vast sums of money have been, and are being, invested, and such data are widely used by engineers engaged in this work."

The securing of long records made under constant conditions is not possible without the co-operation of the public and especially of local bodies, who in the end will be the ones to make the greatest use of them. Regular inspection of stations should be resumed as soon as financial considerations permit.

Increasing use is made of the weather forecasts, and it is desirable that no means of improving their accuracy and availability should be neglected. Advances have been made elsewhere through increasing the density of and the area covered by the reporting stations and the frequency and detail of the reports. The accuracy of short-period forecasts, especially, has been considerably enhanced. The dissemination of the reports and forecasts amongst the public requires to be equally free and rapid. For the greater part of these services wireless telegraphy has special advantages, and the extent to which it is employed is ever increasing. Indeed, so many and varied are the demands made by modern meteorological services on wireless that the majority operate their own stations, and it seems clear that this procedure will, before long, have to be adopted in New Zealand.

The Director, in his report, refers to the publicity given to forecasts by unqualified persons and the adverse effect this has on the progress of the subject.

OBSERVATORIES.

The full routine observational work has been maintained at the Dominion Observatory and at Christchurch Magnetic Observatory. In seismology several new recording-stations have been established, and at Amberley a special new set of magnetographs has been installed in connection with the international polar year observations.

At Apia Observatory the programme of work in terrestrial magnetism, atmospheric electricity, seismology, and meteorology has been generally maintained as in former years. The continuance of a full programme of work at Apia has only been made possible by generous financial support from the Rockefeller Foundation of New York, the Carnegie Institution, and the British Admiralty, and the Department gratefully acknowledges its indebtedness to these bodies.

MINERAL CONTENT OF PASTURES.

The general adoption of the practice of using the limonite salt lick to control bush sickness has given evidence that this treatment is sound. It is recognized, however, that the reasons why this iron-containing specific is efficaceous are not yet fully understood, since it has been shown that not all forms of limonite are satisfactory. This has been indicated clearly in the Nelson experiments, where best results in the control of bush sickness were secured by the dosage of sheep with soil extracts.

NOXIOUS WEEDS.

The investigations sponsored by the Empire Marketing Board were brought to a close during the year, and the work for the quinquennial period is being summarized in a report prepared for submission to the Board. A certain amount of additional work was done in connection with the development of *Antholcus varinervis*, which, having acclimatized satisfactorily in New Zealand, showed promise of being a controller of piripiri. Work on this insect is being continued at the Cawthron Institute.

Towards the close of the period there was also introduced a seed fly which attacks vigorously the seed heads of ragwort. In experimental tests it has destroyed a very high percentage of the seeds. Working in association with *Tyria jacobaeae* this insect may provide another useful method for restraining the spread of this serious noxious weed.

PHORMIUM TENAX.

No new developments have taken place in regard to the growth, breeding, and selection of strains of *Phormium tenax,* but the experimental areas have been maintained, and new knowledge of the growth qualities of those strains already selected for study is being accumulated. The production of a more efficient stripper is still receiving attention, but it has not yet been found possible to conduct trials with a machine of new design, which is being constructed. In view of the possible use of phormium as a source of cellulose, some yield-determinations have been made, but it does not yet appear that this plant can be utilized for the economic production of cellulose in New Zealand.

WHEAT RESEARCH INSTITUTE.

In all sections of its activities the work of the Wheat Research Institute has shown extensions. Progress has been made with a new crossbred wheat, which, after being subjected to very rigorous tests, gives indication that it will equal Tuscan in yield and will excel it in flour extraction and in baking-quality. Investigations of the Jumbuck variety have also revealed the hitherto unrealized good qualities of this wheat as a flour and bread-improver. Investigations of flour-mill technique have shown that a great deal of improvement in flour-quality is possible by the introduction of certain modifications, the details of which have been worked out at the laboratory. In consequence, the chemist will now pay a series of visits to all mills with a view to introducing these newer methods for increasing their efficiency and the quality of the flour-output. As a result of researches made into wheat by-products, the manufacture of several new grain products has been started locally. Similarly, assistance has been rendered to bakers in the development of a number of new products or the improvement of lines which previously were lacking in quality.

The value of scientific assistance to a group of industries and the confidence that such inspires has been evidenced by the unanimous support that has been accorded to the proposal to extend the term of the legislative sanction for the Wheat Research Institute for a further period.

KAURI-GUM.

Sound progress has been made regarding the preparation of high-grade resin extracted by solvents from low-grade dark-coloured swamp-gum. The laboratory tests which previously showed promise have now been tried out on a semi-commercial scale, on a modified extraction plant at Henderson, and have yielded a resin of greatly improved colour and general quality. Sufficiently large samples of this product to enable a commercial assessment and valuation to be made have been sent to Great Britain, and advice has been received that gum of such quality will prove acceptable to British manufacturers of varnishes and lacquers.

PLANT RESEARCH STATION.

The work at this Station has a very direct bearing upon the wide range of farm problems. In consequence of the investigations connected with strains in grasses and clovers, the pastures of the Dominion are now being gradually improved, through the replacement of poorer strains by better types, a course which will increase markedly the standard of land-utilization and result in an increase and a cheapening in production. The disease-investigations have also enabled a large measure of control to be secured over such serious farm pests as smuts, club-root of brassicas, dry-rot of swedes, and collar-rot of peas. The result, in consequence, will reduce the element of risk with these crops and will render a greater supply of fodder to be available for the flocks of the Dominion, as well as provide excellent material for developing an export trade in high-quality farm seeds.

DAIRY RESEARCH.

Conditions in the dairy industry have directed research investigations particularly towards questions of quality in both butter and cheese during the past season. Consequently, in addition to a number of fundamental problems, whose ultimate solution is imperative if the reputation of New Zealand's dairy-produce is to be increased, work has also been directed into certain channels which showed promise of bringing quicker results of benefit to the industry. Hence it has been possible to render useful advice to the industry on a whole range of matters which form integral parts of manufacturing processes, and the accumulated effect of this has been the raising in the standard quality of factory output during the past season. These investigations have revealed that certain parts of the manufacturing processes possess a greater significance than has hitherto been reckoned on, and that due attention devoted to them will be well worth while in order to effect improvements in the

quality of both butter and cheese. It is recognized that the whole chain of processes in the preparation of dairy-produce for overseas markets, right from the pastures and the cows to the retailer's counter, require more attention, and there is very real need for scientific assistance at each of these stages to gauge adequately their importance and to devise such emendations as will enable New Zealand dairy-produce to be raised to a definitely higher standard of quality.

In cheese the main defects are still those connected with texture and with discoloration, and while the multitude of causes of these troubles have not all been ascertained, a certain number have been definitely traced, and hence a certain amount of improvement has been effected largely through recommendations which have a bearing on the hygienic condition of the original milk-supply.

The standard quality of New Zealand butter has always remained high, but endeavours have been directed principally towards effecting improvements in its flavour and physical characteristics so that it may more nearly meet the requirements of overseas customers. Marked success has attended these efforts, as evidenced by the opinions expressed on trial shipments delivered in Great Britain. These trials will give valuable guidance to the adoption of such factory practices as will produce butter possessed of that fuller flavour sought for by overseas customers.

The continuation of the dairy-research programme will be along such lines as will effect improvements in the quality of both butter and cheese, so that ultimately New Zealand produce will be unexcelled.

STANDARDIZATION.

As the outcome of negotiations made by the Development of Industries Committee, an independent body, known as the New Zealand Standards Institution, was definitely constituted during the year. In August, 1932, the headquarters of the institution was established in the premises of the New Zealand Society of Civil Engineers, with Mr. H. L. Cole as secretary, and good progress has since been made in the development of an organization to handle all questions of standardization in New Zealand, and to keep in touch with kindred bodies in other parts of the world. The institution is organized to embrace four technical sections, as follows: (1) Chemical, (2) engineering, (3) electrical engineering, (4) building. These sections are already functioning by giving consideration to draft specifications submitted for comment by the British Standards Institute and other similar bodies located overseas. Consideration is also being given to certain standard specifications of particular application in New Zealand.

FRUIT RESEARCH.

The co-ordinated effort of the various organizations interested in fruit research has resulted in steady progress being made in the various branches of the fruit-research programme. Immediate beneficial results have followed the investigations which have been conducted into spray specifics, as modifications suggested by researches have shown their efficacy when applied in orchard practice. This work, done in association with definite economic studies of fungi and insects, has greatly strengthened the position of the fruitgrower in his control over orchard pests. While manurial trials can only be expected to give results after a long period of years, some useful general information is being secured regarding systems and methods of application, which give fairly rapid indications of what may be expected. In view of the fact that such a large proportion of New Zealand fruit is marketed overseas it is essential that much attention be devoted to methods of transport. Investigations have consequently been continued in this phase of fruit research, and have thrown further light upon conditions of storage and transport which, in the course of time, will exercise an influence in the reduction of wastage. The complicated nature of the problems and the great difficulty experienced in securing a proper understanding of such points as fruit-maturity and bitter-pit render a rapid solution of these difficulties almost impossible.

SOIL SURVEY.

A full understanding of the soils of the Dominion is fundamental to its future agricultural development. The important part which soil influence exerts has been well exemplified in those districts where stock suffered severely from the attacks of bush sickness, a disease closely associated with certain types of volcanic soils. It has been found that soil-forming processes which have been studied fundamentally overseas have important bearings in New Zealand, where both laterization and podsolization have been found to occur. In view of the extensive practice of top-dressing pastures with mineral fertilizers in New Zealand, it is essential that these processes be understood and their reactions on available supplies of phosphates, potash, and nitrogen appreciated. It would appear that a considerable portion of the phosphates applied to soil are, by some types of soil, at any rate, locked up in a form so that it is not available to plants.

Reconnaissance soil survey work has been carried out in Taranaki, the greater part of which has been sorted out into those areas affected by respective types of volcanic showers.

In the Waipa County a beginning has been made with the detailed soil survey of a district which ranks among the most intensively used areas of the Dominion.

LEATHER AND PELTS.

The provision of scientific information on a number of details to the tanners has enabled the industry to keep abreast of modern developments and to avoid mistakes in practice which would cause losses or reduction in the quality of the output. In consequence, New Zealand manufactured leather is finding uses and is being employed in ways in which hitherto it was not.

As a result of investigations with new processes for the treatment of bobby-calf skins, these are now finding uses, and new markets in Great Britain.

Similarly, pelts, which have responded to a new process, have entered new avenues of manufacture, and a new demand has thus arisen for New Zealand produce.

BANANAS.

Supplies of bananas which reached New Zealand from the Pacific Islands have often suffered seriously in quality through defective ripening-methods adopted by retailers in New Zealand. A series of experiments in which temperature, humidities, and supply of coal-gas were carefully controlled provided investigators at the Dominion Laboratory with a knowledge of the optimum conditions suitable for maturing Island bananas. This information, with the co-operation of the Public Works Department, has been applied in practice, on a semi-commercial scale.

Designs of a ripening-cabinet, with facilities for controlling temperatures, humidities, and gas-supplies, have been prepared, its method of operation defined, and this information made available to fruiterers throughout the Dominion.

DEVELOPMENT OF INDUSTRIES COMMITTEE.

The work of this Committee was limited in view of the policy effects developing from the Ottawa Conference, which coincided with its inception, and also by the appointment of the Tariff Commission. The Chairman of the Development of Industries Committee was selected as a member of the Tariff Commission, so that on the termination of the sitting of this Commission definite constructional effort may be made.

The Committee examined in detail many broad factors affecting the economic development of secondary industries, in particular the influence of machinery and similar industrial regulations, coastal and inland transport, restrictions imposed through arbitration awards, rationalization of industry, standardization, apprenticeship legislation, licensing of new industries, co-ordination of established industries, research, and technical services to industry. A large number of industries were investigated from the point of view of economic development, and in this consideration the necessity was felt for an investigatory force which would collect and collate the facts relating to various industries—*e.g.*, the technical efficiency in the various branches of these industries, systems of cost, &c.

MISCELLANEOUS.

During the year an increased number of miscellaneous inquiries have been referred to the Department. Many of these have been of a complicated nature, and their solution was possible only to draw upon the combined resources of the staff and facilities of its various branches. There is evidence that various industries are realizing more fully the value of scientific guidance and assistance in dealing with their problems.

REPORTS OF RESEARCH COMMITTEES OF THE COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

DAIRY RESEARCH INSTITUTE.

Dairy Research Management Committee: Hon. Sir George Fowlds (Chairman), Mr. A. Morton, Mr. J. Murray, Mr. T. A. Winks, Mr. W. Iorns, Mr. Dynes Fulton, Mr. Quentin Donald, Professor H. G. Denham, Dr. C. J. Reakes, Mr. W. Singleton. Director of Research: Professor Wm. Riddet.

During the past dairying season the Dairy Research Institute has continued to make a close study of problems associated with the manufacture of butter and cheese. The following work has been engaging its attention:—

(*a*) *Butter*:—

(1) The effect of different rates of cooling cream on the spreadability of butter made therefrom.
(2) The effect of adding starter to cream—a continuation of the work of previous seasons.
(3) The effect of chemical sterilizers and chemical sterilization of the factory plant on the quality of the butter.
(4) Determination of the usefulness of certain new types of paper and metal foils for wrapping butter, and the effect of metallic contamination arising therefrom.
(5) The cause of changes in surface colour of butter during storage.
(6) The treatment of *Pinus insignis* as a possible timber for butter packages.

(*b*) *Cheese*:—

(1) Continuation of work on "openness" in cheese.
(2) Repetition of previous work on the difference between high- and low-testing milk and between raw and pasteurized milk for cheesemaking.
(3) The influence of variations in the process of manufacture and the control of acidity and moisture on the quality of the cheese.
(4) The factors bearing upon the outbreak of discoloration in cheese last season, and study of the problem from bacteriological and chemical viewpoints.
(5) Starters: Methods and apparatus for keeping starters in the factory; causes of failure and methods of prevention; types of starter for production of flavour in cheese.
(6) The significance of acidometer readings in cheesemaking and the chemistry of cheesemaking.
(7) Cheese-bandages: The effect of different qualities on the shape and quality of the stored cheese.
(8) The usefulness of different methods of grading milk for cheesemaking and factors influencing the yield of cheese.

The following statement briefly summarizes results to date, bearing on the above. A certain amount of research work is still too incomplete for progress reports to be made.

Butter.

Flavour.—Certain potential markets in Great Britain have expressed a preference for a product possessed of a distinct lactic flavour characteristic of some European butters. Trial shipments of butter made during the year from selected fresh cream, pasteurized in the ordinary way, but of such fresh quality and low acidity that no neutralizer was necessary, showed that it was possible to supply the requirements of such a market. Overseas buyers who examined the butter and commented very favourably on it made special reference to the entire absence of undesirable neutralizer flavours which are observed from time to time in New Zealand butter. It was later found possible to improve the flavour still further by the addition to the high-quality fresh cream of a very small amount of starter, which serves the purpose rather of a flavour improver than an acidifier. A most important feature of this work is to ensure that only very high-quality fresh cream is used. This demands, in factory practice, the daily delivery of fresh cream.

Spreadability.—Experiments indicate that butter made from cream which is cooled relatively slowly in the last stages of the process is more spreadable than that made from cream cooled very rapidly after a temperature of about 55° F. is reached. Efforts, however, made to improve spreadability showed that great care needs to be taken to avoid greasiness of body. Further experimental work is necessary before the technique can be applied in factory practice. It has also to be pointed out that any modification in present methods of manufacture should only apply to butter which would be marketed in Great Britain during the winter months.

Cream-quality.—The trial shipments have shown that, on the average, finest-grade cream low in bacterial numbers when received at the factory produced butter of better keeping-quality than did finest-grade cream high in bacterial count.

Salt.—In assessing quality, the overseas buyers showed themselves markedly sensitive to salt; they frequently preferred butter with a salt content less than the legal limit. It is well known that different districts in Britain vary in their preferences for degrees of saltiness in butter, hence it is encumbent upon local buttermakers to study the needs of their special markets before adding salt too generously in their attempts to secure a maximum overrun.

Neutralizer.—It has been shown, too, that great care has to be exercised in the use of the optimum amount of neutralizer, in order to avoid neutralizer-flavour troubles. It has been demonstrated that unexpected differences in flavour occur when the same neutralizers are added to what looks like identical lots of cream; these results consequently require further investigation.

Colour Changes in the Surface of Butter on Storage.—It has been shown that the development of a deep-yellow or primrose colour in the surface layer of butter on storage is due to the evaporation of moisture and consequent concentration of the natural colouring-matters. The use of moisture-proof wrappings, combined with efficient sealing of the open ends of the wrapper, is a preventive measure. The development of a bleached colour which is accompanied by a tallowy flavour is already well known to be a chemical change and one of the first stages in deterioration.

Cheese.

Openness.—It has been demonstrated now beyond all doubt that openness in cheese textures cannot be attributed to any single factor, and that this defect is due to a series of contributory factors operating singly or in combination, among which are milk-supply, starter, manufacture, and curing of cheese. It has also been proved that a number of causes popularly put forth cannot be justified as the fundamental cause of the defect—*e.g.*, pasteurization, milk-test, type of hoop, type of cheese-press, &c. In order to overcome some of the difficulties met with it has become essential to make a scientific study of a part of the manufacturing process, which is still an art. This is naturally a slow and complex piece of research. The incidence of openness can be reduced by employment of particular care in all parts of the cheesemaking process, but in the present state of knowledge it cannot be entirely eliminated.

Starters.—A simple test to determine the vitality of cheese-starters has been elaborated, and this is proving very effective in assisting cheesemakers to select appropriate starters from day to day. It has been shown that by avoidance of weak starters it is possible to reduce to some extent the degree of openness occurring in cheese. In this connection there is need for improvement in the facilities available for preparing starters, holding them at constant temperatures in cheese-factories. Some work is also being followed up on the question of utilizing starters for modifying cheese-flavour.

"*Non-acid Milk.*"—A bacterium which is responsible for causing the condition known as "non-acid milk" has been isolated. Although its source has not been determined, the isolation of it and knowledge of its characteristics marks a very important advance in the practical control of development of acidity in the cheesemaking-process. Pasteurization and sterilization of affected milk, while capable of destroying the germ, is not able to destroy the substance produced by the germ. These processes actually accentuate the condition. The substance produced by the germ is extremely toxic to the starter organisms, and exerts an influence when present even to a small extent. A point of particular interest is that the causal organism belongs to the "lactic streptococci" group. This is the first recorded instance of an organism producing a substance toxic to another of the same group. The germ responsible for the non-acid condition is markedly restrained by reducing the temperature of the milk as quickly as possible after milking to at least 65° F. The extent to which this germ occurs throughout the Dominion and the part it plays in causing "slow" vats cannot be gauged, but it is possibly more widespread than is generally realized.

Mammitis and "Slow" Vats.—Curd made from raw milk received from a cow badly affected with mammitis is slow in developing acidity, and this condition prevails for some time after the mammitis itself has disappeared. In this case the trouble can be detected by the methylene-blue test or the microscope, and overcome by pasteurization.

Other Factors causing "Slow" Vats.—Investigations have shown that the individuality of the cow and the herd both play very important parts in the rate at which acidity develops in milk. There is some unconfirmed evidence that milk of high butterfat content develops acidity at a slower rate than that naturally lower in fat. From evidence which is accumulating it seems also that long spells of dry weather, accompanied by the use of dry feed, restrains development of acidity. In such circumstances the casein content of the milk is lowered and cheese-yield is depressed, but after a fall of rain, and when grass-growth again commences, the milk in the vats resumes its normal rate of acid-development.

Milk-quality.—Experiments have proved definitely that pasteurization of milk is not conducive to the production of open-textured cheese, and when milk not properly cooled, or milk not of the highest quality has been used, the great advantages of pasteurization are revealed. Though cheese from pasteurized milk is slower in developing cheddar flavour than that from high-grade raw milk, it would be deemed unwise to revert to the manufacture of cheese from raw milk until this milk had been raised in grade well above suspicion. It has been ascertained that the range of temperatures for pasteurizing should be kept between 150° F. and 165° F. and the higher the grade of the milk the lower should be the temperature employed.

Milk Composition.—The composition of the milk is much less important than its grade. Abnormal milk is distinctly harmful; for example, even 15 per cent. of discoloured milk from cows affected with mammitis when added to normal milk will result in the production of "stinker" flavour in cheese, even though the discoloured milk has been pasteurized.

High-testing milk requires more starter than that of lower test, in order to allow development of acidity to take its normal course. Various technical reasons make it more difficult to make good cheese from very high-testing milk than from normal milk. Pockets of fat occur in cheese made from raw milk, but this defect does not appear when pasteurization has been resorted to. Cheese, too,

from high-testing milk is too yellow in colour for the white-cheese trade of the United Kingdom. Cheese made from milk of abnormally low test is equally undesirable because it is too lean in body. Trials have shown that in the case of raw-milk cheese the best-quality cheese is manufactured from milk with a butterfat-test ranging between 3·7 per cent. and 4 per cent.

Cheese-manufacture.—The progress of investigations has shown that all practices designed to increase yields favours the development of openness in texture. Cheeses kept in the press for three days, accompanied by daily relaxing and renewing pressure, are definitely closer than cheeses pressed only for one day.

Temperature of Curing-rooms.—Experiments have shown the importance of paying due attention to the temperatures at which cheese matures in curing-rooms. In spring-made cheese, temperatures should always be maintained about 55° F. to hasten the ripening-process. In summer, however, when atmospheric temperature is high, 65° F. should be regarded as the upper limit of safety. Temperatures in excess of this figure have a detrimental effect on cheese-quality.

Discoloration.—Four types of discoloration are under investigation—viz., "mottling," "pink," "bleached," and "muddy." It is possible that the various colours are variants of one. "Mottling," which appears in the form of waves round the original curd particles, frequently arises very shortly after the cheese is made. The other forms of discoloration do not appear till the cheese has undergone considerable ripening. High curing-temperatures favour all forms of discoloration. Pink, bleached, and muddy discolorations are frequently associated with bad flavours and generally start near cracks or openings in the cheese. Investigations to date suggest that the cause of discoloration is bacterial, but the causal organism or combination of organisms has not been determined. Some experimental cheeses made from milk infected with discoloured cheese, and which were allowed to develop cracked rinds, showed discoloration in the vicinity of the cracks, while others of the same make, with sound rinds, showed no evidence of discoloration until some time after they were cut. These trials have shown how important it is to have cheese well bandaged so that the surfaces remain intact and free from cracks.

Dissemination of Results.

In order that the work of the Institute may be translated into practice as rapidly as possible, a course for factory-managers is held at the Institute each year during the first week in May. In view of the very direct contact of factory-managers in the manufacturing processes of the dairy industry, this provides a ready way of rapidly putting into practice new knowledge gained through the research activities of the Institute.

In addition, a monthly bulletin has been regularly supplied to the principal dairy journals of the Dominion. The following are the list of the principal separate publications issued by the Institute during the year:—

"The Effect of Salt on the Quality of Cheddar Cheese," by Riddet, Valentine, McDowall, and Whelan.
"Factors affecting the Rate of Ripening of New Zealand Export Cheese," by Riddet, Valentine, McDowall, and Whelan.
"The Distribution of Salt in Cheddar Cheese."
"The Influence of Bacilli of the Colon Group on the Production of Acid by *Lactic Streptococci* in Milk."
"Slow Development of Acidity in Cheese Manufacture."

PLANT RESEARCH STATION.

The Plant Research Station is conducted in co-operation with the Department of Agriculture. The work is under the direction of Mr. A. H. Cockayne, and is conducted principally at Palmerston North and Marton. This report deals only with those sections of the work at the Plant Research Station which receive assistance from the Department of Scientific and Industrial Research.

Mycological Section.

I. *Brassica Diseases.*

(*a*) *Dry-rot* (Phoma lingam).—A series of eleven trials with a total area of 300 acres, sown in various localities with swede-seed which had been disinfected, demonstrated the efficacy of the treatment by the resulting crops being entirely free from dry-rot. Arrangements are now being made to grow turnip and swede seed within the Dominion, so that stocks of clean seed will be available. For this purpose the Herning type of swede has been selected on account of its resistance also to club-root.

(*b*) *Club-root* (Plasmodiophora brassicae).—Work during the year has been concentrated upon the production of resistant strains of swedes, turnips, and rape and in improving methods of increasing resistance by the use of lime. Resistant strains under tests are several selections of swedes—*e.g.*, Station Herning, Superlative, and Canadian selections of Herning; in turnips, the variety Bruce, of Scottish origin; and, in rape, three selections made at the Plant Research Station.

In these trials local selections of Herning have proved to be the most resistant and showed an immunity greater than that displayed by the mother line. The local selection of Superlative, while showing high resistance in the preliminary tests, gave indifferent results when tested on a field scale.

The turnip Bruce has proved moderately resistant in the South Island. While selected resistant strains of rape have shown distinct promise, work in this connection has not proceeded beyond preliminary trials. It has been found that a practical control of club-root could be secured on land moderately affected, by the application of 33 cwt. of burnt lime applied three months in advance of sowing the crop, followed by drilling with the seed basic slag or with a mixture of equal weights of superphosphate and slaked lime.

It has been found that club-root spores will remain in a live condition in the soil for at least three seasons, and that weeds such as shepherd's purse may act as host plants during this period.

II. *Cereal Diseases.*

In view of the need for cleaning the wheat variety Jumbuck of smut disease, it has been found that a modification of hot-water-treatment method will be necessary, as this variety is very susceptible to germination injury when dealt with by the standard methods. Trials are in progress with copper carbonate and organic mercury compounds in order to test out their efficacy as controllants of smut disease.

Studies of the biotypes of cereal rusts present in the Dominion have been commenced as a preliminary to the production of more resistant types of cereals and grasses, as it is considered that protection from these diseases cannot be secured by any form of chemical treatment.

III. *Potato Diseases.*

Work on the wilt diseases of potatoes has been completed, and four years' investigations have revealed the presence of fifty types of fungi, very few of which, however, were actually responsible for the wilting of the haulms. A report on the work will shortly be published.

Internal brown-fleck disease, common in Northern Star and Victory potatoes, has been investigated, but the work has not been productive of any conclusions, except that tubers grown from infected seed show a marked tendency to development of the trouble.

A small line of virus-free potato-seed, covering four varieties, is now being grown in a selected area for the purpose of providing virus-free seed for commercial distribution.

IV. *Diseases of Legumes.*

Collar-rot of peas has now definitely been proved to be a seed-borne disease, which does not persist in the soil for more than a limited period, and that crops free from the disease can be secured by the use of clean seed. Steps are being taken to provide nucleus lines of such seed.

Bean wilt has been largely controlled by a method of seed-treatment, but further investigations are yet necessary to render this control more complete.

Sore-shin of lupins has been investigated by treatment with various chemical disinfectants, but no satisfactory control has yet been devised. The demand for lucerne cultures has shown a marked increase during the year. A sufficient quantity of the culture has been distributed to inoculate 69,500 lb. of seed, an increase of 80 per cent. over the previous season. These cultures were forwarded to 1,037 farmers, an increase of upwards of 40 per cent. over last season.

Attempts are being made to extend this work to cover the nodule organisms occurring on white and red clover.

V. *Cheese and Butter Moulds.*

Work has been commenced on the various moulds connected in particular with discoloration of cheese and butter.

VI. *Forest-tree Diseases.*

A disease survey of the exotic plantations of the State Forest Service was conducted during the year, and it was found that *Phomopsis Strobi* was located on *Pinus radiata* regions subjected to severe winter conditions.

Diplodia pinea was found to be responsible for serious losses in seedling *Pinus ponderosa* in nursery-beds. This disease also was in evidence in young stands of various pines, when unfavourable conditions were experienced following planting, and in older trees where unseasonable frosts were experienced.

Another form of Phomopsis was found to be responsible for serious losses in nursery stock of *Cupressus Lawsoniana* and *C. Macrocarpa.*

VII. *Fruit-tree Diseases.*

Detailed chemical investigations and orchard trials have been carried out during the year with specifics containing sulphur, lime sulphur, and copper. As the result of these experiments many orchard-spray practices have been profoundly modified and useless sprays discarded.

In the field-work some five hundred experiments were conducted with a view to testing out different sprays and spray practices. Other investigations have been made into fruit-tree canker and in regard to fungous diseases in cold stores.

Investigations of the strawberry disease have revealed the presence of a serious virus in New Zealand. Consequently attempts are being made to raise virus-free strains of these plants.

Five different diseases of tomatoes are also under investigation.

VIII. *Silage.*

With a view to improving the quality, process of manufacture, and palatability of silage a series of experiments has been commenced, and it has now been ascertained that sweet and green silage can be made when cultures are used, that the product can be improved by the addition of molasses, and that by the use of the Virtanen process (which involves the application of certain acids in dilute solutions), a good-quality silage can be produced. The cost of acid, however, makes it use in New Zealand prohibitive.

IX. *Grass and Clover Diseases.*

Owing to defective germination appearing as a serious trouble with certain lines of perennial rye-grass seed, investigations are proceeding to ascertain whether four fungi, found in association with such seed, are in any way responsible for the reduction in vitality.

Owing to variations occurring in rust-immunity in certain lines of selected perennial rye-grass, steps are being taken to ascertain whether rust-resistant lines may be selected.

Agrostology Section.

The investigations of this section have been continued along the lines of searching for desirable strains of all forms of pasture plants, and during the year an additional 1,000 plots of perennial rye-grass have been set out for trial. In these trials are included special selections from the best lines at present being grown, with the object of securing elite strains for future development.

It has been demonstrated from an extensive trial that a negligible amount of deterioration occurs in perennial rye-grass plant type when grown from lines once removed from mother seed. This information has an important practical application in connection with commercial-seed production.

Italian Rye-grass.—Work has commenced upon the strain-characteristics of Italian rye-grass and allied types such as Western Wolths and Wimmera. Three main strains of Italian rye-grass have been selected for further investigation.

Strain investigations are also proceeding with cocksfoot, Yorkshire fog, brown-top, and paspalum.

White Clover.—Strain work with white clover has advanced on parallel lines with that done in connection with perennial rye-grass, and in some elite-strain selections that have been made it has been shown that some of these are as much as 45 per cent. better than the standard certified mother plants.

In order to proceed further with white-clover investigations, a series of crosses was made from various types which reacted differently in regard to their HCN content.

Red clover has also been subjected to strain selection investigations, and, in addition, a number of crosses have been made between desirable types of plants.

Similar work is also proceeding with subterrannean clover and *Lotus major*.

Chemical Section.

The investigations of the Chemical Section have dealt largely with analyses of the samples collected from mowing-trials on the Marton plots. These involved analyses to indicate—

(1) The effect of heavy infrequent against light frequent applications of lime, on the chemical composition of the herbage, and on the lime and phosphate status of the soil.
(2) The effect of various nitrogenous fertilizers, when applied at the same time as superphosphate, compared with the effect of these same fertilizers applied so that the date of application of the nitrogenous fertilizer is some months different from the date of application of the superphosphate, on the chemical composition of the herbage, and their effect on the soil.
(3) The effect on the chemical composition of the herbage and on the phosphate status of the soil of superphosphate, basic slag, and North African phosphates when applied with lime and without.

Chemical Method of determining Type in White Clover.—Some 500-odd samples of white clover herbage have been analysed for potential hydrocyanic-acid content. The percentages of HCN of these have been examined with reference to the type notes made by the Agrostologist. It has been found that an excellent correlation exists, and tentative standards for HCN content have been set to correspond with the standards set for the eye determination of type. It is considered that this determination, when used in conjunction with the eye assessments, will render the determination of type more easy. A preliminary paper dealing with this method is in the press.

General Work.—A number of samples of linseed selections were analysed for oil content for the Agronomist, and an investigation into the chemical composition of various rape types as affected by sampling at different stages of growth is also being carried out for this officer.

Botanical Section.

During the year work on the revision of the systematics of the grasses of New Zealand and of the alien flora has been continued to the extent that the manuscript of two publications has almost been completed. At the same time an introductory book on the grasses of New Zealand has also been prepared.

Investigations have continued into the supposed poisonous plants which have allegedly caused mortality in stock. Particular attention has been devoted to bringing the herbarium up to date, and a considerable number of exchanges have been arranged with overseas stations. The investigation on Northern Spy root-stocks has resulted in the isolation of nine types for further study. These are being propagated and their influence on different scions will be tested out during the coming year.

WHEAT RESEARCH INSTITUTE.

DIRECTOR'S REPORT.

Advisory Committee: Professor H. G. Denham, Chairman. Wheat-growers—Messrs. Jas. Carr, W. W. Mulholland, P. R. Talbot; flour-millers—Mr. R. K. Ireland, R. J. Lyon, W. S. Pratt; master bakers—Messrs. C. E. Boon, F. H. Hawker, and J. G. Laurenson; grain-merchants—Mr. A. Jones; Lincoln College—Mr. C. H. Hewlett; Department of Agriculture—Mr. J. W. Hadfield; Department of Industries and Commerce—Mr. A. G. Cannons. Director of Research—Dr. F. W. Hilgendorf.

Plant-breeding Station, Lincoln.

1. *Imported Varieties.*—A constant stream of imported varieties of wheats are on trial, and to date some 2,200 have been tested out under New Zealand conditions, but none of these have shown promise of surpassing local standard varieties in both yield and quality. Some of the foreign wheats have, however, possessed a distinctly high quality, but their yield has been low. Their high-quality factor, however, has made them useful for crossing purposes with low-quality high-yielding local varieties. During the year wheats from Sinai, Iraq, and India have been used for crossing purposes for the first time. It is worthy of notice that recent successful Australian new hybrid wheats have originated mostly from Indian parentage.

2. *Crossbreeding.*—(*a*) Cross 7: Tuscan × White Fife has reached its eighth generation, has been reduced to five lines, and has been subjected to field trials in six localities. On the average it has yielded as well as Tuscan, gives 2 per cent. more flour, and has produced a 10-per-cent. better loaf. A further and more extensive trial in twenty-five localities has been planned for the coming year, and if the results continue to show promise seed will be made available for general distribution through the Pure Seed Station of the Department of Agriculture at Lincoln. Here a stock of pure seed of Cross 7 has been produced, reselections have been made and tested again in order to maintain adequate supplies to fall back upon when seed from the original distribution becomes mixed.

(*b*) Cross 17: Tuscan × Marquis hybrid is now in its fifth generation, and has been reduced to 165 lines, which were tried in rod rows replicated ten times, with a standard used every fourth row. Of the 165 lines, some forty appeared to equal Tuscan in yield, but the Laboratory trials for quality do not give particularly favourable results. However, the baking-trials gave good results, and so this cross, now reduced to forty lines, will be given further trial.

(*c*) More recent crosses have given generally disappointing results, very few of the segregates approaching Tuscan in yield. Consequently, in order to improve the yield-factor, they have been crossed back to Tuscan.

In December, 1932, 6,700 crosses were made, and from these 6,200 fertile grains have been secured; 2,900 of these were first crossed between Tuscan and various foreign wheats imported from Canada, Australia, Sinai, Iraq, and India. The remaining grains were secured from back crosses.

3. *Laboratory Tests.*—The absence of reliable tests for quality in wheat, when only the few ounces derived from the plant-breeder's activities are available, still holds up progress in producing varieties of wheat of high quality. Baking-tests require at least 6 lb. of grain, and reflect the acquired, as well as the hereditary, quality of the sample. The distensometer test, though it can be made only on a few ounces of grain, is slow, laborious, and applicable only to a fraction of the flour. It shows a high degree of efficacy in picking out the inheritable gluten quality.

During the year a new test, the Pelshenke, a modification of the Saunders test, has been utilized. This test is more rapid than either of the others, requires only a few ounces of wheat, and uses wholemeal instead of flour. Facilities are now available in the laboratory for testing forty meals, in triplicate, at the same time, in a fixed-temperature cabinet. Over one thousand meals were tested during the year, about one hundred of these samples being tested also by distensometer, and actual baking permitted comparison of the results of the three methods to be made. The conclusion drawn is that the Pelshenke test is eminently suitable for the determination of large differences in quality, but does not possess the reliability of the distensometer for finer work.

The haphazard introduction of new wheats by travellers has often caused considerable loss. The new introductions are usually grown under special conditions at first, and appear to be high yielders, so that they attain popularity and quickly spread over a considerable area. They then are often found to be unsuitable to general farm practice, either because of low yield or low quality, but this discovery is not made until after a costly experience. The Institute has, in its collection of over two thousand varieties, all wheats that are likely to be intoduced in this way, and farmers and merchants now look to the Institute for guidance in this matter, instead of making expensive large-scale experiments for themselves.

The question of the quantity of wheat seed to sow per acre is one on which farm practice has reached no general conclusion, different growers using from 1 bushel to 2½ bushels of seed per acre on exactly similar land. The Institute has shown that these variations are due to differences (1) the kind of pickle used, and (2) the evenness of the action of the drill; and instructional work is being undertaken to improve these points in farm practice.

An investigation in soil-moisture was undertaken during the year to supplement the ordinary observations on rainfall and evaporation. When these observations have been continued over several seasons it is expected that they will lead to more accurate forecasts of yield and perhaps to modification of farm practice.

Cereal Laboratory, Christchurch.

The staff at the Cereal Laboratory, Christchurch, where the milling, baking, and chemical testing and research are in progress, had, on account of the peculiar climatic conditions, an unusually large amount of work to do in connection with the 1932 harvest. Millers handling the 1932 season crop found it exceedingly difficult to produce flour satisfactory to the bakers, but a large number realized that the Institute could provide guidance in the direction of blending of wheats which would assist them to overcome some of the difficulties with which they were confronted. Samples accordingly poured into the laboratory, so that it became necessary to run the mill two shifts a day and employ an extra miller.

In 1931 the total number of samples milled amounted to 690, and this was considered a good performance, but in 1932 the numbers rose to the remarkable total of 2,497. In consequence of the large increase made upon the services of the Institute, valuable assistance was rendered in many cases whereby millers were enabled to maintain a relatively satisfactory quality of flour, and the bakers and the public were saved from the worst effects of probably the most difficult wheat-ripening season known in the history of New Zealand.

In South Canterbury and North Otago floods at harvest-time succeeded the drought during the growing season, and great quantities of sprouted wheat were put on to the market. There was naturally a reluctance on the part of millers to buy such wheat, and it became their rule to submit most lines to the Wheat Research Institute before purchases were completed. It was estimated that samples totalling 150,000 bushels of sprouted wheat were dealt with by the Institute, and as the result of the tests carried out approximately 85,000 bushels, which otherwise would have been rejected by millers on the usual tests applied, were found to be still suitable for milling purposes. Farmers were thus enabled to dispose of such grain at milling prices.

The plant-breeding department, in collaboration with the Department of Agriculture, has made many attempts to find a wheat of high quality that would, under some special conditions of soil or climate, give a payable yield. For instance, Marquis was included in elaborate field trials over nine years in fifteen different localities, but failed to give a constantly payable return anywhere. The wheat that promises to fulfil the requirements has now apparently been found by the Laboratory Branch. It is Jumbuck, which has been grown on a small scale in a few localities for many years, but its cultivation did not spread because it did not appear to have any outstanding merit of any sort. It was a fair yielder, but its baking-quality was not known because the quantity of it that any miller was able to include in his grist was so small that it made no difference to the resultant loaf. However, when the millers started to send to the Institute samples of individual wheats to be milled and baked it was found that Jumbuck was by far the best-quality wheat grown in New Zealand, and this has encouraged its cultivation to a marked degree. The area under Jumbuck during the 1932–33 season probably exceeded 5,000 acres. The yield from eighteen farms in the Manawatu averaged 48 bushels per acre, and from fifteen farms in Ellesmere 55 bushels per acre. Thus Jumbuck is obviously a satisfactory yielder in such a season as that of 1932–33, and its quality equals or surpasses that of any Canadian wheat grown in New Zealand. It is possible that the discovery of the high baking-quality of Jumbuck may, to a considerable degree, solve the chief difficulty of improving the quality of the average of the wheat grown in New Zealand.

The 1932 wheat, to whose quality reference has previously been made, was produced under conditions of abnormal drought during the ripening-period. The grain dried off, rather than ripened, and to this fact is ascribed the subsequent difficulties in the bakehouse. Wherever special areas had normal or nearly normal spring rains, the wheat and flour produced were of normal quality, and even special fields where moisture content was kept up by special cultivation, gave a satisfactory product. To avoid droughts in the future is beyond our skill, but the lessons of the 1932 harvest have shown that after specially dry summers extra care must be taken in the blending of wheats for flour-manufacture, and that with this extra care the worse effects of drought on flour-quality can be avoided.

General.

The Institute has maintained a regular contact with all sides of the wheat industry. Co-operation with the Department of Agriculture has enabled the Institute to provide valuable fundamental assistance in regard to seed certification. Consequently, the quality of seed now in general use throughout the wheatgrowing districts has greatly improved regarding its purity and freedom from various diseases. The association between the Institute and the Department of Agriculture, in connection with seed certification, field trials involving manurial treatments, and varieties, has proved most valuable, and has been the means of modifying the growing of wheat to a marked extent.

The Institute, in its collaboration with the milling industry, has enabled several new side-lines of the industry to be developed. Examples of these may be quoted in the production of wheat malt, the preparation of wheat derivatives rich in vitamin E, and the general development of the wheatmeal industry.

The work of the Institute has also assisted in clearing up the question of stock-feeds derived from wheat and other cereal products, so that useful information is now available for any extension of concentrated feeding of stock which may be in contemplation. The Institute has handled a large number of inquiries from bakers throughout New Zealand, who have referred to it specific problems which have arisen directly in ordinary baking practice. Regular articles have been supplied to the press, and particularly to the *Bakers' and Grocers' Review*, which reaches a large number of bakers, regarding measures which may be adopted with advantage in baking practice.

Similarly, a great deal of work has been done for millers on other lines than those mentioned above, in connection with the difficulties arising out of the 1932 harvest. Wheatgrowers have been assisted by numerous moisture and other tests made of their grain, replies have been received to many direct inquiries, and regular articles have been contributed to the press in the wheatgrowing districts concerning points of interest in the growing and production of good-quality wheat.

The Act establishing the Institute expires at the end of 1933. The contributory bodies have all been consulted as to their willingness to continue their levies, and the replies to hand have been almost unanimously favourable. Cabinet is to be requested to bring down legislation to carry the Institute on for another five years.

NOXIOUS WEEDS RESEARCH.

Advisory Committee: Professor H. B. Kirk (Chairman), Mr. A. H. Cockayne, Mr. Q. Donald, Dr. F. W. Hilgendorf. Director of Research: Dr. David Miller.

Though the period of the Empire Marketing Board's grant for the furtherance of biological control of weeds expired on the 31st March, 1932, there was an unexpended balance sufficient for prosecuting the researches on a modified scale for a further twelve months; the Board consented to this balance being so utilized. On the 31st March, 1933, therefore, the funds for Noxious Weeds Research ceased; however, as researches in relation to ragwort and piripiri have reached a critical stage and show possibilities of giving positive results, it is understood that Dr. Miller has made other arrangements for continuing the activities after the expiry of the grant.

During the year the major activities were confined to the work on the ragwort seed-fly (*Pegohylemyia jacobaeae*) and the piripiri saw-fly (*Antholcus varinervis*). In the case of the former a very large consignment was received during November from Farnham Royal; so far it has been found that a fly will usually place only one egg in a head, and the maggot developing from the egg will destroy all the seeds in that head. The evidence gathered to date shows the great possibilities of this fly as a check to the seeding of ragwort. With regard to the piripiri saw-fly, the season's operations further confirm the importance of this insect as a factor in markedly reducing the burrs of the weed; in this alone the insect would play a very important role, but if it became sufficiently well established it would also act as an invaluable check to the whole plant.

Although lack of funds prevented a field survey being made, it is believed that the gorse-seed weevil (*Apion ulicis*) is establishing in the areas where it was liberated in Otago. Owing to the unseasonable flowering of gorse in most parts of New Zealand it is in the Southern districts alone, where flowering takes place in the summer, that the weevil will have an opportunity of actively checking the seeding of gorse.

The utilization of the Buprestid beetle (*Coraebus rubi*) against blackberry has been considered unsafe owing to the tendency of the beetle to attack the foliage of apple-trees. Furthermore, though blackberry-canes are heavily infested by the larvæ, it has been found that the canes are capable of developing fresh shoots even from points within the region damaged by the insect.

The researches carried on into the biological control of noxious weeds in New Zealand during the past six years have brought to light many features of biological importance, and, in the face of many negative results, have resulted in showing that there is every possibility of two species of weeds—ragwort and piripiri—out of the four dealt with during the researches, being successfully controlled, while a partial success is to be expected in the case of a third (gorse).

PHORMIUM RESEARCH.

1. The work done during the past year has been only such as could be carried out at a minimum of expense. Nevertheless, the scheme outlined at the beginning of the investigations has progressed in a general way according to plan. The provision of labour under No. 5 Scheme of the Unemployment Board has enabled a great deal of work to be done at low cost.

2. *Selection and Testing of Varieties.*—The primary object of the investigation was, of course, to select the best varieties after comparative tests of their cropping-power and fibre qualities. This work had resulted in the collection and planting of over 250 varieties before the depression set in. Subsequent work on these varieties has fortunately involved little expense up to the present, since it has been necessary to await their growth to millable age. Nevertheless, a great deal of useful information has been gathered by observation of these plants with respect to such features as vigour of growth, habit of growth, susceptibility to disease, and the date and frequency of flowering. So far as yield and quality of fibre are concerned, it has been possible to obtain only a rough idea by using the Maori hand-stripping method.

From such observations it has been possible to narrow down to some twenty or thirty the varieties which are worthy of more careful study as fibre plants. Many of the others are likely to be of use in breeding work, so that as a rule three or four plants of each are still kept.

A stage has now been reached, however, at which it seems necessary to arrive at some decision as to the future course of the work on these plants. The area of 1 acre of the Ngaro variety has now been planted four years. In spite of its having been set out in land which is not normally considered ideal for flax, this area has grown well and should be cut and stripped in the coming season. Its fibre should be worthy of sending for thorough tests abroad, and the fans can, if necessary, be broken up to plant as much as 12 acres. In yield of leaf and fibre quality combined, this is probably the best commercial variety available. The fear that yellow-leaf disease would ruin the crop has not been realized. A few plants in the area were killed by the disease, but the remainder are growing well, in spite of the land being of a type which is particularly favourable to development of the disease.

Numbers of other excellent varieties, including No. 159 (S.S.), No. 22, and No. 37, have been propagated by fans, so that in about two years there will be enough of each to plant 1 acre and at the same time provide a bulk sample of fibre for commercial trials. These three are all characterized by great strength of fibre and apparently by resistance to disease. No. 37 in particular promises to yield a heavy crop.

Numbers of other promising varieties are now grown to mature bushes, and should be tested at a mill next season before propagating them further.

This aspect of the work—namely, the collection of promising plants—should not be regarded in the least as being complete. There is now available sound knowledge on the sources of desirable varieties, and as soon as financial considerations permit further collecting should be done. This matter is rather urgent, since the plants in these particular spots are rapidly being destroyed.

3. *Inbreeding of Varieties; Pedigree Seedlings.*—The testing of seedling plants from different varieties was the second aspect of the original scheme. The object of this part of the work was to find whether or not any of the better-quality varieties could be grown from seed with a reasonable chance of securing trueness to the type of the parent bush. It has already been reported that no flax plant has yet been found which can be considered to breed true from seed. The pedigree seedlings are now almost mature bushes, and the above statement can be amplified. In general it may be said that there is a very marked similarity between parent and offspring in such features as vigour and habit of growth and in date of flowering. Rows of seedlings from one parent show a marked uniformity in these respects, and usually can, in bulk, be readily distinguished from adjacent rows of seedlings from other parents. Closer examination, however, reveals considerable differences amongst seedling plants of an apparently uniform row. As an instance may be taken the date of flowering. Observations last year showed that in an area of one variety (Ngaro) planted out from fans, the one hundred or so flowering stalks reached the same stage of development within a total range of time of four or five days. On the other hand, within any one row of seedlings from a given parent, there was usually a range of about three weeks in the development of stalks on the various plants.

In other characters, such as vigour and habit of growth and colour of leaf edge, there are also differences to be found within each row of pedigree seedlings. Such differences will be noticed only on close examination, and to a casual observer it might well appear that these varieties breed quite true to type. Without careful milling-tests of hundreds of individual plants we cannot say to what extent these seedling plants are true to type in the most important feature of all—namely, fibre-quality.

The above conclusions regarding inheritance are true only so far as most varieties are concerned. Certain other varieties are characterized by a more obvious failure to breed true. These varieties include, unfortunately, the best fibre plants so far found. The seedlings show extremely wide variations in habit and vigour of growth, in colour, and in fibre-quality. Not 1 per cent. of the progeny could be said to resemble the parent. The extent of this variation naturally emphasizes the need for vegetative reproduction by fans if a uniform and high-grade crop is to be produced. At the same time, by repeated inbreeding, there may in the long-run be secured progeny of the required quality which will breed true from seed. Such work is being carried on, but results cannot be expected in less than another five years.

From another point of view also this inbreeding work is necessary. In order to build up hybrid strains combining all possible desirable features it is necessary, first of all, to secure as parent, plants for crossing varieties those which contain only certain inherent qualities. For instance, as one parent of a cross, a plant might be needed which could be relied on to confer disease-resistance and fibre-strength on all the offspring; as the other parent would be needed a plant which would throw only high-yielding seedlings. It is only by inbreeding and careful testing over many years that this stage can be reached. In addition, by careful testing of inbred plants it should be possible to find out the manner in which important characters are inherited. Such knowledge provides eventually the most reliable method of building up new hybrid strains. At present, for example, it is not known how fibre-strength is inherited. Strong-fibred plants often throw many weak-fibred seedlings, but it is not known if a weak-fibred plant can throw strong-fibred seedlings. Nor can the result of crossing a weak-fibred with a strong-fibred plant be predicted. All this information must be obtained by careful breeding, testing, and recording—a most laborious task when thousands of plants must each be tested and recorded separately.

Regarding the inheritance of certain characters such as leaf-colour, which can be studied without extra help or expenditure, steady progress is being made, and it is hoped that a paper on the subject may be published in the next year or two. The fact that Phormium plants rarely flower before the age of five years makes the work comparatively slow.

4. *Hybridization.*—The third section of the breeding-work is that concerned with the raising of new and superior plants by hybridization. This part of the work has been pushed forward most energetically and about twenty thousand seedling hybrid plants aged from one year to five years have been raised. These represent the best plants from a still greater number, for at about the age of two years all but some 10 per cent. of the best hybrid seedlings are destroyed. Twenty or thirty of the oldest hybrids are now ready to be tested and, if suitable, to be broken up and set out for a further test of yield and resistant to disease.

Some of the crossing has been done chiefly with a view to obtaining information on the inheritance of various characters—knowledge which will at a later stage hasten the work of producing superior hybrid plants. One type of hybrid which is very interesting and likely to be useful is that between *Phormium tenax* (the fibrous species) and *Phormium Colensoi* (so-called mountain flax). It has long been obvious that these two species must inter-cross in nature, but now well-grown plants resulting from artificial pollination of *P. Colensoi* by *P. tenax* have been raised. These plants are definitely much more vigorous in growth than other seedlings resulting from self-pollination of the same plant of *P. Colensoi*. In such features as leaf-edge and fibre-strength they appear to be roughly intermediate.

The reciprocal cross using *P. tenax* as female parent has also been successful. Several hundreds of these hybrids between the two species are being grown. By inbreeding from them it is hoped finally to secure a good fibre type with the uncoloured and almost unthickened leaf-edge and keel of *P. Colensoi*.

5. *Manurial Trials.*—The results from these trials at the Flax Research Station and at the Miranui Mill, near Shannon, cannot be judged by eye. Both of these areas are now ready for actual tests of yield. The results from the Massey area would have much more significance than those from the Shannon area owing to complete uniformity as to the variety of plant. The work of cutting uniformly, weighing, labelling, carting, and following all the various lots through the milling processes would entail considerable expense and the help of a trained assistant. The area in question is that planted with the Ngaro variety, which it is desirable to strip for other reasons also.

There has been no chance of inspecting the trial areas at Gordonton, in the Waikato, and it is therefore impossible to say how the trials have progressed there.

6. *Yellow-leaf Disease.*—Work on this disease for the year has been confined to the breeding of resistant strains and to observations of the susceptibility of different varieties to the disease. Yellow-leaf disease occurs in most of the trial area, so that all strains of flax are subject to attack. It is very noticeable that plants of one variety may show a high percentage of deaths from it, while plants of other varieties nearly either take the disease lightly and recover, or show no signs of infection. The bulk of the hybridization work is, of course, aimed at conferring resistance on otherwise satisfactory varieties.

7. *Fibre-testing.*—The main work in strength-testing of fibre was done in connection with fibre bleached artificially under a new process by Mr. J. Nightingall, of Auckland. The artificially bleached fibre was superior in colour and strength to control lots bleached in the ordinary way. After several months' storage the chemically bleached fibre shows to still greater advantage, having retained its good colour, while the control lots have turned yellowish.

8. *General.*—The point concerning this work which most needs emphasizing at the present time is that a definite stage has been attained beyond which but little progress is possible with the present staff and equipment. Without regular facilities for tests by complete processing of raw material, followed by strength tests, further selection and breeding work will be severely checked. The problem of the best place and method for the further increase of the best-quality strains must also be considered. The Ngaro is now ready to plant as much as 12 acres, and each year now new and excellent strains which need to be grown on a large scale for trials will become available. It seems necessary to propagate these in a neighbourhood from which transport of fans to commercial areas will be as cheap as possible. The reports of fibre-growing in other countries are considered by European fibre-merchants to indicate a certain fibre-shortage within three years. The fact that the fibre industry in other countries is unable to survive with present price-levels show that an energetic policy in New Zealand hemp has every prospect of success. The progress being made in Phormium growing in foreign countries, and the repeated efforts to secure our good varieties in bulk, indicate what other people think of this plant.

During the year co-operation was effected with the Native Department in procuring and removing to suitable land enough fans of the "S.S." variety to plant 1 acre. This variety has very strong fibre and is resistant to yellow-leaf disease. The plants are intended to be the nucleus of a commercial plantation under the control of the Native Department.

Thanks are due to the following donors for plants of rare and valuable varieties: Sir Apirana Ngata, Gisborne; Mr. W. J. Broadfoot, M.P., Te Kuiti; Mrs. Carroll, Wairoa, Hawke's Bay; Mr. H. Bunn, Whakatane; Mr. H. W. Christensen, Matakohi; Mr. G. McGregor, Ranana; Mr. H. Moore, Putaki; Mr. A. Seifert, Palmerston North; Mr. B. B. Wood, Wellington.

A chapter on the New Zealand hemp industry has been written for publication in a work entitled "Land-utilization in New Zealand," which is being published by the Institute of Pacific Relations. In the preparation of the article the writer was greatly helped by Mr. A. Seifert. Sincere thanks are due to the various flax-millers who have shown their usual willingness to help wherever possible.

J. S. Yeates, Botanist.

MINERAL CONTENT OF PASTURES.

EXTRACTS FROM FIFTH ANNUAL REPORT, DEPARTMENT OF AGRICULTURE.

Mr. B. C. Aston, Director of Research.

A notable feature of the year's work has been the extended use of limonite as a stock-lick in districts recognized as affected with bush sickness, and also in those districts where bush sickness is suspected. The good results appear to be due to (1) the power of limonite to correct iron deficiency, and (2) the tonic effects of iron, leading to a suppression of intestinal parasites.

The use of limonite as a lick for preventing and curing bush sickness has now become standard farming practice in the affected districts. It will be realized how important the discovery of the efficacy of the limonite salt lick has been when it is recognized that some 8,000 square miles, or one-fifth of the total area of the North Island, is comprised of air-deposited rhyolite pumice, on over half of which, or more than 2,500,000 acres, bush sickness has been found to occur to an extent which renders farming practically impossible.

Over the remaining portion of the pumice area there are also districts where symptoms of the disease have appeared from time to time, and consequently the full extent of the affected soils is not definitely known.

At Tokoroa, which is situated on pumice soil affected with bush sickness, the average butterfat-production per cow has shown a remarkable increase as a result of the relative using of limonite lick. On one farm the following results were secured :—

	1931 (No Limonite).	1932 (Limonite).
September	17 lb. per cow.	32 lb. per cow.
October	24 ,,	45 ,,

It has been found that not all forms of limonite give satisfactory results. Up to the present time that secured from Whangarei, provided it is sufficiently finely ground, has given consistently good results.

Sheep Experiments.

The sheep used in the experiment at Atiamuri have continued to respond very favourably to the limonite treatment. Ewe hoggets reared in 1931–32 developed into perfectly grown specimens and yielded, on the average, 11·5 lb. of good-quality wool. The mothers of these hoggets, after rearing their second lot of lambs, were killed for consumption, and provided dressed-carcass weights ranging between 80 lb. and 98 lb.

In an experiment in the Kaharoa district, where the soil was of a character which rendered it particularly bad as regards the incidence of bush sickness, thirty limonite-fed ewes, which were mostly broken-mouthed and had failed to rear any lambs the previous year, in the following season developed excellent condition and reared 100 per cent. of lambs, the wethers from which averaged, when dressed, about 32 lb. The ewe lambs are being retained for breeding purposes. A comparative line of ewes kept on the same farm, and not treated, have shown a 90-per-cent. mortality, and their progeny suffered a still higher mortality.

Instances may be quoted of the successful use of limonite in areas bordering the distinctly bush-sick areas. At Putaruru a farmer who in 1931–32 was able to send only 600 out of a line of 3,000 lambs to the freezing-works was able, after he adopted the limonite treatment in the following year, to send all his 3,000 lambs away fat. The cost of treatment for the entire flock, ewes and lambs, was under £20.

Further reports of the good results attaching to limonite treatment have been received from the Bay of Plenty and Gisborne districts. In these cases good results are appearing where the lick has been used for stock which were not definitely liable to bush sickness. One of the drawbacks of the entirely efficient use of the limonite salt mixture is attributable to the spread of ragwort in districts affected with bush sickness. In these instances the toxic effects of the ragwort outweigh the benefits of the lick. Consequently trials are also being conducted with various sprays, in particular with ammonium thiocyanate, as a means of combating the ragwort menance.

Mairoa Experiments.

Stock experiments in the Mairoa district, where "dopiness" was prevalent and attributable to lime and phosphate deficiency, were brought to a conclusion. Briefly, the results of the experiment showed that sheep grazed on a plot which had been treated with 40 cwt. carbonate of lime plus 4 cwt. superphosphate per acre stood out well above others in appearance, being healthier and stronger, their average increase in weight over the period of the trial being 32 lb.

Other treatments consisted of 5 cwt. of lime plus 2 cwt. of super and 3 cwt. of lime plus 2 cwt. of super, but with these lighter dressings a certain amount of unthriftiness appeared. The conclusion was reached that the Mairoa type of soil required both lime and phosphate, with a considerable excess of lime, in order to secure maximum healthiness.

Morton Mains District Southland.

Deficiency diseases have also appeared in this district. The use of the limonite salt lick has, however, given good results, and it has been possible to secure drafts of fat lambs from flocks which have been given access to this lick while grazing on those blocks.

Analyses of the pastures grown in the district have shown them to contain a high content of manganese, and it has been thought that this element may play some part in withholding the iron from being assimilated.

Metabolism Experiments with Sheep.

These have been conducted by Dr. I. J. Cunningham at the Wallaceville Veterinary Laboratory. Investigations have been directed to test the supplementary value of various calcium and phosphorus containing materials, these being fed to supplement a basal diet of poor-quality hay.

The conclusions reached may be summarized as follows : Lambs fed a hay of low nutritive value, deficient chiefly in phosphorus and protein, showed positive calcium balances, but negative balances of phosphorus and nitrogen. Supplementary feeding of potassium phosphate decreased the calcium balances to a negative value. Supplements of dried blood enabled the animals to retain nitrogen and at the same time improved the retention of calcium and phosphorus. The calcium and phosphorus balances were not improved by feeding Nauru rock phosphate as an addition to the hay and dried-blood diet.

The work, though only preliminary in nature, suggests that sheep feeding on a pasture similar in nature to the hay used (*e.g.*, high country or drought conditions) will not benefit by supplementary feeding of mineral mixtures to the same extent as they would by improvement of the nitrogen intake.

Grass Staggers in Dairy Cows.

Factors causing the upset of magnesium metabolism in this disease are being investigated by preliminary work on the rat, which will be later be extended to ruminants. The effect of the level of dietary magnesium on the calcium and magnesium contents of bodies, bones, and blood has been determined. The most interesting finding is that the blood-magnesium level reflects the magnesium content of the diet, and by feeding extra magnesium as carbonate, sulphate, chloride, or phosphate the magnesium content of the blood has been raised considerably above the normal. This relationship is being tested out on sheep which are being drenched daily with magnesium salts, and will later be tested on cows supplied with magnesium-containing licks or with magnesium salts in their drinking-water. The importance of the work resides in the fact that, since the most marked finding in the blood of cows with grass staggers is a greatly reduced magnesium content, then a practicable method of raising the blood magnesium during the period of susceptibility to the disease might help to mitigate its incidence. Such methods as supplying stock-licks containing large proportions of magnesium if these can be made palatable, or the introduction of soluble magnesium salts into drinking-water, might achieve this end.

Different strains of rye-grass, which forms a large proportion of the pasture in districts where grass staggers occur, are being investigated at various stages of growth.

Iodine Investigations.

This work has been very actively prosecuted during the year. Several thousand thyroid glands, comprised in 760 samples, have been forwarded by Veterinarians and Meat Inspectors and analysed for iodine content.

It was thought that bobby calves might provide material for a preliminary survey of Taranaki, and with this aim the Veterinarian at New Plymouth examined 1,750 bobby-calf thyroids during August and September. He found 4 per cent. enlarged above 15 grammes. One hundred and nineteen glands were analysed, and all found to have an iodine content above 0·03 per cent., the critical value.

With three exceptions, the enlarged glands came from two definite but unidentified districts. Lack of iodine is evidently not the cause of enlarged glands among bobby calves in Taranaki. Possibly, except in cases of acute deficiency, lack of iodine is not reflected in the new-born young, which is supplied from the body store of the mother, even though the latter may be depleted.

In the Wairarapa district samples of thyroids from sheep varying from three months to six years old showed that the age considerably affected the iodine content, the percentage of iodine increasing with age. On the other hand, forty-three pairs of samples of lambs' thyroids showed no difference between male and female glands, either in size or iodine content. Certain generalizations were drawn from the analyses of the glands, correlating iodine content with the type of country from which they were derived.

Limestone land, constituting the Maungaraki Range and its northern continuations, produced lambs whose thyroids were definitely high in iodine, the majority giving yields in excess of 0·09 per cent. Thyroids from the greywacke hills of the west and south Wairarapa were considerably lower, the greater number being between 0·06 per cent. and 0·09 per cent. On the mudstone areas of the East Coast figures between 0·03 per cent. and 0·06 per cent. were most common. In the alluvial river valley of the Ruamahanga the majority were also between 0·03 per cent. and 0·06 per cent.

A lick-feeding experiment carried out on the Taratahi plains did not result in any changes in the weights of the animals or their thyroids as against controls, but the iodine content of the glands varied in proportion to the amounts of iodine fed (varying from 3 oz. to 60 oz. potassium iodide per ton of salt).

In the Southland and Otago districts special attention was paid to the occurrence of goitre, which is found in sheep in some parts of these areas. The occurrence of three variables (weight, per cent. iodine, and per cent. moisture) afforded some means of classification and definition of the term "goitre." The variation of moisture content was from 61·2 per cent. to 87·8 per cent. (average 74 per cent.), and the heaviest glands had not necessarily the greatest percentage of moisture. Glands from sheep were appreciably heavier than those from lambs with the same percentage of iodine, but the number was relatively small.

The average weight of glands containing 0·03 per cent. iodine is 3·57 grammes. Accepting this as a provisional standard, about 36 per cent. of the glands in Otago and Southland districts are enlarged above normal, while about 10 per cent. are grossly enlarged—*i.e.*, weigh over 6 grammes—the latter occurring at Mataura Island, Otama, Stirling, Milton, and Awamangu.

Experiments on the efficacy of iodized-salt licks as a means of increasing the iodine content of glands are at present being carried out in Southland.

FIFTH ANNUAL REPORT OF THE MINERAL CONTENT OF PASTURES INVESTIGATION AT THE CAWTHRON INSTITUTE.

(Period: 1st April, 1932, to 31st March, 1933.)

By Mr. T. Rigg, Director of Research.

During the period under review much time has been devoted to a continuation of studies in connection with the cause of bush sickness. Following up the conclusions arrived at in earlier investigations of the Cawthron Institute concerning the important part played by soil iron in determining the incidence or otherwise of bush sickness in particular localities, a very detailed examination of the available iron content of a wide range of volcanic and sedimentary soils was undertaken. Much attention has been paid to the estimation of iron in different pasture and native

plants which are eaten by stock in areas affected with bush sickness. In addition, the effect of fertilizers, including iron compounds, on the intake of iron by different plants has been tested in a series of pot experiments conducted under controlled moisture conditions.

In the field further animal tests have been conducted at Glenhope—a typical bush-sick area of the Waimea County, Nelson—in order to ascertain the relative efficiency of soil, limonite ore, and ferric ammonium citrate in controlling bush sickness.

Another important line of investigation is connected with the potential hydrocyanic acid content of different pasture plants in the Nelson District. This work has involved the exploration of laboratory technique in connection with the estimation of potential hydrocyanic acid production in white-clover samples.

Our field experiments relating to the effect of nitrogenous manures on the yield and chemical composition of typical Nelson pastures have been continued, and some of the more important features emerging from these investigations are summarized in this report.

I. Investigations relating to Bush Sickness.

(*a*) *Available Iron Content of Soils.*

In a previous report mention has been made of a large number of determinations conducted by Miss E. B. Kidson in connection with the available iron content of volcanic soils in the North Island. For the extraction of the iron from the soils N/10 oxalic acid was employed. The results obtained on the volcanic soils showed that samples collected from bush-sick localities, including that of the Glenhope district, Nelson (non-volcanic origin), gave an average figure for available iron of 0·57 per cent. Fe_2O_3. The limits of available iron in these nine samples were 0·43–0·69 per cent. On these soils stock ailment had definitely occurred, and in certain cases serious mortality had been experienced.

Volcanic soils not definitely associated with bush sickness contained much larger amounts of iron soluble in N/10 oxalic acid.

The examination of the "available" iron content of soils has been extended during the period under review to sedimentary and other non-volcanic soils. Soil-samples representing twenty-seven distinct types, mainly collected in the Nelson Province, have been examined for iron content.

As a rule, comparatively high figures for iron were found, in certain cases attaining 6·9 per cent. of iron calculated as Fe_2O_3. Two outstanding exceptions, however, in regard to high iron content were found in the gum-land soils of North Auckland and also in the pakihi soils of the West Coast and Takaka. In these two cases the percentage of iron soluble in N/10 oxalic acid was considerably lower than the lowest figure found on recognized bush-sick soils. Although the area of established pasture on these two soil-types is not extensive, bush sickness so far has not been reported in either case.

In the experiments of the Cawthron Institute conducted on reclaimed pakihi land at Westport, sheep and dairy cows have been grazed on established pastures without detrimental effects, and no symptoms similar to bush sickness have so far been observed. Although, therefore, a low content of available iron has been found in every soil subject to bush sickness, it must not be assumed that a low content of available iron in the soil is, in itself, responsible for the appearance of bush sickness.

(*b*) *Iron Content of Plants.*

A wide range of pasture, native plants, and of fodder crops has been examined by Dr. Askew for iron content. In certain areas affected with bush sickness in the North Island farmers consider that the eating of certain native plants by stock overcomes or reduces the incidence of bush sickness. As it seemed possible that trees and shrubs, owing to their deeper-rooting habit, might obtain iron from substrata not available to pasture plants, a number of samples of green leaves from native plants eaten by stock was analysed for iron content. The plants included mahoe, fivefinger, hange-hange, monoao, *Carmichaelia flagelliformis*, and *Cladium teretifolium*. With the exception of Carmichaelia, the iron percentage of these native plants did not rise above 0·010 per cent. The majority of the plants ranged about 0·008 per cent. for iron, although in certain cases figures as low as 0·004 per cent. were found. The data which have been obtained for iron on these native plants do not indicate that the animals grazing in the bush receive in their diet a greater amount of iron than if their grazing was restricted to typical bush-sick pastures.

In view of the fact that various observers have stated that stock fed on turnips in bush-sick localities show an improvement in health, samples of turnips grown in different parts of the Nelson territory have been analysed in order to ascertain their iron content in comparison with pasture plants. In the case of five samples of Imperial Green Globe turnips collected from different soil-types in the Nelson District very little difference was found in the iron content. The percentage of iron in the leaves ranged around 0·01 per cent. Fe and in the roots about 0·0045 per cent. Fe. A sample of swedes grown on bush-sick granite soil at Glenhope contained a lower percentage of iron than that of the turnips previously discussed. It is impossible to state, owing to the fact that no other samples of swedes were analysed, whether this lower content of iron in the Glenhope swedes is a varietal effect or is due to a lower iron content of the soil. In view of the small variation found in the iron content of turnips grown on different soil-types it would seem probable that the lower iron content of the swedes is more a varietal effect than one due to soil properties. The results of the iron analyses of the turnip samples do not suggest, however, that turnips provide a greater supply of iron than that contained in typical bush-sick pasture.

Effect of Soil-type and Fertilizer on the Iron Content of Pasture Plants.—Several series of pot experiments have been conducted at the Cawthron Institute in order to determine whether plants grown on different soils elaborate different amounts of iron in their tissue, and whether treatment with lime, superphosphate, or iron salts in any way affects the amount of iron elaborated by the plants. White clover, red clover, perennial rye, *Danthonia pilosa*, and *Agrostis alba* have all been grown on the Glenhope granite soil under controlled moisture conditions. Analyses of the plant material cut from the pots during the course of the experiment showed that the plants elaborated different amounts of iron. The highest figures for iron were obtained with white clover and perennial rye, and the lowest figures were associated with *Agrostis alba* and *Danthonia pilosa*. Red clover occupied an intermediate position. Although treatment with lime, superphosphate, and lime plus superphosphate increased materially the yield of crop, practically no difference resulted in the percentage of iron in the plants. The use of iron sulphate or iron citrate in the case of white clover, red clover, and *Danthonia pilosa* had practically no effect in improving the iron intake of the plants. In the case of *Agrostis alba* the use of iron sulphate appeared to effect a small increase in the iron content of the crop, but in the case of perennial rye the use of iron citrate seemed to depress somewhat the iron content.

It must be remarked that the pots were maintained at a 70-per-cent. water saturation of the soil, and rapid growth was made by the different crops. It is possible that the somewhat high figures for iron obtained for the majority of the crops grown in the pots is connected with the rapidity of growth. The results, however, do indicate that plants have little difficulty in obtaining a supply of iron from the Glenhope granite soil and that fertilizer treatment has little effect on the intake of iron by the plants.

In regard to crops grown on different soils possessing great variation in their content of available iron, the amounts of iron found in unit weights of dry matter grown on different soils did not vary greatly. In a number of cases there was a very marked difference in crop yields on all soils, but these differences were not associated with a higher iron content in unit weight of the crops. It would almost appear that crop weights are affected more by deficiency of iron than is the actual percentage of iron contained in the material grown.

(*c*) *Field Experiments at Glenhope.*

During the past season trials have been conducted using different drenches in the case of a new line of sheep brought in from a healthy locality and held on typical bush-sick pastures at Glenhope. At the commencement of the experiment in October, 1932, sheep were divided into four groups of seven to eight hoggets, and arrangements were made for the sheep to receive the following drenches :—

Group I : Received no drench.
Group II : Received a drench of iron ammonium citrate.
Group III : Received a drench of limonite ore obtained from Onekaka.
Group IV : Received a drench of Nelson soil taken from the Cawthron Institute grounds.

The drenches were given twice a week, the sheep being weighed every fortnight, and notes were made regularly concerning their health and condition. The sheep receiving iron ammonium citrate were dosed with 1 fluid ounce of a 10-per-cent. solution. In the case of limonite ore a suspension was made in water and approximately 3 fluid ounces of the suspension was given as a dose. It is estimated that each dose of limonite suspension contained 3–4 grammes of iron oxide. In the case of the Nelson soil a suspension was made in water, and this was administered by bottle in a similar way to the limonite ore. In making the soil suspension approximately 1 lb. of Nelson soil was pestled with 40 oz. of water, and then 100 c.c. of the suspension was used for drenching each sheep. Nelson soil was selected for use as a drench because of its comparatively high content of available iron (6 per cent. Fe_2O_3, soluble in N/10 oxalic acid). With the exception of the use of different drenches, the sheep were held under uniform conditions and grazed in rotation two fields which in previous years had been proved to be associated with bush sickness.

Very favourable weather was experienced during the early part of the season, the rainfall being much lower than the normal for the Glenhope district. Up till the end of December the sheep did relatively well, and it was not until the middle of January that definite symptoms of ailment were noticed in the case of certain sheep. The average live weights for the different groups of hoggets from the 12th October up till the 16th April are shown in Table I below.

Table I.—Control of Bush Sickness : Glenhope Experiments.

Group.	Drench.	Average Weight (Pounds).						
		Oct. 12.	Nov. 12.	Dec. 31.	Feb. 2.	March 2.	April 2.	April 16.
I ..	No drench	70·8	79·6	84·5	84·8	85·4	88·8	85·6
II ..	Ferric ammonium citrate	65·3	76·3	85·3	83·5	85·5	89·0	88·2
III ..	Limonite ore	65·1	77·4	84·9	84·6	82·3	79·7	75·9
IV ..	Nelson soil	68·1	80·6	87·8	91·3	93·9	97·8*	96·6*

* Note.—One sheep got badly staked and fell off in condition, lowering the average weight thereby.

In each group rapid gains in weight were made up till the end of December. During January certain sheep fell back in condition, and the average live weights, with the exception of those receiving Nelson soil, show no increase over the weights for the 31st December. In connection with the group receiving Nelson soil, the animals have shown a consistent increase throughout the summer and early autumn. These sheep are all perfectly healthy, are in excellent condition, and could have been sold as fat sheep. In the case of the control group and the group receiving limonite ore, a number of sheep have gone back rapidly during the late summer, and in April two or three in each group showed acute symptoms of bush sickness. The sheep receiving the iron-ammonium-citrate drench have behaved irregularly, great fluctuations in weight having been noticed in the case of individual sheep. During April certain sheep with the iron-ammonium-citrate drench were doing extremely well, but in one case bush sickness appeared to be definitely present.

The success which has so far been obtained by the use of Nelson soil as a drench for sheep on bush-sick country is of exceptional interest, in that it points clearly to the value of the soil as a supplement in the diet of stock. As previously stated, Nelson soil was chosen for use as a drench on account of its high available iron content. The failure of limonite ore to prevent the onset of bush sickness suggests that Nelson soil is valuable not solely for its iron content, but on account of other properties which are not characteristic of the sample of limonite ore. At the present time no explanation can be offered for the success on the one hand of the Nelson-soil drench, and on the other for the failure of the limonite ore. Further confirmation of the non-efficacy of limonite ore in controlling bush sickness in the Nelson District has been obtained from certain sheep experiments in the Sherry Valley, where both limonite-ore licks and drenches have been employed without securing by any means a control or cure of the ailment.

II. Occurrence of Cyanogenetic Glucosides in Nelson Pasture Plants.

During the course of a series of investigations relating to the chemical composition of pasture plants attention was directed to the possibility of cyanogenetic glucosides affecting the health of stock on certain Nelson pastures. Samples of legumes and grasses were collected from a wide range of pastures within the Nelson Province, and were examined in the chemical laboratory for potential hydrocyanic-acid production. For the initial experiments the technique developed by Brünnich of Queensland was used in the laboratory determinations of hydrocyanic acid. The green plant specimens were ground rapidly in a mill and then left standing overnight in a closed glass vessel containing sufficient water to enable fermentation of the samples to proceed vigorously. The analytical data obtained showed that grasses produced only small quantities of hydrocyanic acid on fermentation. Four samples of perennial rye obtained from different localities gave an average figure for HCN of 0·0003 per cent. on the green material. The variation in HCN content with individual samples was 0·0001 – 0·0005 per cent. Single samples of brown-top, paspalum, cocksfoot, Yorkshire fog, fescue, and danthonia collected from different pastures showed only small production of hydrocyanic acid, the figures varying only from 0·0001 to 0·0002 per cent. HCN on the green material.

In the case of legumes, greater variation was found with individual species. Three red-clover samples obtained from different localities contained approximately the same amount of HCN, the average figure being 0·0003 per cent. HCN on the green material. Alsike, subterranean clover, and Lotus major likewise produced relatively small quantities of HCN in the laboratory determinations, the figures varying from 0·0002 to 0·0003 per cent. on the green material. One sample of lucerne collected from the Cawthron Institute grounds, Nelson, showed a higher content of potential HCN production, the figure being 0·0015 per cent. on the green material. White clover, however, was outstanding in its high HCN production, and also in the great variation found in different samples. In the case of eleven samples collected on different soil-types in the Nelson Province, an average figure of 0·0045 per cent. HCN on the green material was found. The highest figure obtained was 0·0124 per cent. in a sample grown on the Cawthron Institute grounds, and the lowest percentage was found in the case of a sample collected from granite formation in the Sherry River district, the figure in this case being 0·0016 per cent.

In the case of white clover, the samples were obtained from a range of pastures, some of which are highly esteemed for grazing. Samples collected from good pastures at Wakapuaka, Appleby, Stoke, and Richmond fall into this category. Other samples collected in the Sherry River and Glenhope localities were obtained from soils associated with bush sickness. No correlation was obtained between good grazing-qualities and content of hydrocyanic acid in white clover.

Based on the lethal dose of HCN determined by Auld and by Hindmarsh, a cyanogenetic glucoside content equivalent to 0·0045 per cent. HCN should prove fatal to stock, provided the glucosides are fully hydrolysed and the hydrocyanic acid is not exhaled or inactivated before reaching the blood-stream. So far as is known no fatal cases of poisoning have been reported in the case of stock grazing white-clover samples. It seems probable, therefore, that the hydrolysis of the glucosides is only partial under the conditions prevailing in the animal paunch and alimentary tract, or that the HCN is inactivated and never attains a concentration sufficient for toxic results. It is known that the presence of glucose and cellulose in the animal paunch both inhibit the formation of hydrocyanic acid. Certain iron and sulphur compounds which are likely to be present in the paunch and alimentary tract should also reduce the amount of free hydrocyanic acid through the formation of harmless compounds by combination with this acid.

Although it is probable that on many New Zealand white-clover pastures, owing to partial hydrolysis of moderate percentages of cyanogenetic glucosides and owing to the inactivation of the hydrocyanic acid produced during digestion, harmful effects are not experienced in the case of stock, yet it seems possible that in those cases where a particularly high content of cyanogenetic glucosides exists, or where the conditions in the animal system are not favourable to the inactivation of hydrocyanic acid, harmful effects may occur, resulting in a slowing-up or cessation of growth.

The varying percentages of HCN produced in different samples of clover suggest the possibility of many factors operating in controlling cyanogenetic glucoside formation in these plants. It seems probable that soil-type, climate, growth stage, and strain of clover are all connected with the varying percentages of HCN found in the present investigation.

During the conduct of the estimations of hydrocyanic acid in the laboratory it became clear that standardization of technique for HCN determinations in plant material was highly desirable. The opportunity was taken by Dr. H. O. Askew to study sampling and laboratory conditions for the estimation of potential HCN production in white clover. The effect of temperature, duration of fermentation, the effect of dilute acid and alkali on yield of HCN have all been studied, and a paper has been prepared for publication dealing with this work.

III. Effect of Nitrogenous Manures on the Yield and Chemical Composition of Typical Dairying Pastures.

During the period under review the results of the pasture trials located at Appleby have become available. This experiment was commenced in 1930 and was continued for two complete seasons in order to increase the reliability of the results. The experiment was designed to test the effect of different nitrogenous manures on the yield and chemical composition of a good rye and clover pasture. A base treatment of superphosphate and sulphate of potash was given to all plots previous to the application of the nitrogenous manures.

During the first year three applications at the rate of 1 cwt. per acre on each occasion were made of (*a*) Calnitro, (*b*) Nitrochalk, (*c*) ammonium sulphate, (*d*) ammonium sulphate plus an equal quantity of calcium carbonate. In the second year of the experiment the quantity of nitrogenous manures was reduced to a single application of 1½ cwt. in each case applied in the early spring.

The production of dry matter during the two seasons is shown in Table II below.

Table II.

Treatment.	Yield Dry Matter (Pounds per Acre).	
	Season 1930-31.	Season 1931-32.
No nitrogen	4,077	4,654
Nitrochalk	4,308	4,656
Calnitro	4,486	4,830
Ammonium sulphate	4,473	4,606
Ammonium sulphate plus calcium carbonate	4,430	4,492

During the first year of the experiment a significant increase in production of dry matter resulted with each nitrogenous fertilizer. The greatest increase was shown by Calnitro and ammonium sulphate; the effect of Nitrochalk applied at the same rate was not so pronounced. During the first year when three applications of nitrogenous fertilizers were made the greatest increase in pasture production resulted from the spring application of the nitrogenous fertilizers. The November application gave only a small increase, the January application being intermediate in effect between those already mentioned. It must be remarked, however, that droughty weather was experienced in November and during mid-summer. The total increase in yield from the three applications of nitrogenous manures resulted in an increase in dry matter of approximately 400 lb. per acre in the case of Calnitro and of ammonium sulphate.

During the second season only one application of the nitrogenous fertilizers (at the rate of 1½ cwt. per acre) was made in order to study more closely the after-effects on yield resulting from the use of these fertilizers. In Table III the yields of dry matter for (*a*) the initial period when increase in yield was obtained from the nitrogenous fertilizers, (*b*) the remainder of the season when a depression in yield was noted, and (*c*) the full season.

Table III.—Production of Dry Matter, Season 1931-32.

Treatment.	Pounds per Acre.			Increase over No Nitrogen.		
	First Period: August 4th to September 29th, 1931.	Second Period: September 30th, 1931, to May 16th, 1932.	Full Period.	First Period.	Second Period.	Full Period.
Super and potash	843	3,811	4,654	..	..	..
Super plus Calnitro	1,067	3,762	4,830	224	— 49	176
Super plus Nitrochalk	968	3,689	4,656	125	—122	2
Super plus ammomium sulphate	1,055	3,551	4,606	212	—260	— 48
Super plus ammonium sulphate plus calcium carbonate	1,003	3,489	4,492	160	—322	—162

Note.—One application only of the nitrogenous manures was made at the rate of 1½ cwt. per acre early in August, 1931 Super was applied at the rate of 3 cwt. per acre and sulphate of potash at rate of 2 cwt. per acre in July, 1931.

The results given in Table III show the value of nitrogenous fertilizers in producing extra feed at the beginning of the season. In each case, however, a drop in production relative to the no-nitrogen plot occurred at the conclusion of the first period of fifty-six days wherever the nitrogenous fertilizers were used. This drop in production was greatest where ammonium sulphate was employed, and less in the case of Calnitro and Nitrochalk.

An improvement in growth occurred later in the season on all plots where nitrogenous fertilizers were used, but the total production of the nitrogen plots in certain instances fell below that of the no-nitrogen plots. The reduction in yield was greatest where ammonium sulphate was used.

The chemical analyses of samples of mixed pasture taken from the plots regularly throughout the season have shown the great effect of climate on the percentage composition of the pasture. High figures for phosphoric acid, nitrogen, potash, and soluble ash were found in the early spring samples when moisture conditions were favourable. During the droughty period the percentages of these constituents fell greatly, minimum figures being obtained during January and February. The percentages of these constituents rose in the autumn period after rain had effected improvement in growth. The lime figures, on the other hand, were lowest in the spring period, increased to a maximum during January, February, and March, and then fell in the autumn period. The chemical analyses showed that the more important effects of pasture treatment with nitrogenous fertilizers were as follows: (1) The influence of manurial treatment on the chemical composition of mixed pasture was most marked in the case of the plots treated with ammonium sulphate alone. Nitrochalk gave the smallest increase in yield and showed the least effect on the chemical composition of the pasture. Calnitro and a mixture of equal proportions of finely ground limestone with ammonium sulphate occupied an intermediate position in respect to their effects on the composition of the pasture. (2) In the case of all the nitrogenous fertilizers the lime content of the pastures was depressed, particularly in the spring samples following the application of the fertilizers. The percentage of phosphoric acid, potash, nitrogen, and soluble ash were all increased by the use of nitrogenous manures, particularly the yield during spring and early summer. In midsummer the percentages of phosphoric acid, potash, and nitrogen were slightly higher on the control plots (super and potash) than on the plots which in additin to the super and potash received nitrogenous manures. In the case of the nitrogen percentages, lower figures for the nitrogen plots continued not only during midsummer, but also during the autumn.

General.

During the year under review the following papers have been published or have been prepared for publication:—

Published—

No. 17: "Influence of Season and Nitrogenous Fertilizer on the Inorganic and Organic Sulphur Contents of Perrennial Rye, White Clover, and Mixed Pasture," by H. O. Askew and L. Bishop.

No. 18: "The Detection and Approximate Estimation of Soil Contamination in Pasture Samples, with Special Reference to the effect on the Iron Content of Pasture," by H. O. Askew.

No. 19: "Influence of Season and of Ammonium Sulphate on the Chemical Composition of Perennial Rye-grass and of White Clover," by H. O. Askew.

Miscellaneous: "Pasture Research in Nelson District," by T. Rigg and H. O. Askew.

Prepared for publication—

No. 20: "The Occurrence of Cyanogenetic Glucosides in Nelson Pasture Plants," by T. Rigg, H. O. Askew, and E. B. Kidson.

No. 21: "The Estimation of Hydrocyanic Acid in White Clover Samples," by H. O. Askew.

PAKIHI SOILS RESEARCH.

FIFTH ANNUAL REPORT OF THE PAKIHI INVESTIGATIONS CONDUCTED BY THE CAWTHRON INSTITUTE.

(Period 1st April, 1932, to 31st March, 1933.)

During the period under review the small pasture plots laid down in previous years to test the effect of different amounts of lime and of phosphate, and of different methods of seed-bed preparation in the establishment of pasture have been continued. In those cases where the full treatment of lime and phosphate has been applied and where top-dressing with superphosphate has been undertaken good results continue to be obtained. The plots which are cut for hay have also given heavy yields in those cases where superphosphate at the rate of 2 cwt. and sulphate of potash at the rate of 1 cwt. per acre have been employed each year for top-dressing.

Mention was made in the last annual report of an attempt to establish 25 acres in pasture on the Sergeant's Hill area. The pakihis on this locality have a deeper soil than those at Bald Hill or on Skilton's property located on the other side of the Buller. It therefore seemed desirable to conduct a small trial with dairy cows in the Sergeant's Hill area. Ten acres were sown in April, 1932, and a very good take of grasses and clovers was obtained. During the past season the sowing of the 25-acre block has been completed, and arrangements have been made with Mr. C. Lemon to stock and whole of this area next season.

Use of Lime.—The small plots sown at different periods during the last five years continue to show the great importance of lime treatment in the establishment of pastures on pakihi land. The use of 1 ton of ground limestone per acre in the initial establishment of pasture still gives very good results and compares quite favourably with plots treated with larger amounts up to 2 tons of ground limestone per acre. In those cases where small dressings only of ground limestone have been given the plots are very much inferior to those with the standard dressing of 1 ton per acre. Poor growth of clovers is now quite marked on plots treated with ½ ton of ground limestone per acre three years ago. In the comparisons which have been made in connection with the use of lime it must be remarked that 5 cwt. of superphosphate per acre was used in each experiment.

Use of Phosphate.—The continuation of the experiments reveals the great importance of top-dressing established pastures each year with superphosphate at the rate of not less than 2 cwt. per acre. Little change has occurred in the relative position of the plots treated with different phosphatic manures. With lime treatment, superphosphate or basic slag gives excellent results. Where lime is omitted Nauru rock phosphate has given very fair growth, *Lotus major* being luxuriant after the first season. Superphosphate without lime treatment has proved of little value.

Use of Potash.—On those plots where a hay crop has been removed each year the use of 1 cwt. of sulphate of potash per acre in addition to superphosphate has maintained yields very satisfactorily. Under grazing conditions it has been noticed that the stock graze more closely the areas on which sulphate of potash has been included in the top-dressing manure.

Drainage Experiments.—Two years ago a small plot was subdivided and provided with tile drains laid at approximately pan level. The land was left to consolidate, and was then disked and sown under the standard conditions which have been used in the majority of the pasture trials. It is interesting to note that on the plots where lime and phosphate were omitted a total failure of pasture resulted. This confirms in a striking manner the conclusion deduced from earlier observations: that the infertility of the pakihi soil for pasture plants is due to high deficiency of lime and phosphate, and not to the supposed water-logging as a result of the pan formation.

Species Trials.—Small plots sown in the previous year with different legumes and grasses have in a number of cases made excellent growth. In these trials, the standard procedure of burning pakihi vegetation, harrowing, and of treatment with 1 ton of ground limestone and 5 cwt. of superphosphate per acre was adopted. Alsike and *Lotus major*, followed by white and red clover, have done extremely well. Grasses when sown alone using the standard treatment outlined previously have given rather poor results. Crested dogstail, Western Wolths, and Timothy, however, show to some advantage in comparison with perennial rye, cocksfoot, and meadow foxtail. Paspalum so far has made very little growth and appears to be at a standstill.

The species plots, and indeed the seed-mixture trials at Sergeant's Hill, show quite definitely the supreme importance of clovers and lotus in the initial establishment of pasture on the pakihis. Perennial rye and the better grasses in the early stages do not contribute greatly to pasture production. After stocking and consolidation of the land, however, a great improvement in the growth of rye, cocksfoot, and other grasses occurs.

Grazing Results.—On one area established four years ago grazing trials have been conducted. During the past season young heifers have been used for grazing this area. The animals have kept in excellent health, and for the full-year period commencing June, 1932, and concluding May, 1933, an area of 1⅛ acres has provided 362 heifer-days of grazing. This is equivalent on the acre basis to 320 heifer-days per year. In the previous year the same field gave 365 heifer-days per acre. A close sward of clover, lotus, crested dogstail, rye, and other grasses has now been obtained as a result of stocking. The land has consolidated well, and little difficulty has been experienced in holding animals on the land throughout the greater part of the year.

Small-farm Trial.—The 10-acre block, sown in April, 1932, under standard conditions of treatment, has given an excellent result. On this block the vegetation was burnt, and 25 cwt. of ground limestone and 5 cwt. of superphosphate per acre were then distributed. Two harrowings with an improvised set of harrows were then given to aerate somewhat the top inch of soil. A mixture of grasses, clovers, and lotus was sown at the rate of 35 lb. per acre. The cost of establishment is as follows:—

	Cost of Establishment per Acre. £ s. d.
25 cwt. ground limestone	1 5 0
5 cwt. superphosphate	1 5 0
Cartage of lime and superphosphate	0 11 4
Distribution of lime	0 15 0
Distribution of superphosphate	0 3 6
35 lb. seed mixture	1 9 9
Sowing seed	0 2 0
Harrowing	0 7 6
Burning pakihi vegetation and removing timber	0 6 0
Total	£6 5 1

NOTE.—Since the 10-acre block was sown drains have been dug to take off surface water from low-lying locations and also to prevent storm-water from higher ground gaining access to the 10-acre block. This work involved an additional outlay of approximately 12s. per acre. The cost of fencing is not included in the above statement.

During the late spring and early summer good growth was obtained over the whole of the block and a start was made with stocking early in December. During the late summer and autumn more animals were drafted on to the block, until during May it was carrying ten heifers throughout the whole of the month. For the six months commencing December, 1932, and concluding May, 1933, this field, sown less than a year ago, provided ninety-three heifer-days of grazing per acre, or an average of approximately half a heifer per acre for the full six months.

In the early stages of stocking care was exercised in holding the stock on the block during wet weather. As growth thickened it was found that little damage to the pasture resulted even during periods of continued rain. The stock used for grazing have improved in condition, and at the present time are doing remarkably well.

Onekaka Dairying Reclamation.—At the request of Mr. F. G. Gibbs, of Nelson, advice has been given concerning the establishment of 75 acres of pasture on a typical area of pakihi land lying between Takaka and Collingwood. The pakihis in this district have a lower rainfall and the soil contains more coarse particles than is the case on the West Coast. The lands very frequently grow stunted manuka, and in the present case a considerable area of the reclamation had to be cleared of manuka before treatment of the land and sowing could be accomplished. The cutting of manuka and the disking of somewhat hard knobs associated with manuka growth has entailed in Mr. Gibbs's case additional expense which has not been incurred by the Cawthron Institute on the West Coast. Mr. Gibbs has kindly supplied the following figures relative to the cost of establishment of pasture on his reclamation at Onekaka.

	Cost of Establishment per Acre. £ s. d.
Clearing manuka	1 9 1
Disking and harrowing	1 0 4
Cost of lime	1 5 3
Spreading lime	0 16 0
Cost of superphosphate	1 2 6
Distribution of superphosphate	0 6 6
Grass seed	1 13 7
Sowing and harrowing	0 9 9
Total	£8 3 0

NOTE.—Cost of fencing, erection of sheds, &c., are not included in the above statement.

The land treated by Mr. Gibbs is typical of pakihi land at Onekaka, and consists of several nice slopes with comparatively deep soil, and on the other hand drier ridges where a seed-bed could not be obtained without disking. Owing to the presence of manuka-stumps much of the lime and super distribution was performed by hand, resulting probably in an unequal distribution of the lime and superphosphate on certain portions of the block. Many parts of the 75-acre block have taken very well, and a good growth of clovers and rye was noticeable during midsummer. On other parts of the block the results are less favourable, and clovers are not so prominent. In places the growth of young manuka is causing some concern, but it is anticipated that cutting with the mower during the autumn will kill the manuka plants. Taking the block as a whole a very fair result has been obtained, and it is confidently anticipated that the use of superphosphate at the present time will effect a wonderful improvement in the pasture next season.

The 75-acre block has been lightly grazed during this last season, and during the latter part of the season carried twenty head of dry cattle. It is hoped to make a start with dairy cows next spring.

Phormium tenax.—Good growth of *Phormium tenax* continues to be made on those plots where complete manurial treatment has been given. The omission of potash from the manurial programme does not make such a marked difference to the growth of plants as the omission of nitrogen. The omission of phosphate from the manurial programme has resulted in as poor growth as on the untreated plots.

Tree-culture.—In connection with the trials of trees for use on the pakihi land at Westport, *Pinus densiflora* followed by *P. ponderosa* and *P. radiata* have given the best results.

Tobacco.—A small plot of tobacco-plants was tried at Onekaka during the past season. Pakihi soil on well-drained slopes possesses features in common with recognized high-quality tobacco soils in the United States of America. The results obtained during the past season warrant a further trial. Some of the drawbacks to success during the past season have been lack of proper attention in cultivation and also lack of shelter against prevailing strong winds.

General.—Many inquiries have been made by farmers interested in the pakihi reclamations concerning approved methods of pasture establishment. Several new plots are being put in by farmers in the Takaka and Westport districts.

During the coming year it is hoped to maintain without extension the experimental work which is in hand. If funds permit, shelter-belts will be planted along certain boundaries of the small farm which has been sown at Sergeant's Hill.

THOMAS H. EASTERFIELD,
T. RIGG,
Officers in Charge of the Pakihi Investigations.

PIG-RECORDING, PORK, AND BACON.

The grants made by the New Zealand Meat Producers' Board have enabled pig-recording work to be continued in the Waikato district and extended to a group in the Manawatu area. This work has now been consolidated and brought under the general direction of a Pig Advisory Council, established by the Department of Agriculture. This Council is representative of the pig industry, the Meat Producers' Board, and the Departments of Agriculture and Scientific and Industrial Research. Recording-work and feed trials are being continued in the Waikato and Manawatu districts, and the Department has arranged for its Liaison Officer in London to secure expert opinion on trial lines of pork carcasses which have been shipped from time to time.

The Pig Advisory Council has established standards for pork and bacon carcasses along such lines as will enable them to fit in readily with those adopted in our principal market, Great Britain, and arrangements have been made for inspection and grading along those lines to be carried out at various slaughterhouses in New Zealand.

As a result of the attention which has been devoted to these various aspects of the pig industry marked progress has been made, and, in consequence, it has been possible to increase to a considerable extent the total exports of pig-meat from the Dominion. The results of the recording work and field trials have indicated to farmers in a time of depression the potential value to them of pigs properly managed as a means of increasing the value of by-products, particularly of the dairy industry.

WOOL RESEARCH.

Wool research is being carried out at the present time as part of the normal activities of two agricultural Colleges—Massey College and Canterbury Agricultural College. At the former the work is being done at the entire expense of the college, and at the latter use is being made of portion of the research grant made by this Department for the purpose. The nature of the work in progress at Canterbury Agricultural College is set out in the section of this report which deals particularly with all the research activities of that institution.

FRUIT COLD STORAGE COMMITTEE.

Advisory Committee: Messrs. J. A. Campbell (Chairman), R. Sutherland, W. Benzies, F. W. Grainger, L. W. Tiller, A. M. Robertson, Dr. M. A. F. Barnett, and F. R. Callaghan.

Fruit cold-storage research comprises investigations carried out in co-operation with the Horticulture Division of the Department of Agriculture and the Cambridge Low Temperature Research Station. The land-store trials, in continuation of the work originally handled by Cawthron Institute, are now carried out under the direction of Mr. L. W. Tiller at the Stoke Cold Stores, Nelson. The control lots of fruit connected with the overseas transport trials and certain other land-storage trials are undertaken by Mr. R. Sutherland, of the Horticulture Division, in stores located in Wellington.

During the year a comprehensive report on the 1932 season's experiment shipments was received from the Cambridge Low Temperature Research Station, and was given full consideration in the light of the conclusions drawn from the control fruit held in New Zealand. The co-operation with the Cambridge Low Temperature Research Station has proved of the greatest value in assisting the cold-storage investigations undertaken in New Zealand.

During the year useful assistance was also received from the Imperial Bureau of Mycology in connection with the identification of fungal troubles causing wastage in New Zealand apples.

Arising out of the year's investigations, it has been urged that the carrying-temperature of Cox's and Jonathans should be raised from the present level of 33–35° F. to 36–37° F. in order to avoid wastage from breakdown and scald. It is felt, however, that until it is possible to exercise greater control over the range of temperatures in ships' holds such a course would be inadvisable.

The fact that the season was an abnormal one from a climatic point of view precluded arrival at definite conclusions on a number of matters. In districts such as Nelson, where heavy rainfall was experienced in December after a period of drought, all forms of fungal and physiological diseases were more pronounced than was the case with fruit from other parts of the Dominion. The experiments have revealed the important part which naturity plays in connection with wastage, but it is evident that only the collection of data over a period of years will enable adequate light to be thrown on this very difficult problem.

Packing experiments demonstrated the efficacy of the all-round wrap in reducing the amount of bruising, but the occurrence of scald in a susceptible variety such as Jonathans would indicate that more work should be done in order to ascertain how these wraps affect air circulation and temperatures within the cases.

All investigations demonstrated the considerable losses arising from bruising, and consequently a series of new trials have been arranged with the present season's crop, in order to ascertain the causes of such bruising and to devise means whereby it may be reduced.

During the 1933 season some 350 cases of apples were selected for observation in trials connected with the influence on fruit quality of (1) locality and type of soil, (2) drainage, (3) packing, (4) maturity, (5) wrapping, (6) high and low transport temperatures, (7) precooling. These trials have been carried out with the most important export varieties of New Zealand applies.

In addition, experiments are being conducted with passion-fruit, which, in the previous season gave promise of being capable of withstanding transport to Great Britain. This year's investigations, however, have not shown such promise, as the fruit became much affected with mould growths and of a decidedly bad appearance, though the quality of the juice was not impaired. It has therefore been decided to suspend overseas' investigations, and undertake land-storage trials with this fruit.

A number of cases of lettuces were also forwarded overseas, but it was shown that this vegetable would not remain in good condition for more than four weeks' storage.

Plums.—A commercial trial consignment of Grand Duke and Doris plums grown in the Hawke's Bay District was despatched to Great Britain. It was found that both varieties withstood storage conditions well, and were landed in Great Britain in excellent condition.

Tomatoes.—Two small trials with tomatoes were unsuccessful, as the fruit in both instances landed in bad condition in London.

Peaches.—One experimental shipment of late peaches was despatched to London, but it is yet too soon to receive reports as to their condition.

Dunnage.—The work of the Cambridge Low Temperature Research Station in the model ship's hold at the Ditton Laboratory has indicated that a new system of dunnage, known as the "Tower system," has proved very successful. A modification of this system was installed on certain of the fruit-transporting vessels during the season, and the effect of the new system on fruit quality is being closely watched.

One bulletin has been issued during the year: "Relation of Storage Temperature to the Overseas Carriage of some Further Varieties of New Zealand Export Apples," by L. W. Tiller (Bulletin No. 41).

FRUIT RESEARCH.

Advisory Committee: Messrs. H. Vickerman (Chairman), F. Firth, A. M. Robertson, F. S. Pope, Thos. Waugh, H. E. Napier, Wm. Benzies, T. C. Brash, W. J. Rodger, A. H. Cockayne, J. A. Campbell, T. H. Easterfield, T. Rigg, and G. Shirtcliffe. F. R. Callaghan, Secretary.

The Fruit Research programme is being conducted jointly by the Plant Research Station, Cawthron Institute, Horticulture Division of the Department of Agriculture, and the Department of Scientific and Industrial Research. Periodical meetings of investigators are held, when the details of the various researches receive full consideration. The experimental orchard of 72 acres located at Appleby is devoted to field-research work, and, in addition, spray and fertilizer trials are conducted in a number of orchards located in the different fruitgrowing districts of both Islands.

The nursery-work is at present all carried out at the Plant Research Station, Palmerston North.

Research Orchard.

All the trees in the orchards have been fully utilized for experimental work in connection with manurial, spraying, and disease trials. One hundred and eleven spraying trials were in progress, and the full programme of manurial trials laid down in previous seasons was continued. The orchard has also been drawn upon to supply fruit for cold-storage investigations. Both the Cawthron Institute and the Plant Research Station have made use of specified blocks of trees for the conduct of various investigations. A very complete system of tree recording has been developed, each tree bearing an indelible record of all the investigational treatment to which it has been subjected. Standard methods of pruning have been adopted throughout, and attempts are being made to keep precise records of pruning and blossoming by means of photographs.

The weight of fruit yielded by all trees has been carefully recorded and will be available for use in interpretation of the various manurial and spray researches to which each has been subjected. The varieties of apples represented in the orchard are Cox's, Dunns, Jonathans, Delicious, Sturmer, and Statesman. The yield of fruit in the 1933 season was light, being approximately one-half of that in the previous year. The total cases of fruit available for export amounted to 3,462. The season was not a serious one so far as diseases were concerned, though eye-rot and bitter-pit were prevalent to some extent.

During the year an additional building to provide accommodation for six workers was completed. The orchard is now fully supplied as regards office and staff accommodation, and the most necessary additional building now required is a manager's residence. Improvements have also been effected in connection with the packing-shed and the provision of additional water-supply.

Manurial Trials.

While very few of these trials have been running for a sufficiently long period to yield conclusive results, it is no doubt of interest to record some of the principal effects that have been noted to date. At the Research Orchard and elsewhere throughout New Zealand applications of nitrogenous manures produced marked results in regard to tree-growth, the most pronounced effects being seen in the case of trees growing on poorer-quality soils. In some instances excessive growth was produced and the colouring of the fruit was reduced. From all the trials it was not possible to decide whether the time of application of the nitrogen caused any variation in the amount of the response. It was shown, however, by trials at the Research Orchard that the best results were secured from a distribution of the nitrogen in a circle of not more than 6 ft. radius from the trunk of the tree. The effect of nitrogen upon tree yield on poor soils was indicated in a trial at Waimea West, where, following the application of 3 lb. of sulphate of ammonia per tree, a yield of 172½ lb. of fruit was secured, in comparison with one of 102 lb. when only 1 lb. was supplied.

In general, it was difficult to determine the effect of phosphate or potash applications upon growth and yield, and indications were that wide variations occurred.

Applications of lime to lemon-trees in the Auckland District produced yield increases of up to 35 lb. per tree, which is in advance of similar good results secured last season. In Hawke's Bay the colour of Delicious apples was improved slightly by the application of lime, though no similar effect was observable in Nelson trials.

Botanical Investigations.

Nine types of Northern Spy apples have been isolated and worked on to a drawfing stock in order to speed up the date when comparisons will be possible. Studies have commenced on the root systems of Northern Spy in comparison with other varieties, and attempts will be made to ascertain what part the relative amounts of fibrous and large roots may exert upon differences in tree yields.

The stocks secured from East Malling have now been increased in order that they may be tried out in various districts throughout the Dominion.

Mycological Investigations.

Black-spot.—While the incidence of this disease has not been serious in recent years it has been shown that the use of a lime-sulphur spray applied to dead leaves at specified times was responsible for a very large reduction in the amount of fruit infected from this source. Tests revealed the fact that strains of black-spot secured from Dougherty and Cox's Orange Pippin apples possess a greater degree of virulence than those from other varieties of apples. Black-spot was also shown to be capable of development at the temperatures at which fruit was held in cold storage.

Investigations are still proceeding on the types of fungi responsible for wastage during cold storage, and inoculations have been made at regular intervals in order to reach a complete understanding of the activies and nature of the particular fungi concerned.

Experience with the lime-sulphur sprays now used in accordance with their polysulphide content has shown that these sprays are very completely effective in the control of mildew disease in districts such as Central Otago, where, previously, the trouble was very pronounced.

Entomology.

Investigations have been continued in connection with codling-moth, leaf-hopper, bronze beetle, leaf-roller, and red-mite. With codling-moth it now seems definitely established that the calyx infection is not of practical importance, and that only one generation of this insect occurs normally in New Zealand, and though in certain districts a second generation does at times appear this would seem to possess very little real significance in its effect upon fruit.

Emergence of the moths now appears to take place between the last week of October and the end of February and that these are present in maximum numbers generally about mid-December.

The leaf-hopper has been found to be parasitized to some extent by a local insect, and this is now being followed up. The life-history of the two species of red-mite occurring in New Zealand has now been almost completely worked out, and this will provide useful guidance towards devising measures for its more complete control.

Investigations with bronze-beetle control have now reached a stage when fairly definite recommendations can be made. Lead arsenate applied at the strength of 2 lb. per 100 gallons of water effectively poisons the beetle, especially if the coverage is complete, and the efficacy of this application is increased if oil is used in association with the arsenate.

Citrus Investigations.

A survey of the various areas suitable for citrus investigation in the Auckland Province is being continued, and the information so gathered will shortly be put together as a comprehensive report. Trees developed on special stocks at Herd's Nursery, Onehunga, have been planted throughout most of the citrus-growing areas, and later on their yields will indicate how successful are these new varieties in different localities. A lease of 2 acres for a trial area at Mount Albert, Auckland, has been secured, and on this further details trials in connection with citrus grown on various stocks will be conducted.

Publications.

The following publications, embodying the results of various research workers, have been published during the year:—

Journal of Science and Technology—

Influence of CO_2 on Internal Break-down in Sturmer ..	L. W. Tiller, XIV, No. 1.
Codling-moth Investigations..	L. J. Dumbleton, XIV, No. 2.
Apple Leaf-roller	L. J. Dumbleton, XIV, No. 2.
Apple and Pear Black-spot	B. E. Parham, XIV, No. 3.
Relation of Storage Temperature to the Overseas Carriage of some Further Varieties of New Zealand Export Apples	L. W. Tiller, XIV, Nos. 4 and 5.
The Toxicity of Arsenates	W. Cottier, XIV, No. 5.
The Determination of the Distribution of Particle Size in Lead Arsenate Sprays	P. J. Clark
Verticillium Wilt of Tomatoes and Potatoes in New Zealand	E. E. Chamberlain and R. M. Brien } In the press.

New Zealand Journal of Agriculture—

Tomato Leaf-mould	E. E. Chamberlain, Vol. 45, No. 3.
Delicious Spot on Apples	R. M. Brien, Vol. 45, No. 4.
Sclerotium Disease of Tomatoes	E. E. Chamberlain, Vol. 45, No. 5.
The Tomato Stem Borer	J. Muggeridge, Vol. 45, No. 6.
Orchard Sprays in New Zealand (four articles)	G. H. Cunningham and W. Cottier, Vol. 44, No. 3 *et seq.*

LEATHER RESEARCH.

Advisory Committee: Messrs. J. E. Astley, A. E. Lawry, W. Donovan, and F. Johnson. Director of Research: Mr. P. White. Assistant: Mr. F. G. Caughley.

The manufacture of leather has long been regarded as an art rather than a science. As more information has been obtained about the components of leather—*i.e.*, about the materials which constitute hides and about those which serve for tanning purposes—the art has rapidly acquired a scientific basis. Rule-of-thumb methods, which originally controlled the different processes, are gradually being replaced by definite scientific methods of control.

The lack of information of the chemical structure of collagen or true hide, and of the different tanning-materials of either vegetable or mineral origin makes fundamental research on the problems of leather-manufacture long and difficult. A much simpler method of attack, and one which may give results of great value to the industrialist comparatively quickly is that of associating definite results with definite causes. This method is not quite so simple as it first appears to be.

Leather is the resultant product of a whole chain of processes in which any one defective link affects the whole chain. There, however, the analogy ends, for the alteration of any one link in the chain demands that modifications must be made in most of the others before the new one fits in to its best advantage. As the number of processes in the manufacture of leather is large it will be realized how difficult it is to introduce rapidly any improvement before its far-reaching and uncertain effects in the whole series are fully understood.

Under modern conditions of manufacture, progress in the leather industry is intimately connected with scientific methods of control. In the past definite control was possibly not so necessary because time, the healer of many wounds, was allowed to mask or obliterate the faults which arose from a lack of knowledge of factory technique. Those firms which are not only consolidating their position, but extending their activities, are those firms which not only realize the possibilities of science, but take advantage of them.

Chrome Leather.

In the year with which this report deals, some of the processes which are used in the manufacture of chrome leather have been examined from the point of view mentioned above—*i.e.*, cause and effect. Chemical analysis has in the past helped the chrome-tanner materially, but the time has come when other methods must be employed. One of these is the microscopic examination of the fibre-structure of the skin at the various stages in the process of manufacture. Fibre-structure is probably more closely allied to the qualities of the finished leather than is the chemical composition, as revealed by the present system of analysis.

To enable these investigations to be carried out a freezing microtome and a photomicrographic camera have been installed. These have been a valuable aid towards making all reports more clearly understood, through a visual presentation of the points to which attention is specially directed.

The processes of chrome-leather manufacture which were investigated in their relation to the finished leather were soaking, liming, pickling, tanning, and mordanting. It was realized that in the short space of time available a really comprehensive investigation of each of these processes was not possible. The two most desirable features of chrome upper leather are probably rubbery "feel," and fineness of the break after graining. By choosing these two desirable features as the qualities which might be affected by alterations of the different processes the investigation was made much shorter. Several very interesting conclusions were obtained, and these have been tested in different tanneries. The results of these trials have once more illustrated the point mentioned previously that each process is only part of a co-ordinated whole, and that it is not safe to alter any one part without a corresponding alteration in some other part. For example, an alteration in processing was made in one tannery successfully, and the same alteration in other gave an entirely different result.

It may be stated that as a result of the year's work on chrome tanning the quality of this type of leather made in the co-operating tanneries of the Research Association has materially improved.

An investigation was carried out to determine whether it would be possible to institute a microscopical method of checking the processes of the manufacture of sole leather. The difficulty encountered was that small weekly variations were established, but it was possible to determine whether these were due to differences in the hide or in the processes employed. Whilst the result of the investigation was not successful from the point of view of control, more detailed information as to the actual conditions prevailing in the tannery was obtained.

Contact has been maintained as far as possible with the various users of New Zealand leather. This is an important part of the work carried out as it not only establishes the points in which the leather fails to meet the requirements of the user, but also indicates the conditions under which it fails. This is often a very necessary consideration, and it may be more profitable to suggest alterations in the conditions of manufacture of the articles made from leather than in the manufacture of the leather itself.

Further investigations into the tannin-bark resources of New Zealand were carried out. In view of the possible development of the timber of the beech-tree (*Nothofagus* sp.), samples of bark from several of the species were examined. The amount of tannin present was found not to be sufficiently large to warrant any further work being carried out with beech bark.

Further samples of Kamahi bark (*Weinmannia racemosa*), both from South and the North Island, were analysed. The average tannin content in the bark of mature trees was approximately 30 per cent., but values up to 33 per cent. were obtained from air-dried samples. As large areas of kamahi exist in both Islands it appears possible, unless there are factors which militate against their development, these areas should be an asset which could be profitably developed.

The usual routine work has been carried out as previously. This has entailed analyses of oils, barks, spent barks, extracts (liquid and solid), and leather at various stages of manufacture and also in the finished state.

Periodical visits were made to factories to keep in personal touch with the practical work and problems in the tanneries, and also, at the same time, to enable the tanner to keep more closely in touch with the theoretical aspect of leather-manufacture.

The monthly circular letters have been continued, and free discussions of them have been made during the visits of the Research Chemist to the members of the association. There is little doubt that the fuller knowledge of factory technique thus obtained is gradually enabling the workers in the tanneries to improve the quality of their products. The request for more frequent visits of the Research Chemist is an indication that this aspect of the work is fully appreciated and a further indication that progressive firms realize the value of science as an aid to industry.

PELT RESEARCH.

During the past year New Zealand exported approximately twelve million pickled pelts, the value of which was £542,000. A large portion of these pelts were sold at an exceptionally low price, which was only half that of present-day values. The value of the export trade of pickled pelts is considerable, even though it may be regarded as only a by-product of the large industry of killing and freezing meat for export. In normal times the value of this export on the present output should approximate £1,000,000.

The leather into which these pelts are made may vary considerably according to the requirements of the particular uses to which it will be applied. Consequently if every purchaser of pelts is to be satisfied it would be necessary to process the skins differently to suit these individual requirements. By doing this the extent of the market for each type of skin produced would be naturally limited. In order not to restrict sales it is more economical to produce a pelt which, whilst not satisfying all, will satisfy the majority of buyers.

One of the difficulties in the past has been to obtain reports of a general nature on the quality of New Zealand pickled pelts. Manufacturers abroad have given their considered opinions, good or bad, as to the suitability of the pelts for their individual requirements. This has, at times, brought about much confusion, as the producer may have obtained both good and bad reports on identical lines of his pelts.

As trial or experimental shipments are regarded as one of the most important features in the research on pelts it was necessary to obtain, if possible, general rather than individual reports. To achieve this a committee was established in London, called the New Zealand Pelt Committee, and in its personnel are tanners making different types of sheepskin leathers, representatives of the British Leather Research Association, and representatives of the New Zealand Government. New Zealand is greatly indebted to the members of this committee, who have given so generously of their time and have actually processed experimental shipments of pelts in order to be in a position to give a sound considered opinion as to their relative values.

That portion of the work carried out in New Zealand may be divided into three classes :—

(*a*) Laboratory investigations.
(*b*) Factory investigations.
(*c*) Processing of trial shipments.

The laboratory investigations included work on the following problems :—

(*a*) Action of the paint on the skin, and how this is affected by alterations of strength and temperature.
(*b*) The relation of the liming process to the conditions under which the skin was painted.
(*c*) Comparison of sodium sulphide liming with that from which it has been practically eliminated.
(*d*) Effect of time and temperature on sulphide and pure liming processes.
(*e*) Comparison of dolly and stack liming.
(*f*) The source of iron and probable causes of staining in pickled pelts.
(*g*) A comprehensive study of the pickling process in relation to storage conditions and mould-growth. The work on pickling was carried out in London by the British Leather Research Association.

The factory investigations were necessary to investigate methods of control and actual conditions under which the skins were processed. At the same time data were obtained in an endeavour to correlate the laboratory with practical results. In many cases actual works results were secured, and confirmed those obtained in the laboratory. The preliminary work on the effect of mechanical agitation of liquors was commenced, and so far has produced very interesting results. In all the work on pelts more attention has been given to *microscopical methods of investigation* than to chemical. The actual effect on the skin and fibre structure has been examined, and numerous photomicrographs taken to illustrate the different results.

The experimental shipments were planned to confirm or otherwise the results obtained in the laboratory. In order to be able to repeat any experimental trial it is necessary to know the exact conditions under which it was carried out. The conditions under which the shipments of pelts were processed were therefore carefully noted and copies of the records sent to England, so that the London Committee would consider them when discussing the relative merits of the leather formed from each trial.

Trials shipments of specially prepared bobby-calf skins were also sent to England, and the following results were obtained :—

(1) Best results were obtained when the skins were carefully washed immediately after flaying.
(2) The addition of sodium fluoride to the curing-salt was beneficial.
(3) As much as possible of the adhering flesh should be removed before curing.
(4) It is wrong practice not to cure the skins the same day as they taken off the animal.
(5) Probably the best method of preserving this type of skin is to pickle them in somewhat similar way to sheep and lamb skins.

The value of any co-operation in research is not wholly measured by the direct results obtained either in the factory or the laboratory. Equally important is the effect of such work, even if practical results are not apparently obtained, on the men who carry out the operations day by day in the works. Unless there is a ready interchange of ideas, such as is fostered by research, the broader outlook, the spirit of initiative, and general keenness in industry will not be in evidence. In the absence of a proper attitude the line of least resistance is followed. It is this apathy to the spirit of progress which results in countries and firms being content to live on past reputations and which ultimately leads to disaster.

The minutes of the last meeting of the London Committee conclude with the following statement: "All expressed appreciation of the valuable progress made and desired that this should be placed on record." It is gratifying to note that in the collective opinion of the actual buyers themselves progress has been made. This progress has been made possible in a greater degree by a grant from the Empire Marketing Board, without which the results already obtained would not have been possible in the same time.

SOIL SURVEY.—THIRD ANNUAL REPORT.

The soil survey programme for the year was devoted mostly to consideration of important areas located on volcanic soils, which had been intensively farmed for many years. It was felt that the selection of areas which had been farmed for some time past, and which had received generous supplies of mineral fertilizers by way of top-dressing, would afford some interesting information on the potential value of soil surveys and at the same time provide useful guidance towards a better utilization of the land-resources in areas. It is considered that the application of the knowledge gained from soil surveys would throw a great deal of light upon pasture problems, upon soil treatment preparatory to cropping and establishment of pastures, upon stocking, and soil management. The provision of a soil map, whereon were indicated types, the general characteristics of which were better understood, would serve both to guide farm practice and facilitate any experimental work or farm instruction which may be considered necessary.

First, a rapid reconnaissance survey was made of the greater part of western Taranaki, where the soils were very largely influenced by eruptions from Mount Egmont. Secondly, a detailed soil survey of the Waipa County was commenced, and is still in progress.

The field-work has been carried out by Messrs. L. I. Grange and N. H. Taylor, of the Geological Survey Office, assisted by Mr. W. M. Jones and a number of field hands, some of whose services have been made available through the Unemployment Board.

Chemical investigations were, for the most part, carried out under the direction of Mr. T. Rigg at the Cawthron Institute, and a certain amount of this work was undertaken by the Dominion Laboratory and by the Chemical Laboratory of the Department of Agriculture.

Mr. Grange made a soil survey for the Department of Native Affairs of the Puketotara Block, near Kerikeri, in the Bay of Islands. A summary of his report to the Department of Native Affairs is included in this report.

Mr. Rigg's account of the chemical work contains, besides the Taranaki analyses, some analyses of gumland and basic volcanic soils of North Auckland.

Western Taranaki is for the most part comprised of pasture land carrying a dense cow-population. Top-dressing of pastures is very generally a long-established practice in this province, and investigations by the Fields Division of the Department of Agriculture has already provided evidence of variations in responses to dressings of potash, lime, and phosphates, which were difficult to explain. In some instances the response to potash was strong, and it seemed probable that soil investigations might throw some light upon these manurial responses. The Fields Division of the Department of Agriculture rendered the soil-survey operations both in Taranaki and in the Waipa County valuable assistance in a number of problems which appeared during the course of the work.

Western Taranaki consists largely of easy sloping country, with the exception of the Kaitake Hills and the steep land of Egmont National Park. The general slope of the land is outwards from the central cone of Mount Egmont (8,260 ft.).

The soils are derived chiefly from three main volcanic-ash deposits erupted from Mount Egmont—the Egmont, the Stratford, and the Burrell Showers.

The approximate boundaries of the soils derived from these ash-forming showers and from other sources have been mapped and their field characteristics have been carefully noted.

A large number of Taranaki soils have been analysed by the staff of the Cawthron Institute. It has been found that they are high in available phosphoric acid. The amount of available potash in the soils derived from the Stratford Shower is lower than in those from the Egmont Shower. It is thought that in some localities on the Stratford Shower potash manures may be highly beneficial.

The approximate area surveyed was 500,000 acres.

The soil survey of the Waipa County was made in detail, use being made of the 20 chains to the inch maps compiled by the Lands and Survey Department. Assistants were trained to map the topographical features and the position of subdivisional fences on the farms in the area.

The Waipa County is situated between the Waikato and Waipa Rivers adjacent to the Town of Hamilton, and extends from Ngaruawahia in the north to Te Awamutu in the south. The county possesses throughout an easy contour. It has been settled for many years, and is used intensively for dairying, possessing one of the densest cow-populations of any part of the Dominion. The production of butterfat per acre is high on account of the progress which has been made in herd-testing, rotational grazing, and farm-management. Characteristic of the pasture-management in this area is the regular annual applications of heavy dressings of artificial manures, the greater proportion of which consists of phosphates. Approximately 32,000 acres of the northern portion of the county have been mapped.

The swamps which occupy a quarter of the total area surveyed carry a poor pasture. A detailed investigation of these will no doubt prove of great value.

FIELD-WORK ON SOILS OF WESTERN TARANAKI.

(By L. I. Grange and N. H. Taylor.)

Topography and Climate.

Western Taranaki, with the exception of the Kaitake Hills and the steep land of Egmont National Park, is mainly easy country, which, on the north, south, and west, rises gradually from near sea-level towards the central volcanic cone of Mount Egmont (8,260 ft.). On the east the district is bounded by the edge of the deeply dissected upland of eastern Taranaki, which lies approximately five miles east of the railway-line from Hawera to Lepperton. Near its east margin the easy country is 800 ft. above sea-level, from which height it rises gradually towards Mount Egmont. The average height at the National Park boundary is 1,700 ft.

Western Taranaki is well watered by the many streams that rise on the slopes of Mount Egmont. Most of these are not deeply entrenched. Fairly large swamps occur at Ratapiko, Ngaire, and Eltham, near the edge of the eastern upland.

There are great differences in climate in different parts of the district. Close to the sea temperatures are mild and the rainfall ranges from less than 45 in. per annum in the south to 55 in. in the north. As the mountain is approached the winters become more severe and the rainfall increases. Near the National Park boundary the rainfall is 100 to 150 in. per annum.

In pre-European days most of the district was covered with dense forest, but a strip of country bordering the coast and up to four miles wide was covered with fern and scrub. To-day little of this native vegetation remains outside the National Park.

Mount Egmont has erupted from time to time, covering the whole district with a deep mantle of volcanic ash; in addition, mud-flows have descended its western flank, covering the country between Opunake and Okato with rock debris, much of which is mounded, forming multitudes of conical- or dome-shaped hills 10 ft. to 40 ft. high, with hummocky areas and swampy flats between. The three main later ash-showers which give rise to the soil are (1) the Egmont Shower, which is exposed over a belt of four to ten miles wide, bordering the coast from Waitara to Hawera, (2) the Stratford Shower, which overlies the Egmont Shower in the eastern half of the district and extends from four miles south of Waitara to three miles north of Normanby, and (3) the Burrell Shower, which overlies the Stratford Shower between Mount Egmont and a point three miles west of Stratford. This latter shower was erupted probably less than five hundred years ago.

Soils.

The soils of the district fall into two main groups, those derived from subaerial volcanic ash and those derived from material that has been resorted by water or by winds. Altogether thirteen soil series have been recognized, and these have been subdivided into twenty soil types, the more important of which are listed below.

(1) *The Egmont Series* (derived from the Egmont Shower):—

The Egmont black loam is the soil on the former scrublands which bordered the coast between Onairo and Okato in the north (40,000 acres) and in the Manaia and Hawera districts in the south (52,000 acres).

The soil profile is—

9 in. black loam,
10 in. free light-brown loam,
on compact light-brown loam.

The Egmont brown loam is the soil covering an area of 32,000 acres lying east of a line from New Plymouth to Okato, and 42,000 acres lying west of a line from Normanby to Alton. The soil profile is similar to that of the Egmont black loam, but the top 6 in. to 9 in. is dark brown. Although the Egmont loams cover much flat and very easy land, the surface is usually well drained, because the subsoils are free. These soils are at present the most productive soils in Taranaki.

(2) *The Warea Series* (derived from the Egmont Shower and the Warea mud-flows) :—

Warea loam and stony loam is the soil over 50,000 acres lying to the west of Mount Egmont, between Okato and Opunake.

This area, lying in the path of the great mud-flows from Mount Egmont, is covered with thousands of conical hills which in many places are so close together that farming is almost impossible. The flat and hummocky areas between the hills are badly drained, and in some places the surface is strewn with boulders. On the flatter areas the soil is a brown loam, derived from the Egmont Shower, which is here about 3 ft. thick, but much of this ash has been eroded off the conical hills and the soil on them is a stony loam derived partly from the Egmont ash and partly from the material of the mudflow.

(3) *The Stratford Series* (derived from the Stratford Shower) :—

Stratford sand covers a strip of country twenty-five miles long and three to five miles wide (49,000 acres), extending from one mile south of Lepperton to two miles north of Eltham. The soil is dark brown and is free or only moderately compact for 2 ft. from the surface.

Near Stratford the profile is—

Stratford { 7 in. dark-brown sand,
4 in. brown, loamy, gravelly sand.
Egmont : *on* dull-brown loam.

Although the soils are coarse in texture the pastures do not suffer from drought, as the rainfall is high—70 in. to 80 in. per annum.

Stratford sandy loam occurs where the Stratford Shower is less than 9 in. Two belts of this soil have been mapped. One bordering the Stratford sand on the north is two miles wide and covers 16,000 acres, and the other bordering it on the south is five miles wide and covers 49,000 acres. The annual rainfall is about 70 in. in the northern area and 50 in. in the south. The top soil is dark brown to brown and moderately free ; the subsoil is light brown and moderately compact.

Near Lepperton the profile is—

Stratford : 6 in. dark-brown sandy loam.
Egmont { 6 in. free brown loam,
on compact brown loam.

(4) *The Inglewood Series* (derived from the Stratford Shower) :—

Inglewood coarse sandy loam covers 21,000 acres surrounding Inglewood and Egmont village, and 12,500 acres on a strip stretching from Tariki to two miles north of Kaponga. The rainfall is between 70 in. and 100 in. per annum. The top soil has a loamy feel, is dark-brown in colour, and has a crumb structure ; the subsoils are coarse.

Near Inglewood the profile is : 6 in. dark-brown coarse sandy loam on brown, loamy, coarse sand and gravelly sand. The soils are moist and cold during the greater part of the year, conditions which limit the production from them.

(5) *The Norfolk Series* (derived from the Stratford Shower) :—

Norfolk sand and sandy loam covers a rectangular area of 6,000 acres, stretching from Tariki to the National Park boundary. The top soils are brown to dark-brown, the subsoils are brown to grey, and 4 ft. or less below the surface they are underlain by a grey cemented stony layer. As the surface is flat to very gently undulating, drainage is poor, and iron pans, which are forming at different depths, further impede the drainage. From the Park boundary to within two miles of Tariki the drainage is so poor that swamps occupy most of the hollows. This area has been mapped as the swampy phase of the Norfolk sand and sandy loam.

(6) *The Patua Series* (derived from the Stratford and Egmont Showers) :—

Patua sandy loam and sand (31,000 acres) covers a discontinuous curved strip two to four miles wide close to the north and west of the National Park boundary. It is a dark-brown, compact soil with a pronounced crumb structure and with iron compounds accumulating in subsoil crevices or forming thin discontinuous pans. In the north the soil is derived from the Stratford Shower, in the west mainly from the Egmont ; but because of the effect of the heavy rainfall (100 in. and more per annum) the soils appear so similar that for the purposes of a reconnaissance survey they have been placed in the same series. At present only small areas of this soil type are farmed. The soils are more moist and cold than those of the Inglewood Series.

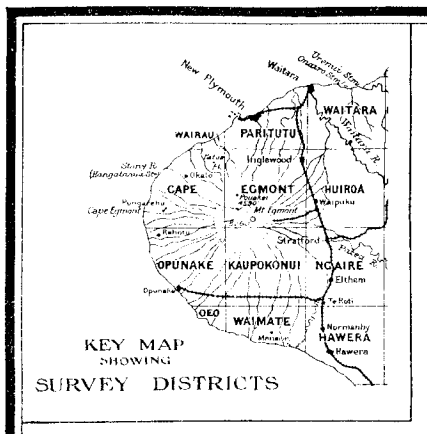
(7) *The Burrell Series* (derived from the Burrell Shower) :—

Burrell gravelly sand covers approximately 12,500 acres, stretching from the National Park boundary, where the deposit is 12 in. thick, to within three miles of Stratford, where it thins to 3 in.

Two miles from the Park boundary the profile is—

Burrell : 8 in. dark-greyish brown gravelly sand.
Stratford { 4 in. brown loam,
8 in. brown gravelly loam,
on dull-brown greasy loam.

North of Radnor Road the soils are complex, and in many places the Burrell gravelly sand rests on water-sorted deposits ranging from gravelly sands to loams in texture. Much of the area is badly drained and there are numerous small swamps in which the Burrell gravelly sand is covered with peaty loams.



KEY MAP
SHOWING
SURVEY DISTRICTS

Soils formed from Tertiary mudstone, sandstone, and volcanic ash

Edge of dissected country

LEGEND

Soils derived from volcanic ash subaerially deposited.

- Burrell Series. Burrell gravelly sand on loam
- Burrell Series. Burrell gravelly sand on loam, and gravelly sand (undifferentiated)
- Newall Series. Newall gravelly sand
- Newall Series. Newall sand and bouldery sand
- Stratford Series. Stratford sandy loam
- Stratford Series. Stratford sand
- Inglewood Series. Inglewood coarse sandy loam
- Norfolk Series. Norfolk sand and sandy loam
- Norfolk Series. Norfolk sand and sandy loam (Swampy phase)
- Egmont Series. Egmont black loam
- Egmont Series. Egmont brown loam
- Warea Series. Warea loam and stony loam
- Patua Series. Patua sandy loam

Soils derived from resorted material

- Patea Series. Patea sands
- Waitara Series. Waitara sandy loam and sand
- Hangatahua Series. Hangatahua sand and gravelly sand
- Hangatahua Series. Hangatahua bouldery peaty loam and sand
- Hangatahua Series. Hangatahua loam
- Glenn Series. Glenn loam
- Eltham Series. Eltham peaty loams

Rainfall in inches. —60— (Isohyets after E. Kidson)

Soil surveys by L.I. Grange and N.H. Taylor, 1933.

J. HENDERSON
DIRECTOR.

RECONNAISSANCE SOIL MAP OF WESTERN TARANAKI

SCALE
CHAINS 80 40 0 5 10 MILES KM. 1 0 5 10 15 KILOMETRES
1 : 253440

G.E.H.

H.-34.

Soils from Resorted Material.

The soils derived from resorted material have been divided into seven types grouped into five series.

The Hangatahua Series, which has been mapped over 18,500 acres, includes all the soils formed from volcanic material resorted by the streams draining from Mount Egmont. This series is subdivided into loams, bouldery loams, sands, and gravelly sands. In general, the sands and gravelly sands lie close to the banks of the streams. The loams which lie behind the sands and farther from the streams are at a lower level than the sands and are in most places swampy. The sands near the coast—*e.g.*, near the mouth of Hangatahua Stream—dry out badly during summer. The bouldery loams are mainly unfitted for agriculture. The swampy loams are at present but little utilized.

The Glenn Series is related to the Hangatahua Series in that the parent material is volcanic debris brought down by the streams. This series is classified separately because 1 ft. or 2 ft. below the surface there is, in many places, a well-developed iron and humus pan up to 18 in. thick. Glenn loam, which has been mapped over 13,500 acres, extends from Kaponga to within two miles of Otakeho. The soil is poorly drained and in its natural state supports swamp vegetation.

The soils of the Waitara Series are derived partly from resorted volcanic debris and partly from material washed from the calcareous mudstones of the eastern upland. Waitara sand and sandy loam have been mapped over 1,500 acres on terraces bordering the Waitara River.

The Eltham Series includes the soils formed from a mixture of peat and volcanic ash, which cover the swamps lying east of the railway-line between Eltham and Inglewood. Eltham peaty loam covers 8,000 acres, the largest areas being the swamps of Ngaire (4,000 acres) and Eltham (3,000 acres). Where properly drained the peaty loams carry a fairly good pasture. In some places the soil is "waterproof" owing to the presence of wax.

The soils of the Patea Series are those derived from wind-blown sands. Patea sand has been mapped over 6,500 acres. It occurs on narrow strips, seldom more than a mile wide, bordering the sea-shore.

FIELD-WORK ON SOILS OF WAIPA COUNTY.

(By L. I. Grange and N. H. Taylor.)

Topography.

Waipa County lies between the Waikato River and its main tributary, the Waipa, and extends from Te Awamutu in the south to the junction of the two rivers at Ngaruawahia. Throughout, the country is easy, wide flats predominating in the north and rolling hills in the south. The flats are approximately 150 ft. above sea-level; the rolling hills rise approximately 300 ft. Many swamps occur throughout the country, the largest being Rukuhia, which lies close south of Hamilton.

Geology.

The geology of the Waipa County is described in Bulletin No. 28 of the New Zealand Geological Survey, and this has proved a valuable aid in the mapping of the soils.

In Pliocene times rivers, draining from the rhyolite-covered hills in the south, filled the Hamilton Basin with beds of rhyolite sands and gravels. The region was then uplifted, and after these sandy beds had been eroded into rolling hills and valleys volcanic eruptions covered the countryside with 10 ft.–15 ft. of ash. Later the Waikato River, issuing from the Maungatautari Gorge, built a gently sloping alluvial fan across the rolling lowlands, filling in the valleys and leaving only the upper parts of the ash-covered hills projecting. The different courses which the river took across the plain are marked by long low ridges of sand and gravel, which in many places form barriers across the mouths of the subsidiary valleys damming back the streams and forming lakes and swamps. Away from the sandy ridges, mud and clay were deposited over wide flats, and as the building-up continued the lower-lying parts were converted into extensive swamps. On the west the Waipa River also built up its bed, keeping pace with the Waikato, but as it flowed more slowly the debris it deposited was finer in texture. At the close of the fan-building stage the rivers entrenched themselves in the easily-eroded alluvium, leaving their banks bordered with long, narrow terraces.

Soils.

In the area so far examined thirteen soil types have been recognized, and these are tentatively classified as follows:—

—	Parent Material.	Soil Type.
Soils of the rolling hills ..	Subaerial volcanic ash, Hamilton Shower ..	Hamilton clay loam.
Soils of the Waikato Fan	Water-sorted rhyolite ash	Horotiu sandy loam and sand. Te Kowhai sandy loam and clay loam, &c. Te Kowhai sand. Te Kowhai sandy clay.
	Decaying swamp vegetation	Rukuhia peat.
	Decaying swamp vegetation and water-sorted rhyolite ash	Rukuhia peaty silt and sand. Rukuhia peaty clay.
	Water-sorted Hamilton ash	Rotokauri clay loam.
Soils of the Waikato Terraces ..	Water-sorted rhyolite ash	Waikato sands.
Soils of the Waipa Terraces ..	Water-sorted rhyolite ash mixed with alluvium from greywacke and mudstone	Waipa sand. Waipa loam.
Maori soils	..	Maori gravelly loam.

Hamilton Clay Loam.—The Hamilton clay loam is derived from the subaerial deposits, mainly andesitic or basaltic in composition, covering the rolling hills.

The soil profile is—

4 in. black to dark-brown clay loam,
8 in. brown compact clay loam,
18 in. reddish-brown compact clay, with horizontal bands, ½ in. thick, of grey clay near its base.

In the top 12 in. of the soil black manganese and iron concretions are common. The profile shows that this soil is mature, clay material having been leached from the top 12 in. layer into the reddish-brown layer, giving it a clay texture. Frosts being infrequent on the hills in spring, pastures came away early. During the summer months, when the clay loam dries out and cracks, the pasture-cover is poor, but when the soil is moist and has received top-dressings of phosphates the pastures on it are excellent.

Horotiu Sandy Loam.—The Horotiu sandy loam occupies the higher portions of the flats and the narrow subparallel ridges crossing the areas covered by the Te Kowhai and Rukuhia soils.

The profile is—

8 in. dark-brown sandy loam,
10 in. light-brown, fairly free, sandy loam,
on light-brown sands.

This soil is well drained and friable, and is consequently easily worked as it is warmer than the other soils of the flats and responds readily to top-dressing. Some of the best pastures in the Waikato are grown on it, but owing to the open nature of the subsoil it will not stand much dry weather. The fertilizers most used on this soil are superphosphate and a mixture of superphosphate and lime.

Te Kowhai Loam, Sandy Loam, Clay Loam, Sandy Clay, and Sand.—The largest area of the Te Kowhai soils occur in the Te Kowhai district, but many small patches are found throughout the area mapped. These soils lie at a slightly lower altitude than the Horotiu sandy loam and were originally badly drained. The profiles vary a good deal in texture and colour, but the common characteristics are top-soil compact, brownish-grey to grey in colour, and subsoil heavy in texture and cream to light brown in colour.

Typical profiles are—

6 in. brownish-grey to grey loam,
10 in. cream clay loam,
on sands.

And 6 in. brownish-grey compact clay loam,
10 in.–40 in. light-brown to cream clay loam,
on sands.

The Te Kowhai clay loam carries excellent pasture of rye and clover, but as the soil contains an excess of moisture during winter the pastures in the spring come away later than those on the well-drained soils. On this type many farmers state that the best results are obtained with basic slag.

Rukuhia Peat, Peaty Sand, Peaty Silt, and Peaty Clay.—The Rukuhia soils cover probably a quarter of Waipa County. The deep peats are at present little farmed. Some of the shallower peat land has been sown down in pasture, but the cost has generally been high, for when the shallower peats are drained the surface sinks and numerous logs and stumps of trees, chiefly kauri, rimu, kahikatea, and manawa, appear. A typical profile on the shallow peat is 9 in. to 36 in. dark-brown powdery peat on buff clay loam.

The peaty silts and sands which occur on the margin of the peats cover a much less area than the peats. They are usually at a slightly higher level, and on them stumps are seldom found.

The profile on the peaty silt is—

9 in. reddish-brown powdery peaty silt,
9 in. darker reddish-brown powdery peaty silt,
on buff clay loam.

The peaty clays border the swamp east of Whatawhata.

A typical profile is—

3 in.–9 in. dark-grey peaty clay,
24 in. grey clay (with waxy appearance),
on peat.

In many places the peaty soils are dry below the top ½ in. of the soil even after heavy rain. These are the "waterproof" soils described by Aston in the *Journal of Agriculture*, Vol. XIII, No. 4, p. 289, 1916. A wax in the soil prevents it from becoming moist, and so pastures are difficult to establish. Generally, the soils of the Rukuhia series carry poor pastures, light in colour, the sward being composed of brown-top, Yorkshire fog, and weeds even where the better grasses were originally sown down.

Rotokauri Clay Loam and Peaty Clay Loam.—The ground covered with Rotokauri clay loam is of comparatively small extent. These soils occur in small swampy arms extending into the rolling hills and on the margins of peaty swamps. The profile is 3 in.–6 in. dark clay loam or peaty clay loam with a crumb structure on sticky translucent grey clay.

These soils are probably derived mainly from the fine textured portion of the volcanic ash covering the Hamilton hills.

Waipa Sands and Loams.—The Waipa sands and loams cover the low terraces of the Waipa River and receive fresh deposits during strong floods. The sands which form a narrow strip close to the river are generally coarse. The loams occupy those parts of the terraces lying farther back from the river and cover a much greater area. Both of these soils are brown in colour and probably have a low nitrogen content. Except for a narrow badly-drained strip at the back of the terraces, they are generally well farmed.

Waikato Sands.—The Waikato sands cover the hummocky terraces bordering the Waikato River. They are not subject to present-day floods. The sands being coarse—to 3 ft. or more below the surface—dry out badly in summer. These soils are brown in colour and probably have a low nitrogen content. Generally the pastures on this soil are poor.

Maori Gravelly Sands.—On the flats covered with the Horotiu sandy loam the Maoris, before the arrival of the pakeha, dug conical holes up to 15 ft. deep to obtain a gravelly sand which they spread over the land to a depth of 9 in. or 10 in. To build up the store of lime, potash, and phosphate in this new soil the Maoris probably burnt manuka on it. These Maori soils occur chiefly near the Waikato River between Ngaruawahia and Hamilton. At Ngaruawahia there is a continuous area of about two hundred acres of Maori gravelly sand. Small patches occur near the Waipa River. These man-made soils, which were used for growing the kumara, are similar to those in Waimea West described by Rigg and Bruce. The Maori gravelly sands are dark brown to black in colour and support a good sward of grass—much better than is to be expected on a soil of such a coarse texture.

PUKETOTARA BLOCK, BAY OF ISLANDS.

(By L. I. Grange.)

Towards the end of May the writer spent a week in the Bay of Islands, at the request of the Department of Native Affairs, examining the soils on the Puketotara Block, which lies about eight miles west of Kerikeri.

The block, containing 2,196 acres, is part of a dissected plateau at between 600 ft. and 850 ft. above sea-level. Kerikeri River, on the north boundary, is entrenched fully 500 ft., and Maungaparerua Stream, on the south, is at most 300 ft. below the plateau. Most of the block consists of flat and rolling land covered with scrub—manuka, fern, hakia, and kumarahou.

There are two types of soil—Kerikeri clay and Kaeo clay: Kerikeri clays, occupying much the larger area, are derived from basalt, whereas the Kaeo clays are derived from fine-grained marine sediments.

The profile on the Kerikeri clay is—

9 in.–11 in. dark-brown clay with occasional iron nodules,
3 in. dark-brown clay containing many iron nodules,
3 in. dark-brown clay with occasional iron nodules,
on light-brown clay.

This is a podsol profile. There has been much downward leaching of the fertility elements. In places the nodule layer is on the surface; the dark-brown clays which formerly overlay it have been washed away.

Similar soil profiles are found at Pungaere, Waipapa, and Okaihau.

The profile on the Kaeo clay is—

10 in. dark-grey compact clay
on light-grey clay.

This soil is a podsol and is considered to be similar to the gum-land soils of North Auckland.

Pastures established by farmers in the neighbouring districts on the Kerikeri clays are satisfactory only when heavy applications of fertilizers are made. A farmer who used 3 cwt. of basic slag when laying down his pasture and did no subsequent top-dressing has an extremely poor cover. Good results have been obtained by an Okaihau farmer by an initial application of 1 ton of ground limestone and 3 cwt. of superphosphate and 2 cwt. of superphosphate each succeeding year. Heavy liming is essential, for the aluminium and iron-compounds of the Kerikeri clays, in the absence of lime, would render the phosphates unavailable to the plants.

The Kaeo clays, if correctly correlated with the gum-land soils, do not need heavy applications of lime. From the experiments made by the Department of Agriculture in the gum-land soil at Puwera, near Whangarei, it was found that the soil needed an initial application of 7 cwt. of a mixture of basic slag and super and 3 cwt. of this mixture in succeeding years.

CHEMICAL WORK ON THE SOILS OF WESTERN TARANAKI AND NORTH AUCKLAND.

(By T. Rigg.)

The chemical work necessary for the characterization of soil types identified by the field-workers in Taranaki and in the Waikato has been done partly at the Dominion Laboratory, Wellington, and partly at the Cawthron Institute. Mr. F. T. Seelye, of the Dominion Laboratory, has continued his work in connection with the fusion analyses of samples taken from different soil profiles, and has supplied much valuable information concerning the chemical processes which have operated in soil formation.

The work at the Cawthron Institute has been connected mainly with a study of the surface soils. Determinations of textural characteristics, of lime status, of soil acidity, and of plant-food content have been carried out by Miss E. B. Kidson and L. Hodgson on a large range of Taranaki soils, and much information has been gained thereby.

Taranaki Soils.

Texture of Taranaki Soils.—Mechanical analyses made by Troell's method of soil samples taken to a depth of 6 in. have shown the great uniformity in texture of soils derived from the Egmont ash-shower. Samples collected from different points in both south and north Taranaki reveal the great constancy in the percentages of the sand, silt, and clay fractions. Typical analyses of samples taken from Waitara in the north and Manaia in the south are shown in Table I below. In both cases the soils belong to the loam group and contain 10–12 per cent. of clay and 18–20 per cent. of the silt fraction.

Table I.—Typical Mechanical Analyses of Taranaki Soils.

Ash-shower	Egmont.				Stratford.						Burrell.	
Locality	Waitara.		Manaia.		Toko.		Stratford.		Inglewood.		Stratford.	
Laboratory No.	487A.	487B.	443A.	443B.	431A.	431B.	429A.	429B.	483A.	483B.	455A.	455B.
Depth of sampling	0–3 in.	3–6 in.	0–3 in.	3–6 in.	0–3 in.	3–6 in.	0–3 in.	3–6 in.	0–3 in.	3–6 in.	0–3 in.	3–6 in.
Coarse sand	17·9	22·4	18·6	22·4	25·3	27·2	41·7	45·4	28·8	32·3	47·4	43·6
Fine sand	16·5	17·6	21·9	22·2	19·7	21·8	14·1	17·6	16·4	16·4	13·1	19·1
Very fine sand	8·9	6·7	8·3	9·5	7·4	7·9	6·0	7·8	5·1	6·3	8·2	7·2
Silt	18·8	19·5	22·0	21·8	17·5	18·9	10·2	10·4	14·5	13·9	11·4	12·6
Clay	12·4	11·2	10·5	8·5	3·3	3·2	2·4	1·1	9·6	8·3	4·2	3·0
Loss on ignition	30·2	24·0	22·7	17·2	23·4	19·1	23·2	14·3	26·8	21·2	17·9	11·9
Difference	−4·7	−1·4	−4·0	−1·4	3·4	1·9	2·4	3·4	−1·2	1·6	−2·2	2·6
Stones	2·5	3·3	Nil	Nil	5·2	11·2	Nil	8·8	10·9	16·1	15·4	14·1
Fine gravel contained in coarse sand	Nil	2·9	3·4	5·9	1·5	2·6	3·1	4·9	8·5	10·2	15·9	10·0
Soil type	Loam.		Loam.		Medium sand.		Coarse sand.		Coarse sandy loam.		Gravelly sand.	

Notes.—Sample 487 from Bell Block, junction of main Waitara and Inglewood roads; sample 443 from Manaia State Farm, Waimate West; sample 431 from Toko Railway-station; sample 429 from virgin soil, Stratford Demonstration Farm; sample 487 taken 1·7 miles north of junction of Lepperton and Mountain Roads; sample 455 from upper end of Hastings Road.

The soils derived from the Stratford ash-shower show much greater variation in textural properties. At Stratford and its immediate vicinity the texture of the soils falls into the coarse sand group. At Inglewood soils belonging to the sandy loam group are more typical. The presence, however, of a considerable amount of fine gravel, both in the surface and sub-strata of Inglewood soils, makes them more open in texture than is indicated by the mechanical analyses. Samples taken from Kaimata and Toko show that, at these centres removed some distance from the centre of volcanic eruption, very coarse particles are generally absent from the surface soils. The soils contain large percentages of the sand fraction, and fall into the medium sand category.

Soil samples taken from the very recent ash-shower (the Burrell Shower) were found to belong to the gravelly sand texture. The coarse-sand fraction amounted to over 45 per cent., and, in addition, the soils contained 14–15 per cent. of small stones.

Lime Status of Taranaki Soils.—Determinations of lime requirement and of pH value have been made on a number of soil samples taken from the different soil types. The pH values show, with few exceptions, a very small range, figures between 5·85 and 6·08 being usually obtained for the top 0–3 in. spit. As a rule, the pH value for the 3 in.–6 in. spit is a little lower than the top 0–3 in. spit, and in both cases indicate that the soils require only small applications of lime for pasture purposes. The Patua soil, derived from mixed volcanic ash in the high-rainfall belt of Mount Egmont, has a lower pH value (5·71) and shows more need of lime treatment. As might be expected, the peaty soils of Eltham have a marked acid reaction, and beneficial results should be obtained from lime treatment. Considering the large percentage of organic matter associated with Taranaki soils, the lime-requirement figures are not high. They show that the soils are unsaturated in regard to lime, but do not necessarily indicate high lime-deficiency in the soil. Average lime-requirement figures and pH values for all the more important soil types are shown in Table II.

TABLE II.—CHEMICAL ANALYSES OF TARANAKI SOILS.

Average Lime-requirement Figures and pH Values.

Soil Group.	Depth of Sampling.	Number of Samples.	Lime Required.	pH Value.	
				Water.	N.KC$_1$
Egmont loam (black)	0 – 3 in.	9	0·47	5·87	5·12
	3 in. – 6 in.	8	0·56	5·82	4·95
Range, 0–3 in. spit; lime-requirement figure = 0·30 – 0·65; pH (water) = 5·57 – 6·06.					
Egmont loam (brown)	0 – 3 in.	6	0·51	5·94	5·20
	3 in. – 6 in.	6	0·58	5·91	5·08
Range, 0 – 3 in. spit; lime-requirement figure = 0·41 – 0·64; pH (water) = 5·87 – 6·12.					
Stratford sandy loam (including Inglewood sandy loams)	0 – 3 in.	5	0·53	5·85	4·96
	3 in. – 6 in.	5	0·58	5·61	4·83
Range, 0 – 3 in. spit; lime-requirement figure = 0·44 – 0·67; pH (water) = 5·64 – 6·06.					
Stratford coarse sand	0 – 3 in.	3	0·39	5·96	5·12
	3 in. – 6 in.	3	0·41	5·95	5·05
Stratford medium sand	0 – 3 in.	3	0·41	6·08	5·27
	3 in. – 6 in.	2	0·50	6·01	5·10
Eltham peaty loam	0 – 3 in.	1	1·02	5·16	4·36
	3 in. – 6 in.	1	1·42	4·77	4·07
Hangatahua	0 – 3 in.	2	0·56	5·97	4·98
	3 in. – 6 in.	2	0·60	5·63	4·79
Patua	0 – 3 in.	2	0·67	5·71	4·83
	3 in. – 6 in.	1	0·45	5·77	4·73

Available Plant-food.—Determinations of plant-food soluble in 1 per cent. citric-acid solution have been made on typical samples taken from the more important soil types. The analyses have not been completed, but a few representative determinations are shown in Table III.

TABLE III.—CHEMICAL ANALYSES OF TARANAKI SOILS.

Available Plant-food.

(Average figures for different soil groups.)

Soil Group.	Depth of Sampling.	Number of Samples.	Phosphoric Acid (P_2O_5).	Potash (K_2O).
Egmont loam (black)	0 – 3 in.	6	0·046	0·033
	3 in. – 6 in.	3	0·048	0·014
	6 in. – 9 in.	2	0·017	0·008
Egmont loam (brown)	0 – 3 in.	3	0·056	0·032
Stratford sands and sandy loams ..	0 – 3 in.	6	0·061	0·015
	3 in. – 6 in.	3	0·042	0·009
Burrell gravelly sand	0 – 3 in.	1	0·089	0·026
Hangatahua loam	0 – 3 in.	1	0·048	0·024
Eltham peaty loam	0 – 3 in.	1	0·053	0·036
Warea sandy loam	0 – 3 in.	1	0·029	0·018
Patua sand	0 – 3 in.	1	0·039	0·018
Glenn loam	0 – 3 in.	1	0·038	0·028

The most outstanding feature of these analyses is the very high content of available phosphoric acid. In the case of a sample of the Burrell gravelly sand, the percentage attained to 0·089 per cent. Six samples derived from the Stratford Shower averaged 0·061 per cent., and nine samples from the Egmont Shower averaged 0·050 per cent. These figures refer to the 0 – 3 in. spit, but even in the case of the 3 in. – 6 in. spit figures in the vicinity of 0·045 per cent. of available phosphoric acid are common. Below the 6 in. depth there is a great drop in the percentage of available phosphoric acid, but even in this case the figures are by no means low. That the high content of available phosphoric acid is not entirely due to the long-continued top-dressing of Taranaki soils with phosphatic manures

is shown by the figure 0·042 per cent. of available phosphoric acid found in a soil at Inglewood, which had received no top-dressing treatment for thirteen years. When it is remembered that on many non-volcanic soils of New Zealand the percentage of available phosphoric acid seldom exceeds 0·02 per cent. the high supply of this constituent in the volcanic soils of Taranaki is clearly apparent. There can be no doubt that the continued use of phosphatic manures for top-dressing pastures has materially increased the supply of available phosphoric acid in Taranaki soils.

Much greater variation in the content of available potash was found in the different soil types and also occasionally in samples from the same soil type located under different rainfall conditions. The average figure for available potash in the case of Egmont loam was comparatively high (0·033 per cent. in the top 0 – 3 in. spit). Samples taken in the Patea locality had a particularly high potash content, in one case attaining to 0·059 per cent. available potash. On the other hand, a sample obtained from Bell Block, near Waitara, under much higher rainfall contained only 0·012 per cent. in the top 0 – 3 in. spit. Soils belonging to the Stratford Series, invariably under higher rainfall conditions than the Egmont loams, contained much smaller amounts of available potash, the average figure for six samples being 0·015 per cent. in the top 0 – 3 in. spit. In certain cases the percentage was as low as 0·011 per cent. The figures for the Stratford Series suggest that in certain cases potash manures may be highly beneficial. It is interesting to note that the gravelly sand of the recent Burrell Shower is not only well supplied with available phosphoric acid, but has a comparatively high content of available potash.

North Auckland Soils.

Advantage was taken of a visit to Whangarei, Kaikohe, and Kerikeri to examine certain typical soils in these localities. At Whangarei a representative area of gum land was inspected, and a sample obtained for laboratory examination. The gum lands in the Whangarei locality have a flora containing certain features in common with the Pakihi lands of the West Coast, *Cladium teretifolium*, *Gleichenia dicarpa*, and stunted manuka being common to both soil types. The vegetation indicates high deficiency of both lime and phosphate. This is borne out by the chemical analyses. The mechanical analyses show that the gum lands in the vicinity of Whangarei have a high content of clay and of silt, these two fractions amounting to over 60 per cent. of the soil.

At Kaikohe and Kerikeri samples of soil derived from basic volcanic rocks were examined. In the case of Kaikohe, the volcanic rock is of Miocene age and is highly weathered. Typical samples contained over 50 per cent. of clay and 15 – 20 per cent. of the silt fraction (see Table IV).

Table IV.—Mechanical Analyses of Typical North Auckland Soils.

Derivation and locality	Gum-lands, Whangarei.	Basic Volcanic Rock.	
		Kaikohe.	Kerikeri.
Laboratory No.	401	403A	413A
Depth of sampling	0 – 6 in.	0 – 6 in.	0 – 9 in.
Coarse sand	1·2	3·0	3·4
Fine sand	13·3	10·6	5·7
Very fine sand	9·9	3·6	3·2
Silt	37·1	15·6	11·2
Clay	30·4	48·7	53·5
Loss on ignition	6·1	15·6	22·4
Loss by soln. and difference	2·0	2·9	0·6
Stones	Nil	Nil	5·0
Fine gravel contained in coarse sand	Nil	Nil	1·4
Type	Clay loam	Clay	Clay

Note.—Mechanical analyses of International Standard method and results expressed as ignited fractions on moisture-feed soil.

The soils derived from these basaltic rocks must therefore be classified as clays, but the soils possess much better drainage-qualities than is indicated by the high clay-content. The Kerikeri soils are derived from basic volcanic rocks of more recent origin, and the soils contain much more rubble than is the case at Kaikohe. The mechanical analyses show a high clay-content, but the presence of rubble near the surface gives good drainage-qualities to the land. In the case of soils derived from the basic volcanic rocks at both Kaikohe and Kerikeri, very small amounts of available plant-food were extracted by 1 per cent. citric acid (see Table V). The figures for available phosphoric acid varied from 0·001 to 0·004 per cent., and in the case of available potash a variation of 0·007 to 0·015 per cent. was found in the surface soils. The pH value (5·1) shows that the soils in both places are highly acid and that lime is very necessary for their treatment.

TABLE V.—CHEMICAL ANALYSES OF TYPICAL NORTH AUCKLAND SOILS.

Derivation and locality	Gum-lands, Whangarei.	Basic Volcanic Rocks.	
		Kaikohe.	Kerikeri.
Laboratory No.	401	405A	413A
Depth of sampling	0–6 in.	0–6 in.	0–9 in.
Lime-requirement figure	0·36	0·41	0·53
pH value (water)	4·73	5·19	5·10
Available plant-food—			
Phosphoric acid P_2O_5	0·001	0·001	0·002
Potash (K_2O)	0·004	0·010	0·015
Replaceable bases —			
Lime (CaO)	..	0·099	0·086
Magnesia (MgO)	..	0·052	0·049
Potash (K_2O)	..	Trace	Trace
Soda (Na_2O)	..	0·022	0·017

T. RIGG.

PUBLICATIONS.

During the year four new bulletins were published as follows:—

No. 36: "Overrun of New Zealand Butter," by W. Riddet, G. M. Valentine, F. H. McDowall, and L. A. Whelan.

No. 37: "The Effect of Salt on the Quality of Cheddar Cheese," by W. Riddet, G. M. Valentine, F. H. McDowall, and L. A. Whelan.

No. 38: "Factors affecting the Rate of Ripening of New Zealand Export Cheese," by W. Riddet, G. M. Valentine, F. H. McDowall, and L. A. Whelan.

No. 39: "Briquetting of New Zealand Coals," by W. A. Joiner, W. G. Hughson, and A. K. R. McDowall.

RESEARCH SCHOLARSHIPS.

Two national Research Scholarships, with an annual value of £100, were awarded during the past year. The holders of these scholarships, and the researches upon which they have been engaged, are as follows:—

I. R. Sherwood, Auckland University: Synthesis of Diterpenes. (Extension for one year.)

E. R. Cooper, Canterbury College: X-ray Crystal Analysis.

"NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY."

The *New Zealand Journal of Science and Technology* has been used for the publication of reports from different branches of the Department and of researches carried out both by departmental officers and others during the year. Considerable use has been made of the *Journal* reprints in the dissemination of knowledge among those interested, both in New Zealand and overseas.

IMPERIAL AGRICULTURAL RESEARCH BUREAUX.

The Department acts as the co-operating link between the Directors of the eight Imperial Agricultural Research Bureaux, whose headquarters are all centred in Great Britain, and local correspondents in New Zealand. During the year a large number of publications have been issued through each Bureau. Among these are numbers containing reviews of all research activities conducted in their respective spheres throughout the world. By means of these reviews New Zealand investigators are readily kept in touch with what is being done overseas and are enabled to have access to translations of articles originally appearing in foreign languages, and which otherwise would not be readily available.

RESEARCH WORK AT CANTERBURY AGRICULTURAL COLLEGE, LINCOLN.

I. Plant Breeding.

(*a*) *Cereals.*

(1) *Wheat.*—The wheat investigations are carried out in co-operation with the Wheat Research Institute and the Pure Seed Station. This arrangement enables the various portions of the work to be satisfactorily co-ordinated. During the year special attention was devoted to elucidate the effect which soil-moisture exerts upon wheat-yield. It was thought that this investigation was appropriate for a year in which yields of wheat have constituted a record for Canterbury. A preliminary investigation has indicated that the soil-moisture conditions approximated the ideal up to the middle of December, when the crop had reached a stage of development at which, given satisfactory harvesting conditions, a high yield was almost assured.

(2) *Oats.*—Investigations are in progress concerning the causes of low germination in oats, especially those of the Algerian variety.

(*b*) *Herbage Plants.*

Cocksfoot.—Strain C 23 of Cocksfoot has now reached a stage when seed is available for a limited amount of commercial growing. Grazing-trials with this strain are being conducted, and preliminary results would indicate that it possesses a feed-value distinctly in advance of that possessed by ordinary commercial lines.

Progeny tests with crossbred strains of cocksfoot made during the past three years are still being conducted, and similar work is being done with rye-grass and red clover.

II. Animal-nutrition.

Trials to ascertain the value of bran alone and in association with barley as pig-feeds have been inaugurated. At the end of a thirteen-weeks trial those fed on bran and meat-meal, or bran, molasses, and meat-meal, were still too thin to kill, but those on bran, barley, and meat-meal, either alone or to which molasses was added, were fit for slaughter. Furthermore, a draft which was fed outside, where access to pasture was available, grew more economically than those fed in sties, presumably for the reason the pasture provided adequately for their mineral-requirements.

Feeding trials with oaten-pollard indicated that when it is used as a fattening feed, along with barley and skim-milk, it has about half the value of barley. The trials would indicate, too, that while oaten-pollard gives a satisfactory return when used as a maintenance ration, pigs fed on it grew slowly and failed to fatten. The conclusions drawn from the trials so far are that oaten-pollard, while suitable as a feed for horses, cattle, and sheep, is not so satisfactory when used for pigs.

Sheep-feeding Trials.

A trial was conducted in order to ascertain the value of adding carbohydrate food to the protein-rich diet secured by lambs grazing on young grass. Accordingly, supplementary diets, including oats, peas, barley, wheat, and meat-meal, were added to the feed consumed by the grazing lambs. The weights revealed that none of these additional supplementary carbohydrates exerted any influence on the carcass-weight.

A series of feed-experiments has also been conducted with lambs which were plainly poor thrivers and good thrivers. This work, however, is not sufficiently far advanced to warrant any conclusions being reached.

III. Veterinary Research.

Investigations into the control and reduction of sheep keds and lice, and various modifications in the dipping programme, have been continued. A series of trials, with curative and preventive vaccines against mammitis of cows, has been inaugurated, and trials to ascertain the effect of milk-products upon the egg-production of poultry are also in progress.

IV. Farm Economic Research.

Investigations have dealt with the costs of supplementary winter feed for dairy cows, and a report has been issued on this topic. At the same time a survey was made of local dairy-farm costs, returns, and methods of management, the results of this study also being embodied in a special report. In view of the importance of costs of maintenance arising out of the provision of supplementary feed to sheep during the winter months, a close analysis of the costs for the provision of this fodder has been undertaken in association with the Veterinary Department, and from details of the actual rations supplied in seven different combinations of various feeds costs of these rations have been worked out.

An economic investigation of the cost and returns from pig-production under Canterbury conditions, where pigs were run as a side-line on different types of farms, has been undertaken. From this it would appear that on a high-cost farm this was not profitable, but that on an average farm there was an annual margin per sow of some £2 10s. between costs and income.

The collection of data on farm prices has been continued with a view to accumulating sufficient information whereby production may be guided in such a manner as will serve the best interest of farmers affected by the present depression.

V. Farm Accounting Associations.

A distinctive development from the economic investigations has been the growth of farm accounting associations. A number of farmers are taking an active interest in this development and will thereby gain information which will lead them to such modifications of their farm practices as will assist in improving their annual net returns.

VI. Economic Zoology.

The life-history of the codling-moth under Canterbury conditions has been investigated and a report prepared thereon.

VII. Mineral Composition of Pasture Plants.

Analytical work has been proceeding on the variation in the mineral composition of different strains of cocksfoot and clover during the various months of the year, and the results obtained indicate that the degree of variation occurring between different strains is negligible. Cocksfoot has a much higher content of chlorine and insoluble ash than clover, but the latter exceeds cocksfoot in its content of lime and phosphorus.

A series of trials has shown that a Woods' filter mounted in a light-proof box and fitted with curtains is an efficient substitute for an ultra-violet light apparatus as a means of indicating true perennial rye-grass seed.

VIII. Engineering.

The work in this Department has been concerned with the designing and supervision of irrigation works at Seafield, where several distinct types of irrigation have been under trial. This has involved the preparation of special channels and dykes and the installation of meters for the purpose of measuring water-flow and soil-moisture requirements. Small-scale-irrigation trials have also been established at Leeston, Hororata, Motukarara, Darfield, and Oxford, and at the end of the present season an interim report will be furnished.

In association with this work a considerable number of investigations upon the physical properties of soil has been carried out in the laboratory at Canterbury College.

IX. Farm Implements.

Special attention has been devoted during the year to the efficacy of grain-drills with a view to ascertaining how far evenness of seed-distribution affected crop yields. In a trial of two plots of wheat, where the drills were spaced respectively at 7 in. and 3½ in. intervals it was found that the number of plants per square yard under the 3½ in. spacing was 100, and that under the 7 in. spacing 106. The yield from each of these plots was 145 lb. for the 3½ in. spacing and 142 lb. in the case of the 7 in. spacing. It is therefore evident that closer spacing in the drilling of wheat exercised no material difference in the yield, a result which confirms the results of similar trials which have previously been carried out in Victoria.

X. Wool Research.

Examination and weighing of individual fleeces from stud-ewe flocks has been continued, and inspection of the figures make it evident that there are certain strains within each breed which are high producers of wool.

The investigations on the influence of feeding upon fleece weight have been continued, and the most recent trials indicate that where the system of feeding has been persisted in for some considerable time there is a significant difference in favour of better feeding. Well-fed sheep in the 1932 trials gave an average fleece weight of 7·6 lb., as compared with 6·8 lb. per fleece from those fed only moderately well. In previous years, when the systems of feeding have been confined to three or four winter months, the benefit from good feeding amounted to about ½ lb. of wool per sheep. Furthermore, an examination of the soundness of the wool at shearing-time showed that wool from the well-fed flock was generally better than that from the sheep which had been moderately well-fed.

In the same examination the indications were that where tender wool was produced, this would have been grown about the time which corresponded with lambing—that is, in the early spring.

An examination of sheep-weights, too, revealed the fact that in the case of all those animals producing tender wool weight-losses occurred during the spring months. However, it is not contended that tenderness in wool can be attributed solely to feeding, but that the general health and constitution of the individual animal must play some part in this connection.

Wool-scouring Trials.

In anticipation that it will ultimately be necessary to introduce into the wool-testing scheme a method for determining the clean-scoured yields of each fleece, work has been continued during the past two seasons on the samples of wool selected from different parts of the fleece. The results secured to date indicate that the selection of samples from the right and left sides of the sheep gives no significant difference as regards the clean yield, and that there is no general rule that the heaviest fleeces have the lowest clean yield, or, in other words, there is no tendency for fleeces to be heavy simply because they have a larger amount of grease and dirt than lighter fleeces possess. The investigations have been designed to find out, in the first place, from which region of the fleece a sample should be taken, and, secondly, the size of the sample which would give the best indication of yield of the whole fleece.

American practices recommend a 1 lb. sample selected from behind the shoulder, but local investigations up to the present indicate that this area does not appear to give results with any greater degree of accuracy than does the shoulder itself or the side.

From the trials already conducted it would appear impossible to attain a degree of accuracy greater than 2·5 per cent. on either side of the mean. The range of the size of sample taken varied from about ½ lb. to 1 lb., and the results from the smaller sample seemed to possess as high a degree of accuracy as from the larger. The conclusion has been reached that the ½ lb. sample would be of a completely satisfactory size for testing purposes.

Sheep-branding Fluids.

The tests with the branding-fluids prepared by the British Wool Industrial Research Association have been continued, and those fluids whose formulæ were established in 1930 and 1931 show that they possess equal, if not superior, qualities to any other fluids at present available on the New Zealand market. In these fluids two earlier defects have apparently been overcome—namely, a tendency for the fluid to be unduly thick, and, secondly, for the particles of the pigment to be unduly coarse.

XI. Farm Advisory Service.

For the year ending 31st March, 1933, considerable progress by the Farm Advisory Service is reported. In fact, upon the publication of a bulletin on the work in February, 1932, the demand for the Service developed so rapidly that assistance had to be secured. Professor Alexander, Director of Lincoln College, arranged for his Assistant, Mr. H. J. Geddes, to assist part-time in the work from April, 1932, until the latter's resignation in January, 1933. Greatly appreciated and valuable as this assistance was, the amount of the work was such that it could still not be handled. In June, 1932, the assistance of Mr. M. H. Rogers was obtained under the 4A Unemployment Scheme. Mr. Rogers is still working under that scheme.

To direct operations in farm-management, to advise on special phases of management, and to report on the management of farms, a total of 400-odd visits were made during the year to over ninety farms. The development of the Service may be shown by the following table:—

Classification of Service.	Number of Farms.	
	31st March, 1931.	31st March, 1933.
Complete control	4	10
Co-operating control, supervision, special and general advice ..	20-odd	90-odd

The farms under complete control may be listed as follows:—

Locality.	Area.	Class of Farming.
	Acres.	
Wheatstone, Ashburton	389	Mixed cropping and sheep.
Fairfield, Ashburton	140	Sheep, fat lamb raising.
Seafield, Ashburton	572	Sheep, fat lamb raising and irrigation experiments.
Belfast, Christchurch	218	Mixed cropping.
McLean's Island	720	Sheep, irrigation experiments.
Halswell	100	Dairying, town supply.
Dunsandel	142	Dairying.
Southbridge	674	Mixed cropping and sheep.
Southbridge	162	Mixed cropping and sheep.
Methven	1,231	Sheep, fat lambs, cattle.

Total number of farms, 10.

Under the heading of "Co-operating control, supervision, special and general advice," there are a number of farms where very definite partial control is exercised by arrangement with the farmer, stock and station agent, and/or mortgagee. These may be listed as follows:—

Locality.	Area.	Class of Farming.
	Acres.	
Waipara	218	Mixed cropping and sheep.
Waipara	2,270	Sheep, fat and store lambs.
Waikari	120	Mixed cropping.
Weka Pass	5,000	Sheep, fat and store lambs.
Horarata	450	Mixed cropping and sheep.
Windwhistle, Hororata	800	Sheep, fat and store lambs, and fat cattle.
Rakaia	650	Mixed cropping and sheep.
Port Levy	1,200	Sheep, fat and store lambs, and fat cattle.
Port Levy	1,400	Sheep, fat and store lambs, and fat cattle.
Coalgate	1,800	Mixed cropping; sheep, fat and store lambs.
Hororata	1,714	Sheep and some cropping.

Total number of farms, 11.

Results:—

(A) COMPLETE CONTROL FARMS.

Of the ten farms under complete control, four have been under supervision for longer than one year. On these, improved financial results alone prove the value of the work. Two others have almost completed a financial year and the indications are that improved net returns over those of the previous year will be secured, and this despite the low prices and unfavourable autumn weather. Of the remaining four farms, two were taken over a short while ago and two are being given up. The two latter being discontinued because the owner has adopted an attitude of passive resistance and consequently is unlikely to derive any benefit from the assistance of the Advisory Service.

(B) CO-OPERATIVE FARMS.

(1) *Partial Control.*

As already stated, there are eleven farms that might be listed under this sub-heading. With the exception of two, excellent results are being secured. Of these two, one varied the policy with unfortunate results, and the other did not put part of the policy into operation owing to shortage of available finance.

(2) *Special and General Advice.*

This section of the work takes up a great deal of time and might be considered to include complete farm report preparation (management and financial analysis, constructive policy, and financial outcome). During the year, apart from the twenty-one farms already mentioned, over seventy farms have been visited and advice given on some special branch of farming and/or on the management of the farm as a financial unit. The advice given has been taken in full in fifty-seven instances, results and progress at present unknown for nine, portion of advice taken in five, and on one farm no attempt was made to improve the position.

Information and advice given to farmers covers a very wide field, and in Canterbury many types of farms are visited. These include small dairy-farms, mixed cropping and sheep enterprises, light land sheep properties, Peninsula farms, and foot-hill sheep propositions. It must be admitted that much care, time, and thought has been given to a study of the problems of each individual class of farm in the various districts. In many instances it is not possible to so arrange the farm-production that the required interest is made even in part, with the farm in its present state. The required interest, of course, usually has no relationship to Government valuation. A perusal of copies of farm reports will show that although on many farms little improvement can be made in the first year, yet by good management and a suitable policy, even at to-day's prices, considerable improvement in the interest earned, and, therefore, in the real value of the property, can be made over a period of years. On many farms where bad management and heavy indebtedness have gone hand in hand for a number of years it is estimated that at to-day's prices, even after several years of good management, interest at 5 per cent. cannot be earned on the present valuation (mortgage or Government).

A brief summary of the main points of improvement in policies usually include the following:—

(1) Improved pastures, suitable grass-seed mixtures, better establishment-methods, manuring, and top-dressing.
(2) Rational controlled grazing and pasture utilization.
(3) Conservation of feeds (reserves)—hay, oatsheaf chaff, ensilage.
(4) Better-judged and properly-timed cultivation for various crops, especially rape, turnips, and grass.
(5) Suitable seedings for various crops.
(6) Suitable manuring for various crops.
(7) Better arrangement of cropping programmes.
(8) Suitable top-dressing where pastures are good.
(9) Sheep policy.
(10) Better sheep-management, especially at tupping, winter, and lambing periods.
(11) Better buying and selling.
(12) Herd-testing.
(13) Better labour and power organization and proper planning of daily work.
(14) Suitable twitch-control and economical cleaning cropping programmes.

On most farms some of these improvements can be made. In addition to the above, work covering management and supervision of ten complete control farms, eleven partial control farms, and general advice on a large number of farms, several manurial trials on the half-field method have been continued. Much time has also been devoted, in co-operation with Mr. R. L. James, to irrigation investigations and experiments. A treatise on "The Management and Establishment of Permanent Pastures on the Light Lands of the Canterbury Plains" has been completed.

In addition, also, to the above for the year under review complete detailed management and financial reports on thirty-seven farms have been prepared. A complete report covering visiting and inspection, analysis, preparation, writing, and typing takes at least three eight-hour days of work.

DOMINION LABORATORY.

The work of the year consisted almost entirely of chemical analyses and investigations undertaken for Government Departments. The numbers of samples received in Wellington from the Departments were Customs, 239; Police, 77; Geological Survey, 118; Main Highways Board, 113; Mines, 708; Health, 3,426; Marine, 8; Post and Telegraph, 36; Public Works, 69; Railways, 32; Stores Control, 13; Agriculture, 85; Defence, 30; Prisons, 32; Government Printing Office, 59; other Departments, 161. In addition to these, 23 samples were received from municipal and other public bodies and 232 from miscellaneous sources, a total of 5,463. The totals for the branch laboratories were: Auckland, 2,362; Christchurch, 2,433; and Dunedin, 2,146.

Comment on the Work.

Customs.—Most of the analyses for this Department were made with a view to providing data in connection with tariff matters. A number of samples, such as iodized salt and cream of tartar, were examined to ascertain if they complied with the regulations under the Sale of Food and Drugs Act.

Police.—As in previous years, the greater part of the work carried out consisted of analyses in connection with suspected poisoning cases; several of the investigations were connected with murder charges.

In Wellington the following poisons were found: aconite and arsenic (one case each), cyanide (two cases).

One particularly interesting problem relating to a charge of theft was the identification of certain tiny splinters of glass. It was shown that the splinters agreed in specific gravity, refractive index, and appearance under ultra-violet light with glass from a broken shop window from which goods had been abstracted, but with no other samples of window or bottle glass which were obtainable.

In Auckland strychnine was found to be the cause of death in two cases and cyanide in one case. Five cases of poisoning by veronal were also investigated. Two of these involved the detection of veronal in bodies which had been buried for seven and thirteen months respectively. A paper dealing with this will probably be submitted for publication in *The Analyst*.

In Christchurch lysol, veronal, and strychnine were detected in samples submitted for analysis.

In Dunedin seven exhibits of various kinds were examined. In one of these strychnine was found, and in another methyl alcohol.

Public Works.—A number of materials were examined as to their suitability for various purposes. They included fish-oil for rust-prevention, gravel for concrete, fencing-wire, lead-headed nails, galvanized iron, battery acid, and various paints. Red lead and petroleum-jelly were examined regarding their suitability for special uses at hydro-electric works. Corrosion of lead cables and of turbine-blades were subjects of special investigations.

Post and Telegraph.—Carbon tetrachloride (for fire-extinguishers), jointers' metal, motor-spirit, shellac, polishing-oil, and sulphuric acid were examined to ascertain if they complied with specifications.

An investigation was made into the causes of corrosion of type-wheels used in telegraphy. Remedial measures were suggested.

Mines.—The continued interest in gold-mining has resulted in a large number of assays for gold and silver. Ores of manganese, copper, and antimony and samples of diatomaceous earth have also been examined. As a guide in the maintenance of safe conditions in mines numerous samples of mine-air were tested for methane (fire-damp), carbon monoxide, and carbon dioxide. Samples of stone-dusting material (used to render coal-dusts non-explosive) were also examined.

Defence.—Brass and other materials used in the manufacture of rifle-cartridges were regularly tested for conformity to specifications. Samples of defective buffer-oil were also examined.

Government Printing Office.—Among other materials examined were inks, adhesives (for paper), glue (for bookbinding), stamp-paper, and typewriter ribbons. Several batches of used monotype metal were examined. The metal is an alloy of lead, antimony, and tin, and by frequent melting when in use loses tin slowly, becoming less fluid and giving defective type. The amounts of tin or tin-rich alloy required to bring these batches back to their original composition were ascertained, and when added in each case satisfactory metal resulted. The average loss of tin on melting was also ascertained, so that by suitable small additions of tin or tin-alloy at each remelting the composition of the metal could be maintained at the original figure.

Department of Health.—As in previous years numerous samples of milk obtained in various parts of the Dominion were analysed. The position in regard to quality of milk supplied is now fairly satisfactory and in marked contrast to the state of affairs which existed previous to the enforcing of the provisions of the Sale of Food and Drugs Act.

Potable waters were regularly examined. This work has an important bearing on public health.

In addition to the above, many other foodstuffs and also various drugs were examined. These include vinegar, condensed milk, cream, butter, ice-cream, malt-extract, spirits, beer, gelatine, pepper, dried fruits, and boric acid, acetyl-salicylic acid (aspirin), camphorated oil, and Friar's balsam. With the exception of camphorated oil, the samples were, on the whole, of satisfactory quality.

Gas Inspection.

Gas-supplies in the four main centres and in most of the other principal towns of the Dominion were regularly examined for heating value, purity, and pressure, and found satisfactory.

Research.

Incidence of Goitre.—This research, undertaken in conjunction with the Department of Health, was completed during the year. The medical part of the work is almost completed, and the whole will be published at an early date.

Sulphuretted Hydrogen in Mines.—Sulphuretted hydrogen, an offensive and highly poisonous gas, is occasionally present in mines, and, at the request of the Under-Secretary for Mines, an investigation was undertaken of methods for its detection underground. A convenient form of detector has been designed and is being tried out in the Laboratory. A full report will be published later.

Gasmaking.—Various samples of Liverpool and other coals were specially examined as to their suitability for gasmaking, both singly and in blends.

Bananas.—A report on suitable conditions for the ripening of bananas has been published in the *New Zealand Journal of Science and Technology*. Further investigations on special phases of transport and storage problem are being carried out.

Kauri-gum.—Research on the extraction of a pure kauri copal from impure swamp gum by means of solvents has been continued with considerable success. The solvent recommended is a mixture of ethyl alcohol and benzol. In evaporating the solution the temperature is kept below 100° C. The last traces of solvent are driven off by live steam, and the product is dried in a current of warm air. The recovered kauri copal is a fine light-coloured powder of uniform composition, readily soluble in many organic liquids, and with possibilities for use in lacquers. It can also be readily "run" for varnish-making. After several trials in a small-scale intermediate plant at the Laboratory a solvent plant lying idle in Auckland was reconditioned, and the process tried out on a commercial scale. Samples of purified copal from this plant have been sent to several manufacturers abroad. The success of the process now depends on the demand for the product from abroad and on the price it is able to command.

Soil Survey.—A number of intricate analyses have been made to provide necessary data for deciding the origin and relation of certain soils in the North Island which are being investigated by the Geological Survey.

Spray Research.—Commercial lead and calcium arsenate sprays, of which practical trials had been made at the Plant Research Station, were analysed for chemical composition and particle size. This latter was determined by first washing through a 200-mesh Tyler sieve, particles greater than 74 microns in diameter being retained on the sieve. The material passing through was stirred to a uniform suspension with water, and the weight noted of material deposited in successive equal units of time on a special pan balanced in the liquid. By application of Stoke's law, aided by graphical methods, the sizes of the particles deposited could be determined and the percentage of each size. (Full details of the method, an adaptation of that of Calbeck and Harner, will be published shortly in the *New Zealand Journal of Science and Technology*.) While chemical analysis showed almost uniform agreement in composition, particle size determination disclosed wide differences. These differences could be correlated with the practical tests, the finer material giving in every case the better results.

Bacon.—Some investigation was made of the relation between feeding-methods and fat-deterioration during freezing and subsequent curing.

Meat Offal.—A small amount of work was done on methods of preparing and packing of meat offal such as livers, kidneys, &c., for export. The value of moisture-proof cellophane for wrapping purposes was demonstrated.

The Director of the Laboratory is a member of the Committee of the Leather Research Association, and also of the Committee of the recently-formed Standards Institute. Both he and other members of the staff have been frequently consulted regarding chemical subjects or processes of which they have special knowledge.

GEOLOGICAL REPORT.

REPORT OF DIRECTOR (Dr. J. HENDERSON).

During the year ended 31st May, 1933, the Director visited Cromwell, Ophir, Roxburgh, and Naseby in the Otago District and Thames, Hamilton, and Huntly in Auckland in connection with work being carried out or proposed in these areas.

Mr. M. Ongley, and, for several months also, Dr. J. Marwick, explored the Tinui and Castle Point districts of the Eketahuna Subdivision in parts of which the structure is decidedly complex. About 400 square miles was mapped. Mr. H. E. Fyfe continued work in the Amuri Subdivision, which has been extended to take in the area between the lower Waiau and Hurunui. Mr. J. H. Williamson began the systematic mapping of the Naseby Subdivision, which will include the Maniototo Basin and part of the surrounding highlands.

Mr. E. O. Macpherson spent most of the field season in Otago Central, where he mapped in considerable detail several gold-bearing areas in the Cromwell and Manuherikia basins. He also visited Roxburgh, Shotover, and Waikaia districts. His chief work was to assist the geophysical parties engaged in the examination of old alluvial diggings, to aid in interpreting their data, and in part to advise on how to continue the investigation of a particular area to the best advantage.

Dr. Marwick began the critical examination of the fossils from the Wairoa Subdivision collected some years ago by Mr. Ongley. He also made preliminary examinations of the fossils sent in by field officers from the Eketahuna, Amuri, and Naseby subdivisions. For several months he was engaged in mapping in the Tinui district.

After Messrs. L. I. Grange and N. H. Taylor had carried out a reconnaissance survey of the soils of 800 square miles in Taranaki, they began the detailed mapping of Waipa County. This closely settled and intensively farmed area was selected so that the relation between the different soils and the value of the pasture they supported could be determined.

About a thousand square miles was geologically mapped in detail. Since the money available was limited, the geologists in two subdivisions boarded; in the third subdivision, Naseby, a camp of minimum size was maintained.

Last year, owing to shortage of funds, the annual report was the only official publication of the Geological Survey. Several inquiries have been received from overseas institutions with which the Survey exchanges as to why so few publications have been issued in the last few years, and in two instances the exchange arrangement has been cancelled on this account. Since there seems little chance of getting the detailed descriptions of the Kaitangata-Green Island and Tongariro subdivisions published for some years, brief accounts of the geology of these districts are published in this annual report. The following were published in the *New Zealand Journal of Science and Technology:* "Earthquakes in New Zealand" (J. Henderson); "Taupo Earthquakes, 1922" (L. I. Grange); "Waikaremoana" (M. Ongley); "Soil Processes in Volcanic Ash-beds" (N. H. Taylor); "Gold-bearing Conglomerates of Central Otago" (E. O. Macpherson); and "Vivianite at Pokeno" (H. E. Fyfe). The Director contributed two short reviews to the same journal, and gave addresses on "Coal in New Zealand" and "Geological Investigations made prior to the Building of Arapuni Dam," to the members of the Wellington Philosophical Society. Dr. Marwick's papers entitled "Tertiary Mollusca from Burnt Hill" and "A New Trigonia from Canterbury" appeared in Vol. 3 of the *Records of the Canterbury Museum.*

Correspondence on matters more or less connected with the work of the Geological Survey was attended to, and many samples of rock, minerals, and ores were examined. A great deal of time was taken up with this onerous and, for the most part profitless, task.

During the year Mr. G. E. Harris drew for photographic reproduction four large maps, thirty-four drawings for blocks, and a number of graphs, sections, &c. He also prepared sixty-three field sheets for different officers as well as sixty-five miscellaneous tracings.

Little, except periodicals and exchanges, was added to the library.

EKETAHUNA SUBDIVISION.

(After M. Ongley.)

In this the third season of work in the Eketahuna Subdivision 400 square miles was geologically mapped. Dr. Marwick co-operated for four months in the field. A total area of 1,300 square miles has now been examined leaving 400 square miles still to map.

Structure.

The district examined consists of a horst of Cretaceous and Jurassic rocks 2,000 ft. high and four or five miles wide running south-south-west through the district with Tertiary rocks on each side. The sea has removed part of the Tertiary beds on the east side, so that for thirty miles Cretaceous rocks form the coast, along which Tertiary beds occur at Castle Point and Cape Turnagain. Near Castle Point west-dipping Tertiary beds form a strip a mile wide extending along the coast for ten miles. The rocks of Cape Turnagain, twenty-eight miles to the north, have been described in an earlier report.

Inland of the Cretaceous ridges is a syncline of Tertiary beds. This syncline, which is thirty-three miles long and up to eight miles wide, extends south to Maunsell or Tinui Taipo, where it ends as a rising synclinal canoe-end truncated by a fault.

The beds of the syncline are gently folded, and eight miles north-west of Tinui near its west edge turn over to form an anticline. South-westward along the belt continuing the syncline the rocks have a complex structure.

Generally, the Tertiary beds are regular; but in one place—that is, in the narrow strip near Castle Point—they are closely bent into many short twists. The Cretaceous beds, on the contrary, are nearly everywhere intricately contorted and badly shattered. Again, while in the broad sense both the Cretaceous and the Tertiary structures trend north-north-east, the Cretaceous structures are in places transverse to the Tertiary, in some places oblique, and in others perpendicular.

As already mentioned, the country is built of major units bounded by faults. In no place can the actual faults be seen, not even where the Cretaceous-Tertiary contact runs out to the coast. Generally, one set of beds is followed for miles by means of scattered outcrops till after crossing an interval without any outcrop the observer finds himself in a different set. Then, after returning over the blank space to trace down the contact, he finds a low slip of crushed rock, a gently swelling mound, or an open valley with no rock exposed. After trying out several of these, he gets familiar with their habits, and recognizes them, as a matter of course, as the indications of fault contacts.

The main Cretaceous block is faulted along both sides. On the east side of it on the coast five miles north of Castle Point a rock platform 20 to 30 chains wide, formed of contorted and brecciated white Cretaceous argillite dipping westward at 80° or standing vertical is interrupted by a gap 15 chains across, east of which regular beds of Tertiary brown sandstone dip east at 80°. To the south the rocks on the west continue unchanged, but the sandstone beds on the east dip less and less steeply for the next 60 chains, and past that all dip to the west. This is a typical Cretaceous-Tertiary fault contact. The break appears to be a steep or vertical thrust with the beds generally parallel to the fault. In many places the margins of the Tertiary are splintered and form jagged salients and narrow outliers.

Within the Cretaceous horst the Jurassic core is bounded by steep pug or shatter belts. On the east side of the Jurassic in Pakowhai River the Cretaceous beds of fine light argillite and siltstone dip 30° westward for half a mile, and next steepen to 80° in 10 chains and end at a narrow gully with a mudflow at the mouth. Across this the rocks are hard, nearly black, polished and slickensided, twisted, shattered, and pugged argillites, sandstone, greywacke, and conglomerate, dipping 80° westward. In other places the rocks are crushed or minutely shattered and slickensided through thousands of feet.

In Mangapakeha Survey District a Jurassic-Tertiary contact is well exposed. The soft Tertiary brown sandstone striking east of north dips 20° to the west. West of the Tertiary is a 2,000 ft. range of crushed and pugged dark argillite, greywacke, and conglomerate. Generally, throughout the Jurassic and Cretaceous wherever a hard and soft bed are in contact the soft bed is crushed and the hard one slickensided; and where the hard bed is thick the adjoining soft beds are finely shattered and crushed.

Within the Tertiary, also, faults have moved the beds 5,000 ft. to 10,000 ft. past one another. Erosion has in places left no fault scarps; and, indeed, at Tinui has gone so far as to remove all the upthrown Tertiary and crushed Cretaceous rocks and to expose obsequent scarps, 1,000 ft. high on the downthrown Tertiary sandstone. Again at Castle Point the mudstone under the Te Aute limestone at the "Castle" has in the late Tertiary been dropped 10,000 ft. past the sandstone of the mainland. The surface was afterwards smoothed down by erosion; but renewed movement on the same faults later on twisted and overturned the limestone.

Stratigraphy.

The Jurassic rocks nowhere crop out in a continuous section. They form ranges two miles and a half wide in the south of Mangapakeha Survey District, and one mile and a half wide in the upper Mangapakeha Stream. The beds are vertical or steep and twisted. They are thick, probably tens of thousands of feet, but underlying rocks are nowhere exposed.

In the big masses of these supposed Jurassic beds no fossil was found. Among similar rocks in the upper Makirikiri Stream, west of Manawa Trig., Mangapakeha Survey District, two loose blocks of limestone contain numerous specimens of a shell identified by Dr. Marwick as *Buchia (Aucella)*, a Jurassic form.

Only one good section of Cretaceous beds is exposed in the district, that along Mataikona River. Here the beds lying between two strong faults dip continuously at 70° for two miles, and contain fossils characteristic of the Raukumara and Tapuwaeroa Series of the East Cape district. Overlying them are fine light-coloured strata resembling the Mangatu Series of the same region. In Waipaua Stream the Raukumara Series of alternating greywacke and argillite with *Inoceramus bicorrugatus* is 7,000 ft. thick. Above it is conglomerate with the Tapuwaeroa fossil *Ostrea lapillicola* and alternating beds of argillite, greywacke, and many beds of fine conglomerate, totalling 5,000 ft. thick. Above this, unfossiliferous, finer, and lighter-coloured beds 2,500 ft. thick are assigned to the Mangatu. They are cut off above by a fault. Among the fine beds of the Mangatu occur thick beds of black shale several hundred feet thick. In other places the Mangatu beds are thicker; 6,000 ft. is exposed in a continuous section in the upper Castlepoint Stream. In many places wide stretches of country are occupied by Mangatu rocks, but the structure is not evident and does not allow the thickness to be estimated.

Cretaceous-Tertiary boundaries are in most places along faults. At sedimentary contacts in some places the Cretaceous beds have the same attitude as the Tertiary; in others there is marked discordance. Parallel Cretaceous and Tertiary beds can be seen in Angle Stream, two miles east of Tinui; unconformable Cretaceous and Tertiary sets almost perpendicular to each other are exposed

near Mount Cameron and at Mataikona River, a mile north of west from Pack Spur in the north-west part of Castlepoint Survey District. Thick conglomerate, containing 6 ft. boulders of upper Cretaceous rocks in the basal Tertiary and resting on the upper Cretaceous occurs in Tinui Stream three-quarters of a mile north of Tinui Taipo. No low Tertiary beds are present, the oldest being the Tutamoe. These consist of basal conglomerate, thick sandstone with lenses of limestone, and alternating beds of sandstone and mudstone 4,000 ft. thick. Upward they grade into mudstone, equivalent to the Morere mudstone of Wairoa Subdivision, 500 ft. thick. On these lie light mudstone with a bed of white tuffaceous siltstone up to 50 ft. thick at the base and many more beds of similar white tuff higher up interbanded with the light mudstone. These beds are 2,500 ft. thick, and the top is not exposed.

In the block dropped down by the fault at Castle Point are mudstones containing fossils of the Opoiti Series. This mudstone is nearly vertical; and horizontally on it rests the current-bedded pebbly shell-fragment rock—the Te Aute limestone.

Economic Geology.

Soils.—The geological features mapped show the main rock groups with which in a striking manner the soils correspond. For instance, the boundary between the Cretaceous and the Tertiary formations near Castle Point in places is marked by a fence between grassed land and scrub, the grass growing well on the Tertiary and the scrub having overgrown the Cretaceous. The white siltstone of the upper Cretaceous carries only a thin soil; and in many places this has been destroyed by repeated burning. Again the west side of the spurs is generally poorer than the east, because the prevailing westerly winds blow the fine soil-particles off them, and redeposit them on the sheltered easterly slopes. Some farms on the upper Cretaceous rocks, although they do not pay well, are being carefully looked after; others have been neglected and are covered with manuka, tauhinu, or heather; and many now being neglected are reverting to scrub, so that on more and more farms the pasture is being confined to the areas of Tertiary rocks, and the upper Cretaceous parts are being covered with scrub. The Jurassic rocks, consisting of hard sandstone with a little argillite, and the lower Cretaceous rocks, consisting of argillite and sandstone, generally well crushed, afford fair soils, thin on the sandstone, thicker on the argillite. The Tertiary contains near its base thick beds of sandstone affording only a poor soil, and large areas of this are now covered in manuka and have not been cleared for years. Good residual soils are confined to the Tertiary siltstone and mudstone. The alluvial areas on the terraces along the coast and in wide valley bottoms are first-class land, and are in parts cultivated in small areas. Most of the district becomes parched in summer. Springs are common on the hills, particularly at the contacts of the Cretaceous and Jurassic with the Tertiary. Water is secured in many valleys by constructing low earth dams across the shallow upper end and so forming a pond. On the flats water is obtained from wells sunk in the gravel, or is led down from springs in the hills.

Natural Gas.—In the districts to the north and south of the part examined this season, strong springs of natural gas are known, but only three weak ones were found in it. A sample from one was found to contain 95 per cent. of methane, 3·3 of nitrogen and inert gases, 0·9 of oxygen, and 0·8 of carbon-dioxide, and therefore this gas cannot be regarded as an indication of oil.

Coal.—The rocks between Castle Point and Ngakawau contain streaks of coal up to ½ in. thick; and it is possible that the coal thickens in places, but as no thick coal crops out it is unlikely there is any.

Limestone.—A big deposit of high-grade limestone occurs at Tinui and is being worked at the gorge of Tinui Stream by a crusher capable of crushing 5 tons a day. Only a little lime is ordered and the crusher works only an odd day or two, chiefly to supply the owner. This limestone and a smaller similar deposit at Langdale produce the best road-metal available. Low-grade argillaceous limestone is widely distributed.

Sandstone.—Along the coast the flaggy sandstone eroded by the sea yields flag-stones used locally for paths. Stones suitable for buildings could be obtained.

AMURI SUBDIVISION.

(By H. E. Fyfe.)

About 250 square miles, chiefly between the Conway and the lower valley of the Waiau-uha, was mapped in the Amuri Subdivision during the 1932–33 field season. Since April the writer has been engaged on other work on the West Coast where this report was prepared without maps and without access to literature.

Structure.

In the lower country south-east of the Seaward Kaikouras and the Sherwood Mountains which continue them to the south-west a number of north-east-trending ranges are arranged roughly *en echelon*. These ranges are greywacke blocks, their longitudinal boundaries, on one side at least, in the main being fault determined. Cretaceous and Tertiary strata, largely covered with the gravels of the extensive Waiau-Hurunui and Cheviot plains occur in the lowlands. These younger beds in places extend over the ends and down-warped portions of the highland blocks.

The Lowry Peak block, tilted south-eastwards, is broadest and highest north-west of Domett. The strip of faulted Cretaceous and Tertiary rocks of the Kaiwara basin rests on the lower edge of this block and strikes north-east, subparallel to the range, and at the south end dips south-east. About three miles south of Trig A, Lowry Peaks Survey District, the strike of the younger rocks swings to the east and finally to the south-east and south-west, forming a south-west plunging syncline, the major portion of the eastern limb of which is cut off by the fault crossing the Hurunui at the Kaiwara junction.

Another south-east-tilted greywacke block, overlain by younger rocks to the south-east, plunges to the north-east at Mount Crombie, Lowry Peaks Survey District, beneath the Tertiary cover. This block increases in height to the south-west, beyond the Hurunui.

About six miles east of Mount Crombie the coastal Hawkswood block plunges to the south beneath Cretaceous and Tertiary rocks, which also flank the western edge of this range to a point almost due east of Parnassus. North of this point the west boundary of the block is fault-determined. The range attains its highest elevation in Mount Wilson.

North of the Waiau-uha the Lowry Peak block continues as the Mount Parnassus block, which plunges gently to the north-east and is almost completely covered by the younger rocks at the point where it crosses the Conway. West of this point, the Mount Peter - Mount Stewart block attains its maximum height in these two peaks, and gently plunges to the north-east and south-west of them. The Humps and the greywacke east of the Lottery-Mason junction are the south-west continuation of this block.

The Cheviot depression from Parnassus southwards appears to be a broad syncline, but further work in this area may prove the structure more complex. The northern portion of this depression is chiefly a structural basin with an axis running north-north-east from a point about four miles west of Parnassus to a point two miles and a half west of Limestone Hill. In its northern portion the Cretaceous rocks crop out beneath the Tertiary rocks, but southwards only Tertiary and younger rocks appear at the surface. Most of the western portion of this basin is cut off by a fault.

The strip of Cretaceous and Tertiary rocks between the Mount Parnassus and Mount Stewart blocks is the north-westward-dipping limb of a north-easterly-striking syncline, the west limb of which has been cut off by a fault. In the vicinity of Mount Highfield it is the south-eastward-dipping western limb of this syncline that is preserved.

Geology.

Pre-Cretaceous Rocks.—Over some areas of the subdivision the greywacke rocks are interbedded with basic pillow lavas, tuffs, and breccias, all more or less calcareous. About two miles and three-quarters west-south-west of Mount Catherine, Lowry Peaks Survey District, these rocks are associated with bands of marble. In other localities, as west of The Wart, Lowry Peaks Survey District, inconsiderable blocks of marble appear with bands of "Red Rock" and jaspilite, and in these areas crushed pillow lavas can occasionally be identified and, rarely, a coarse-grained porphyritic felspathic rock. The occurrence and nature of these rocks is similar to those of the marble, tuffs, and basaltic rocks of the Eketahuna Subdivision.

The massive conglomerate bands in the lower reaches of the Spey Stream contain occasional pebbles of the pillow lava amongst the numerous plutonic, volcanic, and greywacke pebbles, a fact indicating a break in the greywacke rocks.

Cretaceous Rocks.—The Cretaceous rocks mapped are similar to those described in the annual report for 1931. In a tributary of the Conway is a clay apparently interbedded with small lenses of coal, and though it could not be described as a bentonite it has definite bentonitic properties. A similar clay, slightly bentonitic, occurs with the Cretaceous rocks at the Kaiwara mouth.

Amuri Limestone.—This rock forms an escarpment that extends from the right-angled bend of the Gelt to the Leader, whence it shows in places involved in the south-west fault that crosses the road near the Stanton - Long Vale saddle. It also forms bold escarpments in the Conway, west of Limestone Hill, and overlies the Cretaceous rocks that flank the west slope of the Hawkswood Range, east of Spotswood. It crops out for two miles north-east of Trig. K, and again to the south near Mount Styche, Lowry Peaks Survey District.

Weka Pass Stone.—At Trig. K, and in a tributary of the Kaiwara a mile and a half north-east of this, the equivalent of the Weka Pass stone, a glauconitic limestone grading to sandy limestone, overlies a glauconitic sandstone that rests on the bored surface of the Amuri Limestone. At this trig. station the two rocks are weathered in the fashion so characteristic in the Weka Pass district. In the tributary of the Kaiwara, about a mile south of Trig. K, the Weka Pass stone is absent and the sandstones (Mount Brown beds), that northwards overlie the Weka Pass stone, rest on the glauconitic sandstone. The Weka Pass stone here described is probably the equivalent of the Isolated Hill limestone of the Waiau basin. Though the typical Isolated Hill limestone was not recognized in the Cheviot basin, blocks of it or a similar limestone occur in the Bourne conglomerate of that area.

Mount Brown Beds.—A series of sandstones and sandy mudstones with interbedded shelly limestone bands overlies the Weka Pass stone at Trig. K, and these rocks are continuous with the banded sandstones near Kaiwara junction, which Speight considers are the equivalent of the Mount Brown beds. These beds are probably to be correlated with the Sugar Loaf beds of the Waiau basin.

Bourne Conglomerate.—In the Gower River, almost due north of Mount Ellen, Cretaceous sandstones are overlain by a fossiliferous Tertiary sandstone. This break is believed to be the horizon of the Bourne conglomerate, and represents an unconformity in the Tertiary. Elsewhere in the Cheviot depression this break is characterized by greywacke conglomerates containing in places huge blocks of greywacke, Cretaceous, and Tertiary rocks. The beds succeeding the break in the Cheviot area consist of conglomerate bands interbedded with sandstones. These rocks crop out prominently in the One Tree Hill area, Hawkswood Survey District, and in the vicinity of Mount Ward, Lowry Peaks Survey District.

Highfield Beds.—The equivalent of these beds in the Cheviot depression consists of a considerable thickness of massive gravels or conglomerate bands with minor sandstone bands which unconformably overlie the sandstones succeeding the Bourne conglomerate in a tributary of the Leader, a mile and a half west-north-west of One Tree Hill. Here the beds are folded and occupy the centre of the structural basin three miles west of One Tree Hill. They are in part fault-involved along a narrow strip south of the southernmost bend of the Conway. The same or similar fault-involved gravels unconformably overlie Cretaceous rocks at Trig. A, Lowry Peaks Survey District.

Economic Geology.

There is an abundant supply of agricultural linestone in the subdivision.

A gummy, apparently oily, coating covers some of the Cretaceous glauconitic sandstone in the Gower River, north-west of Mount Ellen, but in the area so far examined there is no evidence to suggest the presence of oil in other than minute quantities, and there is an almost complete absence of all the conditions essential for a productive field.

NASEBY SUBDIVISION.

(By J. H. Williamson.)

The geological examination of an area in Otago Central for the most part within the upper basin of the Taieri River was begun in November, 1932, and was continued to May, 1933. During the past field season an area of 330 square miles, which includes the goldfields of Naseby, Kyeburn, Mount Buster and Hyde, was mapped. In addition, the Golden Progress Quartz Mine, near Oturehua, was visited.

Physiography and Structure.

The rocks of Otago Central fall naturally into two divisions, older metamorphic and semi-metamorphic rocks that form the undermass, and younger unaltered sediments, the overmass, that were deposited on the planed surface of the older rocks. The various theories advanced to explain the origin of the relief of this area are reviewed by Cotton (1917). His explanation, here followed, is that the deposition of the younger sediments was followed by a period of deformation, involving block movements on a large scale, which resulted in a chain of broad tectonic depressions separated by mountain blocks, large areas of the planed undermass of which were re-exposed by the stripping of the cover during a subsequent period of erosion.

One of the largest of the depressions, the Maniototo Plain, some 250 square miles in area, forms the northern portion of this subdivision. Its height ranges from 1,100 ft. at the lowest part to about 2,000 ft. at the highest, there being a fairly even up-slope from the Taieri River, which drains it, to the foot of the bounding ranges. In places schist appears above the floor of the plain, which is largely covered by post-deformational gravels resting on early and mid-tertiary quartz conglomerate, sand, and clay. In the south-east part of the plain the surface is broken by hills capped with lava, which has protected the soft Tertiary sediments from erosion.

Delimiting the depression on the north is an elevated block with a general elevation of 4,000 ft. to 5,000 ft., the southern fault-scarp edge of which is known as the Ida Range. This block is tilted to the north-east and on its eastern margin still retains a portion of the cover of Tertiary conglomerate, which is auriferous and is worked at Clarke's or Mount Buster Diggings. The western edge of the block forms the Hawkdun Range. At the junction of this and the Ida Range is Mount Ida (5,548 ft.), which rises a few hundred feet above the level of the fault block. It is described by Park as a monadnock.

On the east side of the basin the scarp of the easterly-tilted Kakanui fault-block rises steeply to form the Kakanui Range, with an elevation in Mount Pisgah of 5,394 ft. The range continues in a south-easterly direction along the north side of the Shag or Waihemo River as the Horse Range, which gives its name to the fault in this locality.

South of the Maniototo basin is the large schist highland which in its southern part forms the Lammerlaw and Lammermoor Ranges. That part of it which lies within this subdivision is broken by north-trending faults, on which the interfracture blocks have rotated and formed a series of sub-parallel fault-angles in the southern portion of the basin. The Taieri River flows along the most easterly fault-angle from Kokonga, on the edge of the Maniototo basin, to the Strath-Taieri plain at Middlemarch. The block between the river and the next depression to the west, known as the Rock and Pillar Range, has a downwarp to the north and dips beneath the Tertiary rocks at Kokonga. There has been faulting along the western side of this block with a decreasing throw southwards, and the adjacent arm, the Patearoa Valley, is V-shaped. The fault on its western side has splintered, forming a small arm known as the White Sow Valley, the elevated block being Rough Ridge, which forms the western boundary of the subdivision. Between the northern edge of this block and Mount Ida the Maniototo basin is separated from the adjoining Manuherikia basin by a low watershed, composed mainly of younger rocks.

The drainage of the depression is by the Taieri River to the south-east corner, whence the river flows south through a gorge to the Taieri Plain. The main stream rises in the high country south of the subdivision and flows north to Waipiata, then east for some six or seven miles to Kokonga, thence south. The largest of its tributaries are the Pigburn and the Sowburn, draining the west side of the Rock and Pillar Range, the Gimmerburn and the Wetherburn, from the east side of Rough Ridge, Eden Creek, the Eweburn, Hogburn, and Kyeburn flowing south from the Ida Range, and the Swinburn, which rises on the south-west side of the Kakanui Range. The south-east part of the subdivision is drained by the headwaters of the Shag or Waihemo River.

The chief settlements in the district are Ranfurly on the Otago Central Railway, in the centre of the basin, and Naseby near its northern edge.

General Geology.

The absence of fossils in almost all the formations and a lack of clear sections render the subdivision of the rock series of Otago Central difficult, with the result that the classification is mainly lithological. The limitations thus imposed preclude the separation of the gravels younger than the Maori Bottom beds, which, though grouped here, do not represent a continuous deposition.

The following tentative table shows the sequence of formations developed in the area examined :—

Series.	Strata.	Approximate Age.
..	Alluvial (auriferous)	Recent.
..	Terrace gravels (non-auriferous)	Pleistocene.
Surface Hill ..	Gravels (auriferous)	Pleistocene.
Maori Bottom	Quartz gravels, clay (auriferous)	Pliocene.
Waipiata ..	Basalt flows	Pliocene or Upper Miocene.
Wedderburn ..	Clays, sand, grit, conglomerate, coal	Miocene.
Naseby ..	Greensand	Oligocene (Ototaran).
Hogburn ..	Quartz conglomerate, quartz grit (auriferous) ..	Eocene (? Ngaparan).
Kyeburn ..	Indurated quartz conglomerate, sandstone, claystone, schist conglomerate	Cretaceous.
Ida	Greywacke, argillite, conglomerate	Triassic ?
Kakanui ..	Greyish argillaceous schist	Palaeozoic.
Wanaka ..	Foliated quartz mica schist (auriferous quartz veins)	Palaeozoic.

Wanaka Series.—The schists of Otago are of economic importance, in that they contain quartz reefs, carrying gold and scheelite, that have probably provided the gold found in the younger beds. They were first subdivided by Hector (1865) as follows :—

(1) Upper : A grey arenaceous, almost slaty rock containing but little quartz in the form of veins or laminæ.
(2) Middle : Soft blue slates often highly micaceous 100 ft. - 200 ft. thick.
(3) Lower : Contorted schist. A micaceous schist foliated with quartz.

The upper division is Hector's Kakanui Series, while the two lower divisions were later called by Hutton the Wanaka Series. Other series names have from time to time been used for these schists by later writers, but there appears to be no valid reason for departing from the original names, which are here retained.

Of the older schists only isolated patches occur in that part of the district already examined. Quartz Reef Hill, west of Naseby, is composed of typical quartz-mica schist, as also is Woodney Hill, some five miles farther west. The same schist outcrops at the head of Hogburn or Main Gully, about a mile and a half north of Naseby, and is the "Blue Bottom" of the miners in this and in Spec Gully to the east. Schist occurs also east of the Kyeburn River. To the north, in the neighbourhood of Kyeburn Diggings, it belongs to the Kakanui Series, but south of the Kyeburn–Palmerston Road it has more resemblance to the older than to the younger schists.

In this part of the subdivision the foliation planes of the Wanaka schists have a general northerly dip, which exceeds 40° only in the neighbourhood of faults. So far no passage beds from the older to the younger schists uninterrupted by fault contacts have been observed.

Kakanui Series.—Schists of this series, which represents the uppermost group of Hector's tripartite division of the Otago schists, form the main mass of the Kakanui Range. The rocks are slate, grey arenaceous mica schist, schistose conglomerate, and talc schist. In some outcrops the rock is only slightly metamorphosed, owing perhaps to infaulting of areas of younger rock. Quartz laminæ, which are a feature of the Wanaka schists, rarely occur.

North of the Dansey Pass Road, in the headwaters of the Kyeburn River, the schistosity planes dip north or north-westward at angles ranging from 30° to 60°, but farther south along the Kakanui Range the dip tends to become north-easterly. North of Mount Buster Diggings the dip is 60° or more to the north or a little west of north. In Robertson Creek in this locality an outcrop of greyish slaty schist with foliation planes dipping 60° N. showed the original bedding planes of the rock dipping 55° north-north-east.

Ida Series.—Between Mount Ida and Mount Buster the Ida Range is formed of unaltered argillite, greywacke, and conglomerate, which are separated by fault boundaries from the Kakanui beds on the east and the older beds to the south. Hutton (1875) included them in his Kakanui Series, but McKay (1884) separated them, writing, "Between Mount Ida and Mount Buster I have not been able to identify these rocks as the next succeeding the Kakanui Series." The problem is still unsolved, and pending evidence of their age and their relation to the fossiliferous Triassic Mount St. Mary Beds they are placed in a separate series. Lithologically they resemble other rocks of known Triassic age, to which period they are tentatively assigned.

Kyeburn Series.—Between this and the preceding series there is a long interval, during which the older rocks were deformed and later reduced by erosion to a peneplain. The basal bed of the new cycle is coarse indurated schist conglomerate, red in colour, and containing neither quartz nor greywacke pebbles. This extends eastward from the Eweburn to the Kyeburn River.

The conglomerate grades upwards into bluish-coloured beds in which the quartz content gradually increases, so that the highest beds consist of at least 80 per cent. quartz. Between these and the lowest bed there occur beds of claystone and sandstone, as well as small lenses of hard shiny coal. Near Naseby the beds dip steeply south, but farther east the dip does not exceed 40° south.

Faulting obscures the relation of these beds to the next series overlying. On the east they are cut off by a fault which follows the Kyeburn River, and on the south override Pliocene beds along a transverse fault. The upper beds have a strong lithological resemblance to the Wetherstones conglomerate, with which they are probably correlative.

Hogburn Series.—Faulting and elevation followed the deposition of the Kyeburn beds, and there was apparently a period of erosion during which those beds were stripped from much of the surface of this area; a period of depression succeeded, during which quartz conglomerates and sands accumulated. These beds are remarkable in that they consist almost entirely of quartz. The pebbles of the conglomerates are flattish rather than rounded, and, though some are 3 in. or more in greatest diameter, they are generally less than 1 in. In places the conglomerate is silicified to a hard quartz rock, boulders of which, locally called "Chinamen," are common as residuals on the schist surface and in the Maori Bottom gravels.

These beds outcrop in Hogburn Gully, north of Naseby, and similar beds are found at Mount Buster or Clarke's Diggings, at Hamilton's, and at Hyde. At Naseby the beds were prospected by a shaft 350 ft. deep, which was abandoned before reaching the schist bottom, and cannot therefore be regarded as proving the absence of payable gold at this point. At the other three localities rich returns were obtained for many years, and work ceased apparently on account of difficulty and cost of mining rather than of exhaustion of the gold-bearing area.

The beds contain no internal evidence of age; but they are overlain by a greensand containing fossils that are probably Ototaran. The quartz conglomerates are a shore-line or a terrestrial phase of the Tertiary transgression, and are accordingly placed in the Ngaparan stage.

Naseby Series.—Fossiliferous greensand, which overlies the quartz conglomerates, outcrops near the Government Dam west of Naseby and at Upper Kyeburn; here a well-preserved marine fauna is found, which, according to Dr. Marwick, is similar to that of the Wharekuri beds in the Waitaki basin some thirty miles north, and is probably of Ototaran age.

Wedderburn Series.—Overlying the greensand are clay, shale, and sand and lignite bands, the latter occurring at or near the bottom of the series. There is a good exposure of these beds in Eden Creek and westward, where they have yet to be examined in detail.

Waipiata Series.—Overlying the Tertiary beds near Waipiata and thence eastward to the Waihemo Valley are basaltic lava flows, which have protected the less resistant Tertiaries from erosion. From its distribution this lava may be the result of fissure eruption; but at Tiroiti, on the east bank of the Taieri, there are indications of a central vent. The lava is dark and fine-grained.

In a section in the upper Houndburn basin, Maori Bottom beds, containing rounded basalt boulders at the base, rest on an eroded surface of quartz conglomerate. No trace of basalt is found in the Wedderburn beds, so that the lava is intermediate in age between these two series.

Maori Bottom Series.—Unconformably overlying the quartz conglomerate beds at Naseby is a reddish-yellow loosely compacted conglomerate containing numerous bands of sandy clay. The conglomerate contains pebbles and boulders of decomposed schist and greywacke, generally up to 6 in. in greatest length, but sometimes up to 6 ft., and silicified quartz conglomerate boulders (Chinamen) of similar size, together with small quartz pebbles, which may amount to 40 per cent. of the mass. The conglomerate or gravel beds appear to contain a little gold throughout, though bands of wash occur, usually on the clay bottoms, which carry payable gold. In the early days sluicing was confined to the surface wash, probably a concentration of the gold left after the erosion of upper beds, and it was not till later that the miners realized that Maori Bottom gravels would pay to work.

On the east side of the Kyeburn, gravels classed as Maori Bottom contain iron-stained pebbles and boulders derived from the Kyeburn conglomerate, and the percentage of quartz is much lower than at Naseby. In the Houndburn basalt boulders occur sparingly. On the east bank of the Kyeburn, between that stream and the Swinburn, is a wide development of sandy clays considered to belong here.

Near Naseby and eastward therefrom, the Maori Bottom gravels are payably auriferous; but the gold content decreases southward. The gold is fine and of high quality.

Surface Hill Gravels.—Unconformably overlying the Maori Bottom gravels on Surface Hill, between Hogburn and No. 1 Spec Gully, near Naseby, are auriferous reddish-brown gravels containing decomposed greywacke boulders. They differ from the underlying Maori Bottom gravels chiefly in the colour, in the absence of quartz pebbles, the increased coarseness of the material, and the absence of the thick clay bands which are a feature of the underlying series. Similar gravels in the Kyeburn Valley near Nobbler Creek and Camp Creek are believed to belong here.

Pleistocene and Recent.—There is a considerable development of terrace gravels overlying the Maori Bottom gravels and older beds in the central and eastern portion of the Maniototo basin; and westward from the foot of the Kakanui Range, south of Nobbler Creek, are coarse post-deformational gravels derived from the erosion of the Kakanui Range. They are of Pleistocene age and non-auriferous. Recent gravels occurring in the beds of the streams flowing south and south-west are generally gold-bearing, the gold being derived from the denudation of the Maori Bottom gravels and the quartz conglomerate.

Economic Geology.

Gold.—Some seventy years have elapsed since gold was first discovered in this district, and although gold-mining waned for many years, it is now an increasingly important industry. This is due rather to the present-day high price of the metal than to new discoveries or improved methods of working. Gold is found both in alluvial deposits and in reefs, the former ranging in age from early Tertiary to Recent, the latter occurring in the Palaeozoic schists. The gold of the oldest alluvial deposits is a concentration of the gold of the quartz leaders and veins of the schists, that of the younger detrital deposits being derived mainly from a rewash of earlier ones.

Three classes of alluvial deposits have been worked (*a*) the quartz conglomerate beds at Mount Buster, Hamilton's, and Hyde; (*b*) the Maori Bottom gravels at Naseby and Middle Kyeburn; and (*c*) the younger gravels at Naseby, Little Kyeburn, and Upper Kyeburn. The methods used, adapted to the particular deposits, include cradling, ground sluicing, hydraulic sluicing and elevating, driving and sinking, and dredging.

A brief description is given of the fields examined during the past season.

Naseby.—The stream beds of Hogburn and Spec Gullies were first worked, and next the enriched surface deposits and the gravels of Surface Hill. Later the presence of payable gold in the Maori Bottom gravels was realized, and these beds are still being worked. The gold content is not high, but the quantity of material available offsets this.

At the head of No. 1 Spec Gully residual gravels, lying unconformably on Kyeburn conglomerate beds or "Red Bottom" in the gullies, are being sluiced with satisfactory results. The gold obtained is coarser, darker in colour, and of lower value than that recovered from the Maori Bottom gravels, which has a fineness of 990. Lower down Spec Gully residual gravels on schist or "Blue Bottom" also yield coarse gold, which has a fineness intermediate between that of gold off the "Red Bottom" and that from the Maori Bottom gravels.

Mining at Naseby is severely handicapped by a shortage of water. The Mount Ida water-race, originally constructed for mining purposes, is used for irrigation in the summer months, and during part of the period over which it is available for mining weather conditions are such that work is impossible. Operations are thus mainly restricted to miners owning private water-rights. There is no doubt that with a sufficient supply of water and the use of modern methods there is in the Maori Bottom gravels a field for gold recovery on a large scale.

Kyeburn.—From Naseby east to Kyeburn Diggings residual gravels have been extensively worked, and in places have yielded rich returns. With gold at its present price, patches too poor to work in the early days should now be payable. At Kyeburn Diggings (Upper Kyeburn) much work is now being done in the river-bed and on the adjacent terraces. A water-race is being constructed to sluice the flat near Kyeburn Diggings School. This flat consists of heavy fluviatile gravels with a large proportion of boulders from 1 ft. to 2 ft. in greatest length. A similar flat to the south has been partly dredged, but as the dredge was too small to handle the heavy gravel the attempt failed. The river-bed south of the junction of Kyeburn and Little Kyeburn Streams is to be worked by a small dredge, formerly operating in the Little Kyeburn valley.

Mount Buster or Clarke's Diggings.—This field lies at an altitude of 4,000 ft. on the plateau west of Mount Kyeburn, and extends from the foot of Mount Kyeburn north to Old Hut Creek. Auriferous quartz conglomerate lying on eroded schist occurs on the interfluves of small streams flowing west. Some of the tributary gullies were very rich. The gold content is not evenly distributed through the conglomerate, much of which is unpayable. Thus the difficulty of water-supply and the fact that work is possible for only six months of the year limit the prospects of the field, which in the early days yielded rich returns.

Hyde Deep Lead.—Immediately north of Hyde is a strip of quartz conglomerate, known as the Hyde Deep Lead, which has been involved in the faulting along the east edge of the Rock and Pillar Range. The deposit, which has been worked over a length of about 50 chains, increases in depth and width southward. The payable wash lies on the schist and in the north end has yielded rich returns; southward the ground was not bottomed. Useful geophysical prospecting could be done in this area, particularly in the part held by the Employment Board.

Quartz Mining.—Quartz veins in the older schist at Oturehua—formerly Rough Ridge—have been worked spasmodically for over sixty years. There are several parallel reefs, striking north-west, the more important being the Homeward Bound, Lloyd's, Perseverance, West of England, Great Eastern, and Queen of the Isles reefs. The Homeward Bound, Lloyd's, and Perseverance are faulted portions of the same lode, and the West of England and Queen of the Isles reefs appear to be similarly related.

The only company at present operating on the field—the Golden Progress Quartz-mining Co.—is working the Homeward Bound-Lloyd's reef system, by a shaft 150 ft. deep, from which levels have been driven west 500 ft. and east for 100 ft. on the old Homeward Bound reef. In the east drive the reef was cut off by a fault striking 60° and dipping 75° west, but on crosscutting 130 ft. south a reef track was picked up—Lloyd's Reef—which, according to latest reports, is showing quartz of fair thickness.

The reef is also broken by a series of low-angle thrust faults, on which the reef is stepped up 10 ft. to 25 ft. to the north at each break and by a later series of steeply dipping north to north-east faults, none of those so far encountered having a large displacement. As a result of the faulting the mine is difficult and costly to work.

Coal.—Lignites of poor quality occur at Oturehua, Idaburn and Wedderburn, and supply local needs. Seams at Kyeburn extensively worked in the early days of the goldfield are now abandoned. The most promising mine is that at Oturehua, where a seam 20 ft. thick is being opened out from an incline, which in December, 1932, was down 700 ft.

Peat occurs in swampy patches near Mount Buster Diggings. It contains large numbers of moa bones in a poor state of preservation.

OTAGO CENTRAL GOLDFIELDS.

(By E. O. Macpherson.)

During the season several of the old goldfields in the Manuherikia Valley were examined and mapped. The following formations are distinguished in downward order :—

	Thickness. Ft.	Age.
Flood plain and terrace gravels	20–50	Recent and Pleistocene.
Brown consolidated gravels	800	Late Pliocene (Moutere ?).
Lacustrine silts and clays	300	Miocene ?
Quartz conglomerates	400	
Greywacke and schist	Unknown	Carboniferous and older.

For some account of these formations the reader is referred to the writer's article on pp. 262–74 of the *New Zealand Journal of Science and Technology*, 1933. Briefly, the quartz conglomerates are a sheet of fluviatile beds laid down on a deeply weathered and nearly flat surface of schist, semi-schist, and greywacke. Earth stresses deformed this surface, hollows in it were occupied by lakes in which clays and silts accumulated. Deformation continued, the crust fractured, and segments of it rose in mountains from which the debris now forming the rusty late Pliocene gravels were chiefly derived. Earth-movements still continued, though probably on a smaller scale, and the Pliocene gravels are in places folded.

The gravels of the flood-plains and terraces contain gold, the best wash lying usually directly on the brown consolidated gravels. This surface is the Maori Bottom of the old miners. The Maori Bottom gravels also contain gold, but are generally too poor to work, though in parts they have been rather extensively sluiced. The quartz conglomerates everywhere are auriferous, and as they are better sorted than the Pliocene and Post-Tertiary gravels some bands are rich enough not only to sluice, but even to drive out. Forty years ago McKay, after examining the quartz conglomerates at eighty localities in Otago, stated that at forty places, though these beds had enriched the nearby streams, they were too poor to work by any method, and at the other forty they were rich enough to be sluiced. Altogether, at half a dozen places some bands of the conglomerates contained enough gold to make underground mining profitable.

Practically all the readily worked gravels of the flood-plains and terraces are now exhausted. But the area between Devonshire and Matakanui, and possibly north-eastward to Drybread, may repay prospecting. Here 30 ft. of gravel rests on the Maori Bottom.

The well-consolidated gravels of the Maori Bottom have been sluiced at Drybread, Matakanui, and Waikerikeri Diggings. In the past where good prospects were found in these gravels a "paddock" was sluiced out, and work was continued if it paid. But no systematic prospecting of the different layers seems to have been undertaken. Since the gravel beds have a decided dip at many points, especially close to the foot of the Dunstan Range, and since the bedding and the different "bottoms" are not everywhere distinct, a paddock may well have been sluiced from practically barren layers though an adjacent layer may have contained sufficient gold to pay. Prospecting should be first across the strike of the gravels and then along the strike of the more promising layers.

The quartz conglomerates are exposed either (*a*) resting on the gentle lower slopes of the Raggedy Range, the tilted block on the south-east side of the Manuherikia Valley ; or (*b*) upturned along the great fault at the foot of the Dunstan Range ; or (*c*) covering knobs of ancient rocks rising through the gravels of the valley. The extensive erosion following the uplift of the mountains stripped off most of the exposed parts of the poorly consolidated quartz conglomerates, and the later in-filling of the fault-angle with gravel concealed the undisturbed remnants on the lower slopes of the Raggedy Range black-slope and also the folded and broken fragments along the other side of the depression. Later deformation and down-cutting by streams have exposed the quartz conglomerates at several places along the foot of the Dunstan Range. At most of these localities, which are where the larger streams issue from the highlands, the miners have sluiced the beds as deeply as practicable with the water at their disposal. Between these worked areas quartz conglomerates along the fault at the base of the range are concealed by terrace gravels and slope deposits. Prospecting for such beds of quartz conglomerate as are above drainage level by means of adits from suitable points is suggested. Again the remnants of quartz conglomerates along the toe of the gently tilted Raggedy Range block must have in places but a thin cover of young gravels. Such deposits are worth finding and prospecting, for they may be shallow enough and rich enough to work by open-cast mining or other means.

The quartz conglomerates outcropping round knobs of ancient rocks surrounded by the gravels of the valley have been extensively worked at Surface Hill, Muddy Creek, St. Bathans, Vinegar Hill, and Cambrians. From the structure of the quartz conglomerates and lake-beds mantling them the hills must be high points on small folds in the basement rocks formed after the quartz conglomerates and lake beds had accumulated and raised in front of the main mountain-building fault by the same earth stresses that produced those faults and forced up the earth-blocks now forming the mountains.

The above-mentioned hills of old rock are all at the upper end of the valley, but there is evidence farther south near Drybread of a subsidiary fold in front of the mountains. Here, however, neither the old rocks nor the quartz conglomerates are exposed, and boring through the dome of lake-beds will be necessary to ascertain the depth and gold content of the quartz conglomerates.

Geological mapping to guide the geophysical surveys along lines most likely to give positive results was done at Cromwell Flat, Cornish Point, Quartz Reef Point, Drybread, St. Bathans, Vinegar Hill, and other parts ; and maps and reports have been prepared or are in course of preparation dealing with the geology and its relation to the gold resources of these areas.

PALÆONTOLOGICAL WORK.

(By J. Marwick.)

A considerable part of the past year was spent in the preparation and study of the fossil mollusca of the Wairoa Subdivision. Most of the material was collected by Mr. Ongley during his survey of that area during 1929–30, but some collections were also forwarded by geologists of Taranaki Oil Fields, Ltd. The rocks of the subdivision range in age from Upper Jurassic to Lower Pliocene, and, although the older ones contain few fossils, the younger ones have provided large and varied collections. The evidence so far obtained indicates that the earlier correlation of the upper beds (Waihua Series) with the Ormond Series is not altogether correct; the correlation is with the upper part of the Ormond only.

Most of the latter half of the year was occupied in field-work with Mr. Ongley in the Castle Point-Tinui district. Good molluscan collections were obtained from the Castle Point limestone, clearly showing its Waitotaran age (Te Aute limestone). Many fine specimens from the middle Tertiary beds were collected in the Mangapakeha Valley. They belong to the typical lower Tutamoe fauna, and contain *Macoma tenuiplicata* (Bartrum), which is characteristic of the Mokau beds of North Taranaki.

Mr. Fyfe's collections from Waiau Subdivision have been only hastily examined. They can be divided into two main groups (1) Awamoan, (2) Nukumaruan. These correlations are only approximate, but they show beyond any doubt that a long period of time intervened between the deposition of the lower and that of the upper beds.

From a greensand and from a glauconitic sandstone in the Kyeburn Survey District Mr. Williamson collected two marine faunules which are undoubtedly of Middle Tertiary age, and suggest correlation with the Wharekuri beds (Ototaran). In 1883 A. McKay collected from the Kyeburn greensands and correlated the beds with the Hutchinson's Quarry beds of Oamaru. He also classed the Wharekuri beds as of similar age. All the collections from these and other localities in the Maerewhenua and Waitaki Valleys should be intensively studied to gain all possible knowledge on the rather obscure period of New Zealand's history represented by these beds.

KAITANGATA-GREEN ISLAND SUBDIVISION.

(By M. Ongley.)

The Kaitangata-Green Island Subdivision of Eastern Otago lies in the south-east of the South Island, between 45° 47′ and 46° 23′ S., and 169° 17′ and 170° 27′ E. It occupies the coast for forty-seven miles and extends thirty miles inland, comprising altogether 1,100 square miles. It includes the coalfields at Green Island, Tokomairiro, Taratu, Benhar, and Kaitangata, from which coal has been extracted for eighty years, so that no easy coal remains. It borders the goldfields of Otago, and contains the same geologic formations.

Physiography.

The subdivision consists of two major units perpendicular to each other, the Kaihiku Ranges trending south of east and the remainder trending north-east. The Kaihiku Ranges lie partly outside the subdivision; the part inside, altogether eight miles across, consists of a dozen hogbacks trending south of east across the south-west corner. Each hogback has a nearly vertical escarpment on the north-east and a steep dip-slope on the south-west, the dip-slopes being successively more gentle the farther south they lie. Peaks on the hogbacks range about 2,000 ft. Out in front at the foot of the range, downs about 400 ft. high extend eight miles to the north to the Molyneux River. Near Clinton they are interrupted by the isolated peak, Popotunoa, 1,100 ft. high, three-quarters of a mile in front of the northern escarpment of the range.

All the rest of the subdivision trends north-east. Its chief feature is a depression four miles wide extending from Molyneux River north-east for forty miles across the subdivision to the Dunedin volcanic hills, parallel to the coast and three to six miles in from it. The depression is divided into three basins by two divides, one 180 ft. high, twenty-two miles from the north end, and the other 150 ft. high, ten miles from the south end. The basins contain rich infilled alluvial plains, and the two end ones still contain large lakes with their bottoms at and below sea-level.

The ridge between this depression and the coast is at the south a single anticlinal block six miles wide with a long gentle east limb and a short steep west limb broken by many faults. The steep west limb grades into a fault and the anticline into a tilted block. This ridge continues single from Molyneux River for ten miles to the north, as far as Tokomairiro River. North of this, for the next twelve miles, it has on its seaward side at Akatore another up-faulted block two miles wide with a steep westward-facing escarpment and a gentle eastward-dipping back-slope. The crest of this coastal cuesta is 600 ft. high, the crest of the one inland of it is 1,500 ft.

Near Taieri River, 12 miles north of the Tokomairiro, the Akatore cuesta is truncated by the coast, and north of this again only a single ridge lies between the depression and the coast. The ridge, however, is not simple near Taieri River, but consists of an eastern anticlinal ridge and a western synclinal part. Five miles north of the river it is broken by a cross fault that drops the beds to the south; another five miles to the north it is crossed by a parallel fault that drops the beds to the north.

The inland edge of this ridge where it borders the depression is marked at the south by the faults and vertical beds at Kaitangata, farther north along its course by the outcrops of schist at Milburn and Titri, and by the numerous volcanic necks at Milburn, Waihola, Henley, Allanton, and Riccarton. It is a fault forty miles long, concave to the south-east and evidently thrust from that direction. The ridge also is not simple, but is broken by longitudinal and transverse faults and several volcanic plugs.

Inland of the depression the slope, with beds of quartz conglomerate at the toe, rises gently to the west. The upper part is stripped of the covering beds, but continues as an even gentle slope, obviously a stripped erosion plane. This gentle west side is interrupted, however, from seven to fourteen miles from the north end, by a high steep cliff of schist—Maungatua—towering over the plain, indicating that in this part the stress was relieved differently, the block on the west rising over that to the east. From the middle of the depression the west slope rises gently for twelve miles to the Waitahuna Heights (2,000 ft.), west of which the ground drops suddenly down at Marshall's Waitahuna fault. In the south it rises gently to 1,500 ft. and dips away as gently to the south-west as a curved dome-shaped old erosion surface.

Structure.

As already mentioned, the subdivision consists of two different parts that differ in structure, the southern strip trending south of east and the northern and much larger part consisting of blocks that trend north-east. The southern strip has no Tertiary beds at all, and shows the structure due to the Hokonui late Mesozoic folding; the rest of the district with Tertiary beds dipping into the fault-angles was broken into north-east trending blocks in the late Tertiary. This difference is most marked; but both parts are more complicated in detail.

The Kaihiku Range trends south of east across the south-west of the subdivision and extends away for miles in both directions with the same structure. The part in the subdivision is eight miles wide and twelve miles long, and consists of a dozen hogback ridges, up to 2,000 ft. high. The beds forming them are steep and in places overturned along their northern front, and dip less and less steeply the farther south. Immediately to the north of Kaihiku Range the country is a low (500 ft. – 300 ft.), even, gently-sloping downs (2° – 3°), which continues uninterrupted to the Molyneux River, seven miles to the north. Its structure is not evident, for the outcrops are scarce and poor. It is covered deep with residual clay and the under-rock is partly changed silicified greywacke with rare obscure bedding. The little evidence available indicates that the beds are steep. The smooth surface is evidently a stripped erosion surface, and has on it a few flat remnants of lignite and fine white sand and clay. The front of the Kaihiku Range is accordingly a fault along which this block to the north with its old deeply weathered and mature erosion surface and sedimentary remnants has dropped at least the height of the range, 2,000 ft.; but, on the other hand, as the beds in the Kaihiku Range are Triassic and the beds a mile and half north of it at Clinton are Carboniferous, the older rocks of the undermass are to the north; and so the north must have been uplifted far more in the early folding, either probably, by tight folding in the Hokonui movements or, possibly, by bedding faults.

The position and attitude of the parallel Triassic ranges, the Kaihiku in the south and the matching Kakanui Mountains, with Mount St. Mary, eighty miles to the north, suggest an anticlinal structure for Otago as was recognized by Hutton in 1875 and McKay in 1894. This is in agreement with the older beds being in the middle. All the rocks up to and including the Jurassic were deeply buried and intruded by dykes, possibly approached by a subjacent batholith, metamorphosed, folded, and faulted. This land was eroded to a plain, with the result that the lower-lying younger beds, Jurassic and Triassic, were left on the flanks, but removed from the middle where deeper older more metamorphosed rocks were exposed.

Upon this plain in the Cretaceous coarse conglomerates began to be deposited, derived from adjacent cliffs; and, later, finer conglomerates, coal-measures, and other strata were laid down, deposition being interrupted by several periods of elevation and erosion, until, in the late Tertiary, the eroded anticlinal was badly broken by the rising-up of the Kakanui block in the north, the Kaihiku block in the south, the Akatore block and the Kaitangata-Green Island block in the east, with the consequent pinching-in and the preservation of strips of the covering strata along the low part of the back slopes and in the fault-angles below the steep scarps.

The part of the subdivision north-east of the Molyneux consists of three fault-blocks trending north-east and tilted south-east. The one at the coast is fourteen miles long and two miles wide. Its surface rises gently from the sea to 600 ft. on the crest, and drops steeply again to sea-level. West of it the next block, forty miles long and six wide, rises gently inland to 1,500 ft. at the crest, and drops steeply to the Taieri-Tokomairiro-Kaitangata depression. The third rises gently from beneath the young deposits of the depression westward for ten miles to 2,000 ft., and in part drops suddenly at Waitahuna Fault, and in part descends gently south-westward to the Molyneux. At Maungatua it rises steeply to 3,000 ft., and declines gently westward to 2,000 ft., and thence continues westward as a plateau at this level.

The coastal or Akatore block is simple; the other two are composite, and are broken by longitudinal and transverse faults into smaller blocks.

Stratigraphy.

Otago geology has been much confused through two fundamental errors. First, it has been assumed that the age of the schists is the same as the age of the schistosity, as in Marshall's argument that the schists must be Trias-Jura because no pebbles of schist are found in the Trias-Jura conglomerates. Secondly, it has been assumed that the beds can be divided into formations of different ages corresponding with the different degree of metamorphism of the schist. Though it is likely that lower beds would be more metamorphosed, it is fallacious to regard the degree of metamorphism as an indication of age, as Hutton did. Accordingly, in looking at the different opinions of previous writers, we must more than usually examine what evidence is relied on.

The sequence of the Mesozoic formations is on the whole well exposed and the classification of them should be reliable. The Palæozoic beds are not sufficiently characteristic to establish definite conclusions. A little additional evidence about them has been obtained, and this shows that part of the series is upper Palæozoic and part older. The less known parts are correlated on scrappy evidence.

Series.	Rocks.	Thickness in Feet.	Characteristic Fossils.	Age.
..	Clay, sand, gravel ..	..	..	Recent and Pleistocene.
Tertiary (?)	Clay, lignite ..	100	..	..
Caversham	Calcareous sandstone, greensand	350	*Pachymagas abnormis*	Basal Awamoan.
Burnside	Calcareous mudstone, coarse sandstone	350	*Callolima* ..	Ototaran.
Wangaloa	Glauconitic mudstone, coarse sandstone	1,000	*Conchothyra australis*	Top Cretaceous.
Brighton	Shell limestone ..	100	*Dimitobelus* ..	Cretaceous.
Taratu	Quartz conglomerate	1,000	No fossils ..	Cretaceous.
Kaitangata	Schist conglomerate	3,000	No fossils ..	Cretaceous.
Putataka	Sandstone, current-bedded and carbonaceous	3,500	*Inoceramus haasti* ..	Bathonian and Oxfordian.
Bastion	Carbonaceous sandstone, conglomerate	4,300	*Pleuromya* ..	Middle Triassic.
Warepa	Spheroidal sandstone	1,100	*Pseudomonitis richmondiana*	Noric.
Otamita	Mudstone, sandstone	2,500	*Maoria problematica*	Carnic.
Oreti	Siliceous greywacke	4,000	*Halobia zitteli* ..	Carnic.
Kaihiku	Sandstone, greywacke, conglomerate	7,000	*Daonella indica*, *Spirgera kaihikuana*	Landino-Carnic.
Clinton	Coarse greywacke, conglomerate	10,000	*Zaphrentis*, *Chonetes*	Permian or Carboniferous.
Tuapeka	Dense greywacke, schist	100,000	No fossils known ..	Palæozoic.

Tuapeka Series.—The lowest fossiliferous bed is at Clinton and with it are classified the adjacent strata, including several beds of conglomerate down to a strong conglomerate that separates two different types of greywacke, a coarse-grained greenish red-spotted greywacke above, and a dense dark fine greywacke below. This lower greywacke grades into obscurely bedded more siliceous greywacke and into gradually more changed beds till it forms the well-known mica schists with crenulated quartz laminæ. The Tuapeka Series includes the schists, the less metamorphosed rocks, and the greywacke. The less metamorphosed rocks are not, however, the equivalents of the schist, for no place is recorded where the schist grades along the strike into greywacke. All the sections described to show the gradation are across the strike from lower beds to upper ones. Besides the common grey mica schist green chloritic schist is common, and pink and light grey schist are less common. The less metamorphosed beds include silky phyllite, semi-schist, schistose greywacke, &c.

These beds are continuous with the schist and greywacke of the Tuapeka Subdivision described by Marshall in Bulletin 19 as the Tuapeka Series.

Since Hutton suggested the structure in 1875, it has generally been accepted that Otago is an anticline trending north-west. The evidence supporting this idea is derived from the northward dipping Mesozoic Kakanui mountains forming the north flank and the parallel southward dipping Mesozoic Kaihiku mountains, eighty miles distant, forming the south flank. No evidence has been obtained to show that the schist is anticlinal. The statements as to the attitude of the beds given in Park's bulletins are strongly opposed to it, and so are the attitudes of the beds mapped by Marshall in Tuapeka. Similarly, in this subdivision the beds do not indicate an anticline, but dip inwards for ten miles on the north side and six miles on the south side towards Taieri Mouth.

The evidence is not favourable for the simple, anticlinal structure of the schist; but it is too poor to support a conclusion about the regional structure. The Kakanui and Kaihiku Ranges appear as ramps rising over a depressed block of schist.

As the schist and greywacke of the Tuapeka Series, where their relation can be seen, underlie the Clinton (upper Palæozoic) fossiliferous beds, they cannot be Trias-Jura, but must be pre-Carboniferous. The schists are metamorphosed sediments and it would be profitable to ascertain when they were metamorphosed. The pre-Kaitangatan conglomerates contain many pebbles of greywacke but none of schist, which indicates that no schist was exposed when they were forming. It may be that the old land had a cover of greywacke protecting an undermass of schist; but it appears more probable that a land containing schist would have yielded some pebbles of schist. Accordingly, in this report it is inferred that when the conglomerates of greywacke without schist were forming the land consisted of unmetamorphosed greywacke. This means that the beds were metamorphosed by the Hokonui movements at the end of the Jurassic. In agreement with this, hand specimens of the Kaihiku beds at Mount St. Mary are sub-metamorphic, contain Triassic fossils deformed through the alteration of the rocks, and are described by Park as passing gradually into the highly schistose rock at the base of the series.

Clinton Series.—The Clinton Series of beds, containing fossiliferous greywacke, at Clinton consists mainly of greywacke beds, some fine like the Tuapeka greywacke, many coarse, green, spotted red, and slicken-sided red. The thick conglomerate bed at Clinton below the fossiliferous bed consists of well-rounded pebbles and boulders of greywacke, porphyrite, and granite from ¼ in. up to 3 ft. through, forming a bed 150 ft. thick. For a mile across the strike on each side of this bed the greywacke contains frequent beds of coarse igneous and greywacke conglomerate standing vertical, and these are included in the Clinton Series, which is accordingly 10,000 ft. thick.

The fossils from Clinton have been described by Dr. Marwick in the *Journal of Science*, Vol. 7. No. 6, pp. 362–64, 1925, and classified as Permian or Carboniferous. The upper and lower beds included in the Clinton Series show no evidence of their age.

Kaihiku Series.—If the name Kaihiku Series is kept for the formation containing the fossiliferous beds at Kaihiku Gorge and its equivalents and if its base is the thick coarse conglomerate at the front of the Kaihiku Range then the Kaihiku Series includes siliceous greywacke, flinty argillite, slaty greywacke, sandstone, and many beds of conglomerate. These beds form the northern front of the Kaihiku Range and continue as far as the subsequent eastward-flowing courses of the Kaihiku and Puerua Streams. They thus extend a mile and a half across the strike, and are 7,000 ft. thick.

These beds stand nearly vertical and strike south-east along the range. They appear as a simple set, but the overturned and shattered parts may be broken by strong bedding faults. Large lumps of an oyster-bed half a mile outside the subdivision at the right-angle bend of Puerua River indicate either that there are two different oyster-beds one high in the sequence described at Roaring Bay and the other in Puerua Valley, not the same, as McKay said, but low in the sequence, or that if the oyster-bed is repeated so as to bring the high Roaring Bay oyster-bed down close to the Kaihiku beds at Puerua then the structure cannot be simple, as it has been described by McKay, Cox, Park, &c.

Dr. Marwick has identified many fossils including: *Daonella indica* Bitt.; *Rhynconella nuggetensis* Wilck.; *Halorella zealandica* Trech.; *Dielesma zelandica* Trech.; *Spiriferina kaihikuana* Trech.; *Spirifernia fragilis* Schlotheim; *Mentzeliopsis spinosa* Trech.; *Spirigera kaihikuana* Trech.; *Cyrtona trechmanni* Wilckens; and has assigned the beds to the Ladino-Carnic part of the Middle Trias.

Oreti Series.—Correlated with the beds in Oreti River described by Cox in 1878 under the name of the Lower Wairoa Series, and renamed by Hector the Oreti Series, is a set of beds of greywacke, fine siliceous greywacke, and flint, and also beds of fine conglomerate lying above the beds with the Kaihiku fauna and below the beds with *Maoria problematica*. Along Waiwera Stream the beds dip at 80° for 60 chains and are thus 4,000 ft. thick.

Between the Kaihiku fossiliferous beds and the Oreti fossiliferous beds occur beds of coarse conglomerate containing worn and angular pieces of mudstone, and pebbles of greywacke derived from the under-beds. In Waiwera River the upper Kaihiku beds are contorted and shattered and the Oreti flint beds are strong and unbroken and stand vertical. It appears to be a sedimentary erosion contact subsequently disturbed by bedding thrusts. Among the fossils from the beds classed in the Oreti Dr. Marwick has identified: *Halobia zitteli* var. *zealandica* Trech.; ? *Hokonuia* sp.; *Gonodon mellingi* as of Wilck. not Zittel; *Nuggetia morganiana* Wilck.; *Pleurophorus zealandicus* Trech.

As the fossils from the Oreti beds of Oreti River were listed by Trechmann as three doubtful brachiopods without a single positive identification, the beds here classed as Oreti are so classified on their position, not on their fossils; until the type Oreti is better known this correlation will serve.

Trechmann placed the Oreti in the lowest Carnic.

Wairoa Series.—Owing to the confusion in the use of the name Wairoa Series and the lumping into it of beds that are distinct stratigraphically and have different faunas, it is here subdivided into—

Warepa Series (*Pseudomonotis richmondiana* beds), overlying
Otamita Series (*Maoria problematica* beds).

Otamita Series.—Trechmann described the beds in the valley of Otamita Stream west of East Peak from the *Maoria problematica* beds up to the top of the Carnic, and these are taken as the type Otamita Series. The same beds extend across the subdivision from Waiwera River, up Harris Stream, along the south side of Kaihiku Stream, leaving the subdivision at Glenomaru boundary, and continuing along the strike to the coast at the Nuggets.

The lowest *Maoria problematica* bed is a shell rock composed almost entirely of masses of the one shell. Above it is a soft bluish-grey mudstone with many scattered shells of *Maoria*. This soft bed forms a conspicuous depression between the hogbacks of the ranges. These beds occupy half a mile across the strike and, dipping steeply at 80° to 60°, are thus 2,500 ft. thick.

The *Maoria* bed is everywhere steep, in places vertical, in places overturned and in contact with steep underlying beds. The actual contact was not seen, but the attitude suggests faulting. Among the fossils collected from beds classed in the Otamita Series Dr. Marwick has identified: *Maoria problematica* (Zitt); *Halobia zitteli* var. *zealandica* Trech.; *Hokonuia limæformis* Trech.

Trechmann classed these beds in the middle Carnic part of the Upper Trias.

Warepa Series.—The *Pseudomonotis* bed crops out in Warepa Survey District, 70 chains north of west along the ridge from Rocky Dome and dips south at 60°. On the north side of the ridge is the soft-mudstone bed with *Maoria* and the upper part of it is a coarse sandstone that weathers out in large spheroids. This spheroidal sandstone and a conglomerate in places exposed below it, are taken as the base of the series. The beds from the base up to another strong conglomerate above the *Pseudomonotis* are grouped in the Warepa Series. They dip 60°, and extend a quarter of a mile across the strike, being therefore 1,100 ft. thick. They stand steep in contact with steep underlying beds. In Waiwera Stream the underlying *Maoria* beds dip south at 80° and the basal Warepa greywacke dips north at 70°, but no contact is exposed. Probably the beds are overturned at a fault. In other places there is no reversal of dip, the beds of the two formations being parallel.

Trechmann classed the *Pseudomonotis* beds in the Noric part of the Upper Trias.

Bastion Series. — In the subdivision no fossiliferous beds were found corresponding to the Rhaetic, Lower Lias, or Middle Lias. The first fossiliferous bed found above the *Pseudomonotis* bed is 70 chains away from it, across the strike of beds dipping at 50°, and is accordingly 3,500 ft. above it. The fossil is *Pleuromya*. Trechmann regarded the Hokonui Hills *Pleuromya* beds as Callovian (Lower Oolite) and Spath classed the Kawhia *Pleuromya* beds as Toarcian (Upper Lias).

The base of the Bastion Series is taken as being at the coarse conglomerate close above the *Pseudomonotis* bed, and the formation extends up to the thick sandstone, with layers of plant remains forming the ridge above the Duke's Nose and running from Trig. H, in Warepa Survey District, through the Dromedary and Trig. P, to Brown Dome. This includes three strong hogbacks of sandstone separated by valleys eroded along mudstone, and can readily be subdivided when more faunas are found. Along Little Puerua Stream this formation extends for a mile across beds dipping at 60°, and is evidently 4,300 ft. thick. In the south the beds dip south at 40° for half a mile and in the next half mile to the north they turn up to vertical as if thrust from the south at a fault contact. East of Rocky Dome the underlying Warepa and the basal Bastion beds dip south at 80° for five miles along the strike to the boundary.

Dr. Marwick has identified among the fossils collected from these beds indistinct specimens of *Cucullaea, Pleuromya, Modiolus,* and *Tellina.*

Putataka? Series.—No fossils corresponding to the Flag Hill Series of Cox and McKay distinguished by Spirifers and Belemnites were found, but their next series in the Hokonui Hills, the Putataka, characterized by *Inoceramus* and *Astarte,* appears to be represented by an *Inoceramus* bed that crops out for a mile along the strike on the dip-slope a quarter of a mile north of Trig. N, in Warepa Survey District. The Flag Hill fauna and the lower Putataka fauna are missing. The hogbacks dip steeply about 60°, and the beds appear as a normal sequence of concordant dip-slopes as if eroded from a parallel series of beds. The evidence is, however, scrappy. The basal bed is in places current bedded, in places full of magnetite corresponding to an old black-sand beach, and in places full of plant remains and welded angular conglomerate.

The series includes the hogback extending from Brown Dome, through Trig. P and the Dromedary, to Trig. A, another similar hogback passing through Trig. N, and all the beds to the southern boundary. These are included, because no higher fauna was found; but vertical beds, conglomerates, and carbonaceous beds near the southern boundary indicate that more formations are present.

The beds included dip south for more than a mile along Lochindorb Road at 45°, and are 3,500 ft. thick.

Among the fossils identified by Dr. Marwick are: *Pleuromya* sp.; *Inoceramus* cf. *galoi.*; *Mytilus* sp.; *Pseudomonotis* cf. *echinata* group; *Modiolus* sp.; *Tancredia* sp. According to Trechmann these fossils indicate the Bathonian-Oxfordian part of the Lower Oolite. These beds are called Putataka Series after Cox and McKay's usage in the Hokonui Hills.

Kaitangata Series.—The Kaitangata Series of this report includes the greywacke conglomerates and coal-measures at Kaitangata and their equivalents. The base is exposed in several places as a coarse subangular conglomerate, resting unconformably on a red weathered surface of schist. At Kaitangata the boulders and pebbles are mostly greywacke and sandstone with rare chert, quartz, and conglomerate. They average about 2 in. and rarely are 1 ft. through, and are enclosed in a scant matrix, so that the pebbles rest on one another. The fine material forms some thin beds less than 1 ft. thick. The beds vary sharply laterally, and contain irregular fragments and thin streaks of coal; and where the fine beds are thick the coal is thick. Irregular lenses and pockets of gravel have been deposited side by side with different attitudes, current bedded and irregular, and on weathering the conglomerate and current-bedded sand forms rude spheroids 12 ft. through.

The greywacke boulders predominate at Molyneux mouth; in other places the boulders are schist. In many places the conglomerate is bright red, in some places blue. It is evidently the same bed as at Bluespur. In the Taieri Gorge this formation is estimated as 3,000 ft. thick. As the Kaitangata beds are conglomerates of greywacke and schist resting on greywacke and schist, no one has ever doubted the big unconformity below them. The youngest beds of the undermass are the beds that at Kawhia contain ammonites indicative of the Oolite, Tithonian, or later. Evidently after that time the Hokonui sedimentation was stopped by folding, elevation, erosion, and depression, and then the Kaitangata conglomerate formed of fragments from the under-beds was laid down upon them. The conglomerate has no fauna; but it appears in the same place in the sequence as similar conglomerate at Shag Point, Waitaki Valley, Malvern Hills, Pakawau, Hawk's Crag, and Paparoa, which have all the same facies. Certainly it is not Pleistocene, as thought by Park, or Eocene, as described by Marshall, but is older than the upper Cretaceous.

The conglomerate at Kaitangata forms an asymmetrical anticline with a steep faulted west limb and a long gentle east limb corresponding to the surface.

Quartz Conglomerate.—Above the Kaitangata conglomerate lie thick deposits of quartz conglomerate that are difficult to subdivide and to correlate from place to place. At one place, Brighton, there is a belemnite fauna, at two places, Measly Beach and Boulder Hill, a rich Upper Cretaceous molluscan fauna, and loose blocks found in the Castle Hill shaft in 1892 have another fauna. There is also the "black bituminous limestone of Tokomairiro," reported in the Catalogue of the Colonial Museum, 1870, and never since observed, although, as Hutton said in 1875, he "made many inquiries about it." It is lithologically similar to the Castle Hill shaft rock, or, as Hector stated in 1892, "The material from the Castle Hill shaft also proves to be identical with the black limestone of Tokomairiro."

The Brighton fossiliferous beds are taken as the type of the Brighton Series, the Measly Beach fossiliferous beds are taken as the type of the Wangaloa Series, the Castle Hill shaft beds and the black limestone of Tokomairiro were not found, and are left out of the classification. This leaves the unfossiliferous underlying quartz conglomerate in a separate series, here called the Taratu Series.

Taratu Series.—Quartz conglomerate at many places rests on the schist; at Molyneux mouth, Mount Misery, Waronui, and Saddle Hill indistinguishable quartz conglomerate rests on Kaitangata conglomerate. At Brighton the quartz conglomerate below the Brighton fossiliferous beds is 100 ft. thick. At Boulder Hill the quartz conglomerate below the Boulder Hill fossiliferous beds (Wangaloan) is 400 ft. thick, no Brighton fossils are found, so there the 400 ft. quartz conglomerate is classed as Taratu. At Coal Point and Tokomairiro mouth quartz conglomerate below Wangaloa fossils is 1,000 ft. thick, and no Brighton fossils are found, so the 1,000 ft. of quartz conglomerate is included in the Taratu. It is likely enough that, during the sea transgression in which the marine beds at Brighton were deposited, the quartz conglomerate at other places was also eroded and redeposited without leaving any evidence. Concealed breaks are well known to be prevalent in thick quartz conglomerate formations of this kind; but where no fossils or erosion breaks are found the quartz conglomerate cannot be divided. The Taratu Series accordingly includes the quartz conglomerate at Taratu, Castle Point, Waronui, Saddle Hill, Green Island, and Boulder Hill up to the first recognizable marine bed. Evidence that the Taratu conglomerate unconformably overlies the Kaitangata conglomerate is given in the report on the Dominion Mining Conference, 1926, pages 84–85. It is clearly a series of fluvial conglomerates torrent-bedded, scoured, and filled, with lenses of clay, carbonaceous lumps, films, streaks, and coal-seams. No marine fossils occur in it, and all we know of its age is that at least parts of it are post-Kaitangatan and pre-Brighton. Probably the Taratu Series as mapped contains more than one formation; and it must correspond in age to some part of the Cretaceous. It forms homoclines on the back slopes of tilted blocks dipping into the fault angles. At Kaitangata and south of Milton it is preserved on both flanks of the block and is anticlinal.

Brighton Series.—The formation that contains the fossiliferous beds at Brighton, being distinct from any other beds, is separated as the Brighton Series. The beds are best described by Grange in Vol. 53, pages 162–64, of the Transactions of the New Zealand Institute. The section exposed at Brighton shows 30 ft. of shell limestone with an eroded upper surface, overlying 80 ft. quartz conglomerate resting unconformably on schist. There is a 12 ft. coal-seam 50 ft. from the base. The shell limestone with its eroded top and everywhere less than 100 ft. thick is the Brighton Series, the current-bedded beds below being placed in the Taratu Series. The shell limestone consists of shell fragments broken too small to be identified, except for an occasional piece of oyster-shell and worn Belemnites. It is evenly bedded in contrast with the cross-bedded quartz conglomerate below, and represents a marine transgression unrecorded elsewhere. It is of Cretaceous age.

Wangaloa Series.—In spite of some confusion in nomenclature the fossiliferous beds of Measly Beach are taken as the type of the Wangaloa Series. This is limited to the marine sorted and bedded top part of the quartz conglomerate and the overlying fossiliferous sandstone, and extends from Mitchell Point four miles to the north across the Tokomairiro River. The same bed was found by Fyfe at Boulder Hill thirty miles to the north, but it was only 1 ft. thick and 3 ft. long and 6 ft. wide. The same fossils were seen as casts in quartzite at the same level farther west on the hill.

From Measly Beach to Tokomairiro the Wangaloa conglomerate and sandstone dip continuously at 3° for a mile across the strike, and are accordingly 200 ft. thick. In Measly Beach sea-cliff and at Boulder Hill the rusty sandstone is 50 ft. thick. At Boulder Hill the sandstone grades upward into glauconitic sandstone and mudstone 300 ft. thick, above which lies the basal conglomerates of the overlying series. South of Scrogg's Hill, too, the quartz conglomerate grades upward into quartz sandstone, this into grey micaceous sandstone, and this into glauconitic sandstone and mudstone.

The relation of the glauconitic sandstone and mudstone is puzzling. It directly overlies the fossiliferous shell-bed at Brighton from which it was described by Grange as being separated by a small erosion interval. It overlies the fossiliferous beds at Boulder Hill which are not present in the Brighton section. Again the quartz conglomerate at Brighton below the Brighton fauna is but 80 ft. thick, and at Boulder Hill below the Wangaloa 400 ft. thick, and at Measly Beach 1,000 ft. thick. This suggests that the quartz conglomerate is not contemporaneous throughout. The evidence available is not sufficient to prove the details. For want of better evidence, the Wangaloa Series is taken to include the overlying glauconitic mudstone 800 ft. thick into which the fossiliferous sandstone appears to grade up.

Dr. Marwick is working on the fauna, and reports that it is of youngest Cretaceous age.

Burnside Series.—The Burnside Series is a new series proposed to include the fine mudstone known as the " Burnside Marl " and the underlying coarse white quartz sandstone that rests on the glauconitic mudstone of the Wangaloa Series. The sandstone at Kaikorai mouth is 200 ft. thick and the mudstone 150 ft. The top of the Burnside beds is marked by the bed of phosphatized pebbly greensand exposed in the Burnside quarry and in Kaikorai Stream 15 chains to the south-east. The change from the glauconitic mudstone of the Wangaloa Series to the pebbly coarse current-bedded sandstone of the basal Burnside indicates elevation and probably erosion between the two sets.

The series is of Ototaran age.

Caversham Series.—Burnside mudstone is broken by a 6 ft. bed of greensand containing pieces of the underbed and phosphatized pebbles, shark-teeth, &c., which is taken as the base of the Caversham Series. The complete succession is not exposed, but the pebbly greensand is overlain by glauconitic mudstone that grades into greensand, and greensand is seen grading up into the Caversham sandstone. The Caversham sandstone is 300 ft. thick, and has an eroded top covered with volcanic rock. The beds at Milburn and Clarendon are classed in the Caversham Series. These include in upward sequence 5 ft. of quartz conglomerate and sandstone, 10 ft. of glauconitic sandstone, 120 ft. limestone, and 150 ft. of brown sandstone.

Thomson considered that the brachiopods from the Waikouaiti sandstone indicated that the Caversham sandstone should be classed as Awamoan, and Finlay and McDowell regarded it as basal Awamoan.

Tertiary (?).—White clays interbedded with thick bands of lignite cover considerable areas in the Pomahaka basin. They are tentatively placed in the Upper Tertiary.

Pleistocene and Recent.—Among the Pleistocene and Recent beds are the terraces of the Pomahaka, Molyneux, Waipori, and Post Office Streams, the Taieri, Tokomairiro, and Clutha Plains, the dunes along the coast, the heavy gravels above Jubilee Mine, and Shiel's sand-pit and at Kaikorai mouth. These include beds of lignite, white clay, and auriferous gravels.

Igneous Rocks.—Tuapeka Series contains red and green schists that probably are metamorphosed igneous rock. The Clinton conglomerate contains igneous boulders of unknown origin. A coarse pink feldspar porphyry crops out in the greywacke a mile and a half north of west from Otanomomo, a township four miles south of Balclutha, exposing about 10 ft. by 15 ft. of rock. Decomposed dark-greenish coarse-grained igneous rock forms a cliff to the left bank of Puerua Stream, a mile and three-quarters south of west from Otanomomo. It apparently stands vertical, bedded in the greywacke.

In the Clinton greywacke, too, half a mile south-east from Waitepeka vesicular basalt crops out along the small stream, and also a quarter-mile farther east just east of the road, and again another quarter-mile farther on.

In several places as mapped fresh basalt breaks through schist, and is not in contact with younger rock. Similar basalt breaks through the Kaitangata conglomerate and the Taratu conglomerate.

A quarter of a mile west of Lake Waihola two peaks of basalt agglomerate lie on the schist. Waihola Hill, Trig. L, Cemetery Hill, Trig. D, and the other peaks a mile and a quarter north-east, east, and south-west of Milburn Railway-station, and also the low hills alongside the railway near Allanton and Owhiro rest on schist. These are probably not older than the nearby volcanic rocks that rest on the Dowling Bay limestone considered by Finlay and McDowell as equivalent to Target Gully beds.

Economic Geology.

The district contains many large deposits of clay, some of which are being used. The mapping shows the extent of the formations in which each deposit occurs.

Beds of conglomerate and sand abound, many consisting of clean quartz used for different purposes in industry. The schist, greywacke, igneous rocks, sandstone, and limestone have all been used as building stone. Rocks suitable for road-metal are abundant. The Milburn limestone and the Burnside calcareous mudstone are used for cementmaking. The limestone has been of great agricultural value on the Taieri Plains. It is still in demand as also is the phosphatic part of it. The Dominion Co. grinds together the limestone, phosphate, and greensand and produces a satisfactory fertilizer.

Coal has been known in the subdivision since 1844. The extent of the coal-measures is shown on the maps.

The "quartz grits" and "cements" of the miners, represented on the maps as "Taratu conglomerate" and "Kaitangata conglomerate," are not known to contain payable gold in the subdivision.

TONGARIRO DISTRICT.

(By L. I. Grange and J. H. Williamson.)

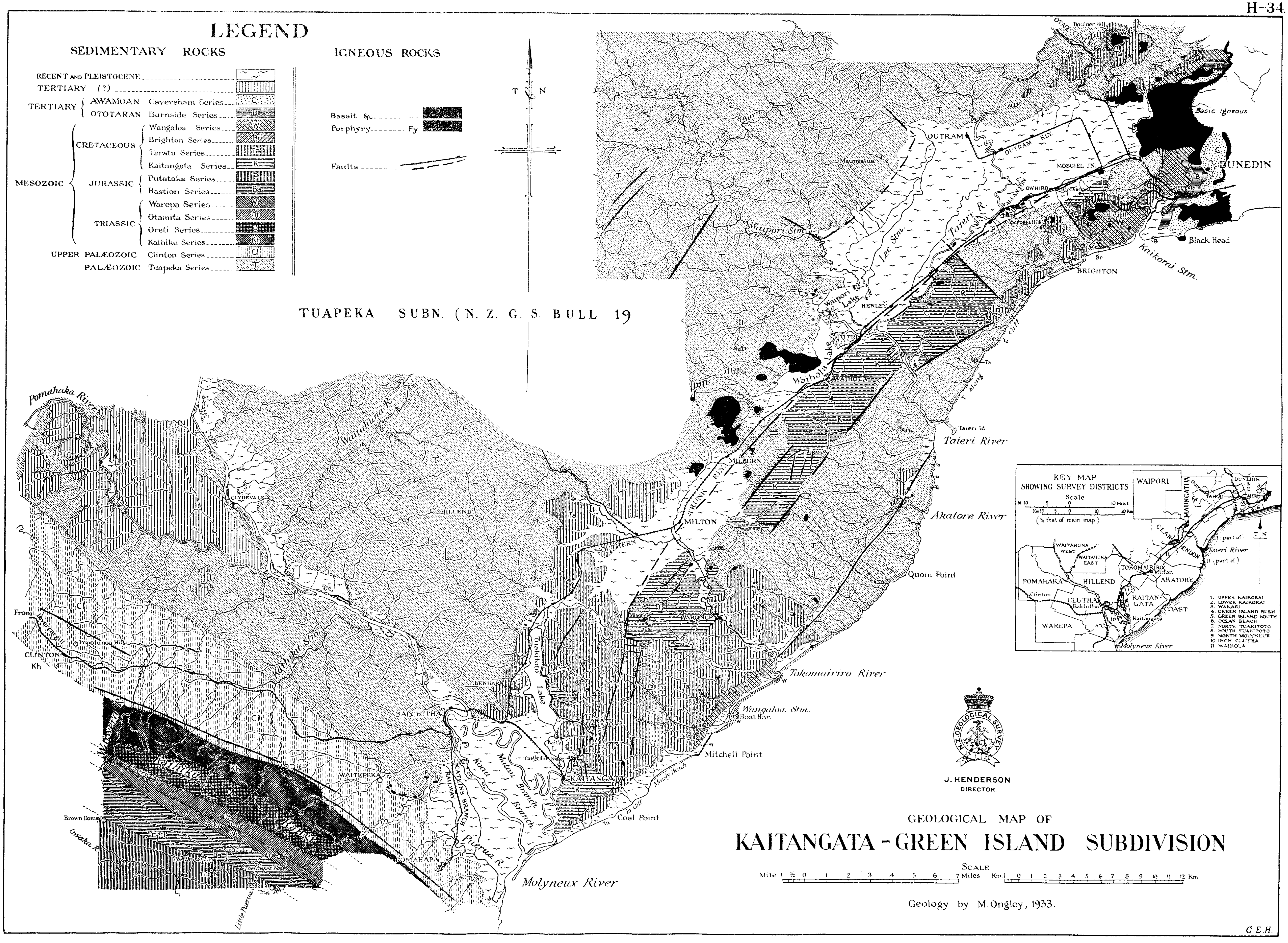
The district here described lies between Lake Taupo on the north and Waiouru on the south, and extends eastward from the Wellington–Auckland Main Trunk Railway to the Kaimanawa Mountains. It includes the Tongariro National Park, and forms the southern portion of the active volcanic belt of the North Island of New Zealand, progress reports on the survey of which were published in the Geological Survey Annual Reports Nos. 21 to 24, for the years 1927–1931.

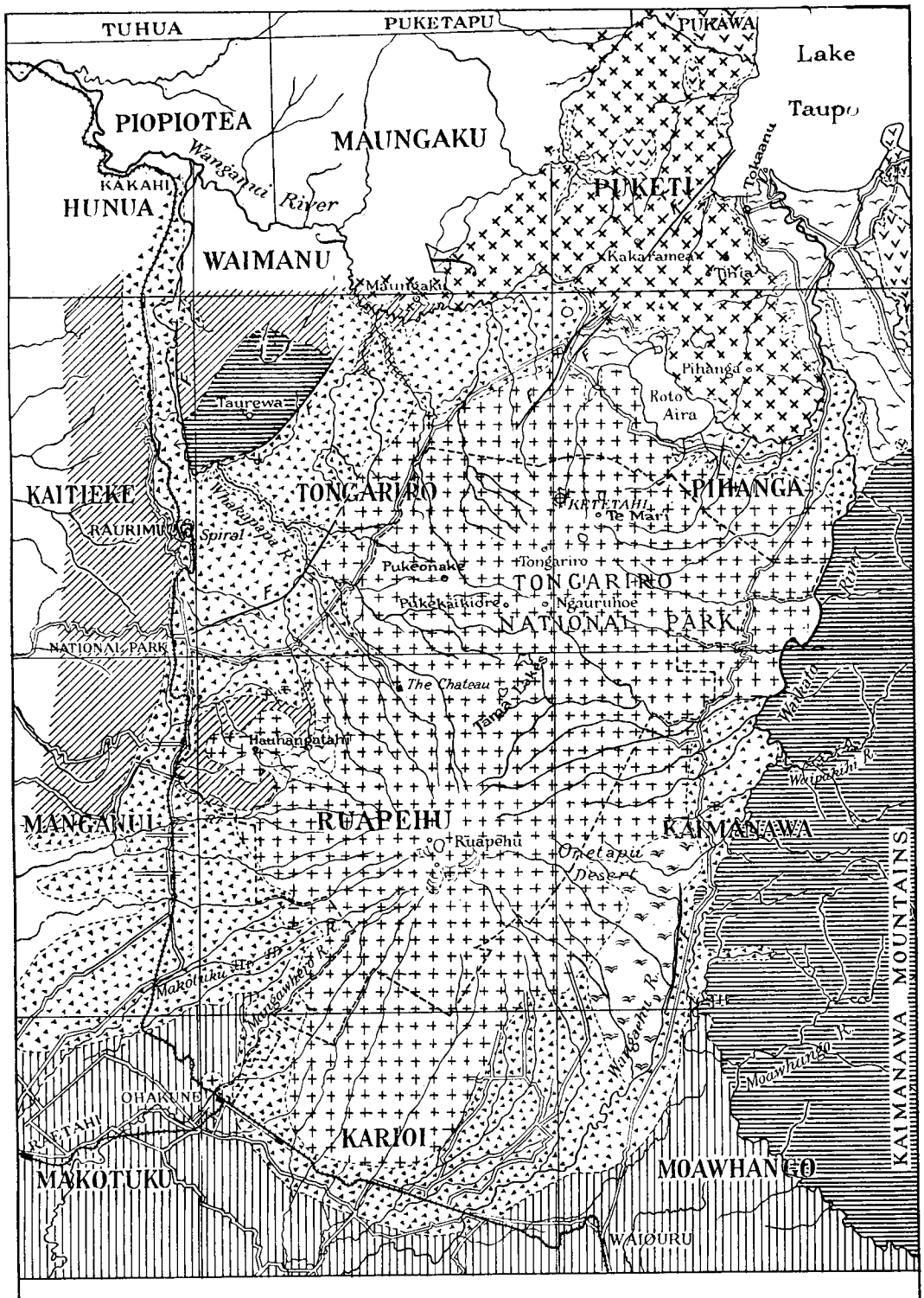
Structure and Physiography.

Structurally the district consists of an eastern highland of Pre-tertiary greywacke, which is part of the Kaimanawa Range, and a western plateau of younger Tertiary rocks which is part of the central plateau of the North Island.

This highland area, the Kaimanawa Range, is a raised block here bounded by strong faults, the chief evidence for which is physiographic. From a distant aspect the range is even-crested, the peaks rising from 4,500 ft. to 5,000 ft. above sea-level, and there are remnants of a mature upland surface not yet destroyed by erosion. The highlands, which increase in height northward beyond the district, are drained by streams that issue from them by way of deep narrow gorges. The Kaimanawa Range is the watershed between the Hawke's Bay drainage system on the east and the Waikato and Rangitikei Rivers, the former of which draws water from the northern half of their western front and the latter from the southern half.

The western plateau, which occupies more than three-fourths of the district, is here formed of Tertiary beds lying horizontal or dipping gently westward and overlain with volcanic debris. From it rise the volcanic piles of Ruapehu, Ngauruhoe, and Tongariro and dominate the landscape. From their tops the essential flatness of the plateau both within and beyond the district is clearly seen, but at close quarters its surface is extremely broken.


LEGEND
SEDIMENTARY ROCKS
IGNEOUS ROCKS
RECENT AND PLEISTOCENE
TERTIARY (?)
TERTIARY
AWAMOAN Caversham Series
OTOTARAN Burnside Series
CRETACEOUS
Wangaloa Series
Brighton Series
Taratu Series
Kaitangata Series
MESOZOIC
JURASSIC
Putataka Series
Bastion Series
TRIASSIC
Warepa Series
Otamita Series
Oreti Series
Kaihiku Series
UPPER PALÆOZOIC Clinton Series
PALÆOZOIC Tuapeka Series
Basalt &c.
Porphyry Py
Faults
TUAPEKA SUBN. (N. Z. G. S. BULL 19
OUTRAM
MOSGIEL JN.
DUNEDIN
Basic Igneous
Black Head
BRIGHTON
Kaikorai Stm.
Taieri R.
Waipori Stm.
Lee Stm.
Waipori Lake
HENLEY
Waihola Lake
WAIHOLA
MILBURN
MILTON
Taieri River
Akatore River
Quoin Point
Tokomairiro River
Wangaloa Stm.
Mitchell Point
Coal Point
KAITANGATA
Molyneux River
BALCLUTHA
WAITEPEKA
Pomahaka River
CLYDEVALE
HILLEND
Waitahuna R.
CLINTON
Brown Dome
KEY MAP
SHOWING SURVEY DISTRICTS
WAIPORI
POMAHAKA
HILLEND
CLUTHA
KAITANGATA
WAREPA
AKATORE
COAST
J. HENDERSON
DIRECTOR
GEOLOGICAL MAP OF
KAITANGATA - GREEN ISLAND SUBDIVISION
Scale
Geology by M. Ongley, 1933.
G.E.H.



GEOLOGICAL MAP OF

TONGARIRO DISTRICT

Scale

MILES 5 0 5

KM 5 0 5 10

J. HENDERSON
DIRECTOR

Reference

SEDIMENTARY ROCKS

RECENT	Alluvium	
PLEISTOCENE	Conglomerate	
PLIOCENE	Waitotaran Series: Sandstones, mudstones	
MIOCENE	Mokau Series: Sandstones, mudstones	
MESOZOIC (?) PALÆOZOIC	Greywacke & argillite	

IGNEOUS ROCKS

RECENT	Mud flow	
PLIOCENE TO RECENT	Tongariro andesites; Ruapehu andesites	
PLEISTOCENE	Pihanga basalts; Kakaramea andesites	
PLIOCENE	Rhyolites	
	Faults	F

Geology by L.I.Grange, J.H.Williamson and J.A.Hurst, 1933.

G.E.H.

The plateau slopes gently outward from a height of 3,500 ft. at the foot of the Kaimanawa Range to 2,300 ft. on the western boundary of the district, where it merges into the well-dissected Wanganui peneplain. Between the eastern highlands and the volcanic peaks the ground slopes north to Lake Taupo (1,200 ft.) and south to Waiouru (2,660 ft.). The Onetapu Desert forms part of this southern slope. It is a wind-swept area covered here and there with moving sand-dunes, its scanty vegetation mostly of a drought-resisting type. Northward sand-dunes are absent, vegetation increases, and patches of bush appear. The western flanks of the volcanoes and the plateau west of them are densely wooded.

The three main volcanic peaks, Ruapehu, Ngauruhoe, and Tongariro lie on a line trending north-north-east toward Rotorua and White Island. Ruapehu, 9,175 ft. high, at the southern end of the volcanic belt of the North Island, is a shapely cone with an oval uneven summit about one mile and a half across. Tongariro, 6,458 ft. high, eleven miles to the north and separated from Ruapehu by a 4,200 ft. saddle, is a truncated cone nine miles long and five miles wide at its base, and about five miles long and two miles wide on top. Ngauruhoe, a scoria cone rising 2,100 ft. above an old crater near the southern end of Tongariro, is 7,515 ft. high.

The extinct volcanoes Pihanga (4,352 ft.), Tihia (3,824 ft.) and Kakaramea (4,269 ft.) form a highland in the northern part of the district; Maungakakote (2,792 ft.) and Maungaku (3,213 ft.) lie farther west.

Some seven miles west-north-west from Ruapehu is Hauhangatahi, a small crescent shaped mesa, two miles and a half long and rather more than a mile wide, surmounted on its eastern edge by a small volcano 4,983 ft. high. The eroded east side of this cone is very steep, but westward it slopes gently down to a high level flat, from which there is an abrupt drop of 1,000 ft. to the plateau below.

Farther north, 3½ miles west from Ngauruhoe, Pukeonake, a small cone 4,018 ft. high stands out from Tongariro.

Raetihi, a small basaltic cone, rises to 2,923 ft. a few miles north of Ohakune.

Taurewa Mountain (3,530 ft.), in the north-west corner of the district, is a fault-bounded block of greywacke sloping north-west, in which direction it is covered with Tertiary strata. The fault on the west edge of the block follows the Whakapapa River for several miles; the one on the south-east side marks the course of a considerable tributary of that stream.

The region is the highest portion of the North Island and several important rivers have their sources in it. The headwaters of the Wanganui are on the west slopes of Tongariro, and a large tributary, the Whakapapa, drains the north-west flanks of Ruapehu. The Manganui-a-te-ao, another large tributary, has several important sources on the west side of the same mountain.

The Wangaehu and its branch the Mangawhero drain the south slopes of Ruapehu. The chief streams radiating from this great peak rise in small glaciers fed from the snowfield in its crater, but the Wangaehu draws part of its waters by way of an underground channel from a small lake in the crater of the volcano.

The Waikato drains the north-east slopes of Ruapehu, the east and northern faces of Tongariro, and most of the Pihanga-Kakaramea group of volcanoes. Roto Aira, a shallow lake between the last-mentioned highlands and Tongariro discharging by way of the Pouto to the Waikato, probably occupies part of the upper basin of that stream which was depressed when the vast masses of Tongariro and Ruapehu caused the crust under and near them to sink. A fault with downthrow of 40 ft. to the west cuts young gravels immediately east of the lake. The Waikato also drains a considerable part of the Kaimanawa Range.

The southern portion of these highlands is in the basin of the Moawhango, a branch of the Rangitikei. The Moawhango and a branch flow south and south-west along the foot of the Kaimanawa highland for many miles. For six miles the Wangaehu follows a parallel course about a mile to the west along a fault downthrowing young gravels to the west. This fault, which has a displacement up to 100 ft., originated in the same way as the Pouto fault farther north.

General Geology.

The table below shows the sequence in downward order and the approximate age of the rocks of the district.

	Age.
Alluvium, mud-flows, andesitic scoria, and ash from Ngauruhoe, &c.	Recent.
White rhyolitic pumice from near Lake Taupo	Recent.
Dark andesite flows, scoria, and ash from Ruapehu, Tongariro, and Ngauruhoe	Recent and Pleistocene.
Fluviatile gravels and conglomerates	Recent and Pleistocene.
Basalts from Pihanga and andesites from Kakaramea	Pleistocene.
Grey andesite flows and agglomerates from Ruapehu and Tongariro	Pliocene.
Sandstone and mudstone	Waitotaran.
Sandstone and mudstone	Mokau (Awamoan).
Greywacke, argillite, and sandstone	Mesozoic (?Paleozoic).

The oldest rocks of the district are the grey and green sandstones, dark argillite, and greywacke of the Kaimanawa Range and of Taurewa Mountain. The rocks of the Kaimanawas are tightly folded, strike north-north-east, and dip steeply; in the western portion, which was examined in detail, they are much crushed and rarely somewhat schistose. Greywacke and argillite were found as boulders and small fragments on the north-east slopes of Ruapehu, and as inclusions in lava flows showing so little alteration as to suggest their presence at a shallow depth below the volcanoes.

These rocks, which contain no interval evidence of age, lithologically resemble the greywacke and argillite of the central mountain ranges and are probably of Mesozoic age.

Mokau Beds.—Sandstone and argillaceous sandstone, with thin bands of greywacke conglomerate, striking east and dipping gently south, cover a considerable area in the north-west part of the district. They outcrop more or less continuously in the steep cliffs bordering the Whakapapa River and in places contain fossils of Mokau age. Similar beds outcrop on the upper Wanganui River, and the exposures between this and the Whakapapa River are probably part of the same series.

Pliocene Beds.—Beds of Pliocene age outcrop along the southern edge of the district, but no section shows the contact of the Mokau with them. They contain few fossils, so that it is difficult to correlate them. Even the fossils that have been found do not definitely fix the series age. These were collected in three localities, one south-west of the Kaimanawa Range, where 300 ft. of calcareous soft sandstone and mudstone are exposed in a railway cutting about three-quarters of a mile north of Waiouru station, the second two miles west of Raetihi, and the third in a railway cutting a mile and a half north of Ohakune. In an earlier account of the district the first collection was regarded as Nukumaruan and the last one as Taranakian; but as a result of a further examination Dr. Marwick is of opinion that all the collections could be Waitotaran.

Pleistocene and Recent.—East of the volcanoes alternating beds of coarse and fine fluvial conglomerates 125 ft. thick are exposed on the east bank of the Wangaehu River, and similar beds outcrop in places along the Waikato River and its branches from the east. West of the volcanoes similar conglomerates are exposed in the gorges of the deeply entrenched streams and on the Waimarino Plains. In the lower Whakapapa valley high river terraces are composed largely of pumiceous material.

Recent and Pleistocene deposits are not separated on the accompanying map.

Volcanoes.

Volcanic activity began in Pliocene times, and still continues. Ruapehu has been built up by successive lava-flows and showers of scoria and ash. Its old top down to the 7,000 ft. level was removed by collapse and by explosions, but later eruptions have almost restored the mountain to its former size and shape. Three ridges of grey andesite extend up to 7,000 ft., the most prominent being that on which stand the needle-shaped rocks called the Pinnacles. The latest lava-flows—hypersthene andesites—extend far down into the valleys. They are dark-coloured and have a rough surface.

The top of Ruapehu is above the permanent snow-level, and several glaciers occur, each fed from the main crateral glacier, which is nearly circular and about a mile across. In the centre of this is a hot lake, about 30 chains in diameter, bounded on the south and west sides by vertical cliffs of ice; on the north-east side lava walls are visible, and on the east a cinder cone rises to a height of 250 ft. above the level of the lake. At the time the lake was visited (February, 1930) the temperature of the water was below blood-heat; previous observers have seen steam rising from the water, and on two occasions—in 1886 and 1926—it has been frozen over. No outlet is visible, but the evidence points to an underground outlet to the Wangaehu River.

Mud-flows have swept down the slopes of Ruapehu. One that rushed down the north-western slopes extended a few miles beyond the National Park–Tokaanu Road and left numerous conical hills up to about 18 ft. in height and composed of coarse agglomerate. The latest one came down the Wangaehu in 1869 and spread out on the flats immediately west of the Waiouru–Tokaanu Road without forming any conical hills.

Hauhangatahi, a low flat cone 4,983 ft. high lying to the west of Ruapehu, owes its present outline to the fact that a lava-flow has protected the underlying Tertiary rocks from erosion. It erupted a purplish-grey andesite in which greenish augite phenocrysts are conspicuous.

The history of Tongariro is similar to that of Ruapehu. It, too, is formed of grey andesite; it was reduced from its ancient form by collapse and by explosions on an even grander scale than Ruapehu. New craters were formed and later explosions built scoria cones, much the largest being Ngauruhoe (7,515 ft.), which is still in active eruption. Though the major cones are built mainly of hypersthene augite andesite, the minor surrounding ones have erupted more basic lavas. Thus Pukeonake (4,018 ft.) on the west flank of Tongariro is formed of olivine basalt; Tama Lakes, on the saddle between Ruapehu and Tongariro, lie in explosion craters from which dense black augite andesites were erupted; and a viscous flow of dark olivine basalt poured out of a fissure on Pukekaikiore and ran several chains down the side of the hill.

Te Mari, an active scoria cone on the northern slope of Tongariro, has within tolerably recent times poured out a dark andesite lava which cut a path through the bush at the foot of the mountain. It was last in active eruption in 1896, but the only present sign of activity is a line of weak fumaroles high on the eastern rim of the crater.

At Ketetahi, about a mile west of Te Mari there is a group of fumaroles and small hot springs in a depression some 12 chains square. Fumaroles occur also on Tongariro and Ngauruhoe, and hot springs near Tokaanu, on Lake Taupo (1,200 ft.). Taumatapuhipuhi, a small geyser at Tokaanu, plays regularly to a height of 20 ft. at intervals varying from twelve to fifteen minutes.

The extinct volcanoes Pihanga, Tihia, and Kakaramea, aligned in a south-east to north-west direction, occupy the north-eastern corner of the district. Their northern slopes end near Tokaanu. Pihanga, a conical mountain without a crater, is composed of basalt. Kakaramea and Tihia are of hyperstene augite andesite.

METEOROLOGICAL BRANCH.

REPORT BY THE DIRECTOR, 1932–33.

General.

The most important event of the year from the point of view of the meteorologist was the successful inauguration of the International Polar Year on the 1st August, 1932. The zeal with which the scheme is being carried out by the peoples of Europe and America, in spite of the financial straits in which most of the countries concerned are labouring, illustrates the value attached in the Northern Hemisphere to research on the lines covered. Valuable theoretical results have already been obtained in the researches in wireless telegraphy and terrestrial magnetism, the observations having thrown considerable light on the nature of the radiations from the sun which are responsible for magnetic storms, auroræ, and the ionization of the upper atmosphere to which the phenomena of the Heaviside layer are due.

In meteorology the results will not be known until the collected observations come to be discussed by various committees of experts. Numbers of stations have been established in the Arctic regions and are carrying out the organized programmes. The total activity is greater than was hoped for, several nations, which in the preliminary stages had promised no assistance, making substantial contributions. In the Southern Hemisphere, unfortunately, much less is being done. There is no station on the Antarctic Continent itself. Instruments for special researches in terrestrial magnetism have been provided by the International Polar Year Commission for several Southern Hemisphere stations, including the Christchurch Magnetic Observatory. Under the direction of Professor Florance, experiments are being carried out at Victoria University College, largely with apparatus lent by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, on the height of the Heaviside layer. At the Meteorological Office extra observations, including an hourly record of the cloud on certain "term days" are made according to the general plan. As New Zealand's representative on the International Commission, I am kept informed of all developments.

In other directions little advance has been possible owing to the limitations imposed by the successive economies of the past three years. Considerably greater use continues to be made of the records collected and published by the Meteorological Office. The same is true in regard to the weather forecasts. Farmers, particularly, are tending more and more to regulate their daily activities in accordance with the weather forecast.

Observing-stations.

Again there have been several requests for the establishment of climatological stations at places whence no observations are at present available. Though, especially in some cases, the observations would have been of considerable interest, these requests have had to be refused as being beyond the resources of the Branch.

Rainfall records are now published from nineteen new stations. These are all well placed and will supplement our knowledge of the distribution of the rainfall in a useful manner. Six of the gauges are the property of the observers themselves. Five of the older stations have lapsed for various reasons.

The only inspection possible was in Taranaki, where the majority of the stations were visited in the course of a hurried journey, which, however, exhausted the funds available. Among those visited for the first time were Riversdale, Inglewood, and Opunake, which have been maintained continuously for fifty-one and forty-five years respectively by Miss Nora Trimble and Mr. A. D. Moore. Both have furnished excellent notes of various meteorological phenomena in addition to rainfall. Records of this type are extremely valuable in connection with the study of climatic changes, periodicities, and the factors controlling the weather generally. The country owes a debt of gratitude to the observers concerned.

There is urgent need for more inspection, particularly of climatological stations. Brief inspection would often prevent errors or accidents leading to loss of observations which, even if confined to a short period, seriously detracts from the record of a station.

I wish again to thank the many observers who so cheerfully devote much of their time to the making and tabulating of observations in the public interest.

Forecasting.

As indicated above, the interest in the weather forecasts continue to grow, particularly amongst the farming community. Many requests for special forecasts have been received. Amongst the requirements of those making these requests have been suitable weather for (1) burning off bush or scrub, (2) cutting hay, (3) the movement of small vessels, such as launches, from port to port across the open sea, (4) the leading of prospecting expeditions into mountainous areas, and (5) for invalids and elderly people to make a sea journey. In the very great majority of cases the forecasts supplied have been quite successful.

I wish to acknowledge the ever cordial co-operation of the officers of the Telegraph Branch of the Post and Telegraph Department.

With the general public, meteorology is apt to be regarded as synonymous with weather forecasting. Such is far from being the case, and, indeed, weather forecasting is not the most important part of the subject. Even were it so, an intensive study of climate and weather from the theoretical aspect would be necessary if any advance were to be made. Among scientific pursuits, forecasting

weather occupies a somewhat unique position. Volcanic eruptions, geological changes, and other phenomena undoubtedly influence the weather of the world, but for day-to-day practical purposes it may be said to be governed by the existing state of the atmosphere and the earth's surface and the influence thereon of solar radiation. There are certain known slight fluctuations in solar radiation, and in past ages there may have been considerable changes. But, again, as regards daily weather-variations these may be, to a large extent at least, neglected. Seasonal changes are very important, but they are regular and can be allowed for. The weather of to-morrow may thus be said to be implicit in that of to-day. The ideal attainment would therefore be to be able to calculate it with precision by the application of known physical laws. But the atmosphere is so complex and extensive a body that hitherto it has been possible to obtain only partial solutions to its equations of motion, and never yet have we had complete knowledge of its state. From the oceans and the polar regions, particularly, the information is always scanty. And there is no doubt that conditions out almost to the extreme limits of the atmosphere are important. It has thus not been possible to put forecasting on an exact basis. The existing systems depend on the securing of as complete a knowledge as feasible of the state of the weather over an area extending as far possible in all directions around the region for which the forecast is required, and then deducing the changes that will occur. The latter is done principally on the basis of general physical principles and a knowledge of the processes of the atmosphere but, also, unfortunately, for the reasons stated above, partly on empirical grounds. The forecaster has to use his knowledge of previous situations which most nearly resembled the existing one in estimating the coming changes. The meterologist is fully aware that the result falls short of perfection, and if circumstances permitted he would prefer to defer the issuing of regular public forecasts until the system had been placed on a sounder basis. Forecasts are, however, sufficiently accurate to create an insistent public demand for them, and the only thing to do is to endeavour continuously to improve their accuracy, and this is being done. The principal advances naturally come from Europe, where science and civilization are most highly organized. The advances have all been in the way of collecting more and more information at more frequent intervals and the application of the methods of physical research to the information thus gathered. Weather phenomena are due principally to the inter-play of air masses of different origin and consequently of different characteristics as regards temperature and moisture content. The Norwegian School of Meteorologists, particularly, has become extremely expert at deducing the nature of the interaction of these currents and also the changes which will take place in the air-masses themselves as they pass over ocean or land surfaces or meet with the obstructions caused by mountain-ranges or plateaux. Their forecasts for short periods of from an hour or two to about twelve hours are usually very accurate, and by dividing the forecast area into a large number of small districts they can be made very precise. For the longer periods the limitations mentioned earlier become increasingly important and the accuracy begins to fall off rapidly. For the value of these developments to be passed on to the public it is necessary that the collection and dissemination of information should be both very complete and rapid. This is secured largely by the use of wireless telegraphy. Four weather charts are prepared daily, two of them covering a large part of the Northern Hemisphere.

Here we must mention one of the unavoidable limitations of weather forecasts, and that is the difficulty of describing the weather. On most days there is so great a variation from place to place that merely to describe the weather over a country like New Zealand at any one instant would require a large number of words, while to give a detailed account of that occurring in twenty-four hours would require pages. This is a difficulty that is seldom realized, especially by city folk. When showers are moving at intervals across the country for example, it never will be possible in a general forecast to tell the people in all the suburbs of a large city at precisely what times to expect rain.

It will be clear from the foregoing that the success of a forecasting-service depends first and foremost on the availability of free and rapid means of intercommunication by telegraph, cable, and wireless. This is generally realized. In Australia, for example, the telegraph and wireless services are available to the Meteorological Bureau free of charge, the only limitation being that the use should be reasonable. The amount of traffic thus handled is between fifteen and twenty times that in New Zealand. The leading wireless-telegraph companies throughout the world have agreed to transmit weather messages at half the ordinary rates and priority is accorded to them. The private cable companies in the China seas transmit weather cables free of charge. In England quarter-rates are charged for meteorological messages. In New Zealand, on the other hand, there have in recent years been progressive restrictions. The Meteorological Office is charged, in accordance with the present system, for all services by the Post and Telegraph Department, which has a monopoly of communications. The item for telegrams is consequently the largest in the budget of the Branch and the first to be attacked when an economy campaign is in progress. Some years ago morning reports from all over the Dominion used to be displayed daily for the public information in all the important ports. It was thus possible for shipmasters and others to form a reasonably complete view of the state of the weather over the country and interpret intelligently the official forecast. The number of places to which the report is not sent has been greatly reduced, and not more than twelve stations may be included in the list of reports to any one place. Such a service is quite inadequate. A more complete one would be of great use to motorists and aviators, as well as other interests. Again, the number of towns to which the mid-day forecast is sent has been progressively restricted. The official forecast itself has to be sent in a code such as is used in no other country and which is quite unsuitable. It is true that the wireless-broadcasting services have become available for disseminating information, and in many respects they have advantages over line services or issues in Morse code. But a telephoned broadcast is not a good medium for transmitting actual weather reports, and in general does not altogether replace the written word. As regards information received by the Meteorological Office, there has also been a considerable reduction in the number of reporting-stations.

This has a definite effect on the forecasts apart from the inevitable reduction in the completeness of knowledge of the general situation. For example, the forecaster will often cease predicting rain in a particular district because in the same type of weather the few reports he has received from the district indicate fine weather. Yet reports received later by post may show that rain has fallen in many places. Then, there are numbers of reports issued by wireless which we have at present no means of intercepting. Particularly valuable would be a long list of reports now broadcasted in Australia, the receipt of which would enable us to apply the Norwegian methods with some success in this region, in spite of the difficulties created by our ocean surroundings. Reports from New Caledonia, which are not intercepted here, would also be useful. Furthermore, we are not able to take advantage of weather reports at standard hours broadcasted by certain "selected ships" according to a recent international arrangement. I find it difficult to believe that the supplying of these reports to us would really involve any considerable expense to the Dominion or that the other restrictions imposed on us represent a real economy. It is sincerely to be hoped that the facilities available will, before long, be largely increased.

Difficulties due to the complexity of the weather have been referred to above. The meteorologist attacks them by codifying reports and so reducing their volume to a minimum. Next, in order to make all the information readily appreciable, he plots them on a suitable chart. Once this is done, a mere glance at the chart is sufficient to enable the main features of the situation to be understood. Such charts, published in simplified form, are equally valuable to the layman. In Australia each of the important daily newspapers prints a copy of the day's weather map. In other countries printed copies are delivered to subscribers and posted in numerous prominent positions. Better still, in America and Germany it is possible, with the aid of inexpensive apparatus, to receive a copy of the latest chart by wireless in the course of a very few minutes. The receiving-machine automatically prints the chart as the signals come from the issuing-station. It is often through the teaching of a certain amount of meteorology in the schools and the general employment of the weather-chart that full use can be made of a forecasting service. An elementary knowledge of meteorology is becoming of increasing importance in many walks of life, especially in connection with aviation. Therefore it is most desirable that the Meteorological Office should have sufficient staff and resources to enable it to publish a daily weather-chart.

In common with the other professions in New Zealand, meteorology suffers from the activities of persons who, without proper knowledge or training, have no hesitation in making pronouncements on the most technical subjects. A large proportion of the public is, unfortunately, unable to distinguish between these self-appointed authorities and the individual who, by the work of a life-time, has endeavoured to qualify himself as an expert in the subject, and the authority of the latter is undermined. Weather-forecasting is obviously a happy hunting-ground for the pseudo-scientist of the type referred to. The result of his efforts is to give the impression that forecasting is at best a kind of inspired divination. There is a dissipation of energy, and attention is diverted from the directions in which real advance may be made. The only successful way of combating these activities is by education and by the free dissemination of accurate information in the ways suggested above.

The non-official forecasters are of three types. The first and least objectionable have some knowledge of meteorology and of the local conditions in their particular districts. Not being cramped by having to express themselves in a telegram limited to a certain number of words, they are able to paraphraze and expand the official forecast without the use of the technical terms which brevity demands. They also have the advantage of issuing their forecasts several hours later than the official one. It would be more honest if their indebtedness to official sources were acknowledged. Their work does, however, arise from a real demand which cannot wholly be met by the methods we have been urging. This demand could be more satisfactorily catered for by having forecasting-officers stationed, say at Auckland and Christchurch. These local forecasters would receive sufficient reports to enable them to draw their own weather-chart and, on the arrival of the official forecast, expand it in accordance with their knowledge of the local weather and local interests. Such a development would not prove very expensive.

It has been shown above that recent developments have been made in the direction of increasing the accuracy of short-range forecasts. At the same time researches have been carried on with a view to finding a basis for long-range forecasting. Sir Gilbert Walker and his school have been particularly active in this respect. Many interesting relationships have been brought to light and formulæ developed which enable useful forecasts of the character of the monsoon in India, for example, to be made. But to have real practical value a seasonal forecast must be very reliable, and in the temperate regions especially results have so far not been promising. In New Zealand we are continually being urged towards the extension of our forecasts to cover longer periods. We endeavour to meet this demand as far as possible in the special forecast for farmers which is issued at 4 p.m. from the Broadcasting Stations during the months of November to April. It is quite frequently possible to anticipate the type of weather which will prevail for some days to come, but there are also many times when such is not the case. Consequently the same accuracy cannot be expected in a forecast for several days in advance as in the normal prediction for the ensuing twenty-four hours. But this desire for long-range forecasts is one that can be very easily exploited. This is done by numbers of people belonging to the second and third of the three classes of non-official forecaster mentioned above. The second class claim to base their predictions on some secret principle or formula which, if divulged, would make everything clear. This is a line of conduct which no one with genuine scientific interests would adopt. The true investigator presents his deductions to those who are acknowledged experts in the subject dealt with, and by them they are subjected to criticism. Unless unsound they are published in scientific journals when they can either be made use of or rejected by those concerned. Consequently a claim to the possession of some secret and revolutionary knowledge would naturally excite suspicion.

As a matter of fact, the secret system either never comes to light or proves to have no sound basis. Gradually its possessor and his forecasts fade away into oblivion. The third class of forecaster gives as the ground of his pronouncements theories which to any one with any knowledge of physics are either totally impossible or highly improbable. But nothing is too fantastic to prevent its gaining a certain amount of publicity. The number of systems based on lunar phenomena is extraordinary. The majority are mutually exclusive. If one were correct, the others could not be. Now, any such theory can be proved to be right or wrong by means of available statistics. Yet such a course is never followed. The secret of the popularity enjoyed by the two classes of forecaster mentioned is that they assess the correctness of their forecasts themselves. They seldom have any knowledge of the weather away from their own districts except that which may be gained from the newspapers, but their readers generally have less and their memories are short. Consequently claims to success accompanied by plausible references to outstanding occurrences anywhere within a radius of a thousand miles or more are usually accepted by a large number. To try to correct such impressions through the columns of the ordinary newspaper is hopeless.

Upper-air Observations.

Observations of wind in the upper air by means of pilot balloons have been continued at Wellington throughout the year on all working-days. The normal programme is for one observation per day, but on the "term days" of the International Polar Year an additional one is made. The results of similar observations at the Christchurch Magnetic Observatory are received daily by telegraph for use in connection with the forecast. They are valuable, particularly because the surface-winds at Christchurch are often very local in origin and give little indication of the general wind régime. The co-operation of Mr. H. F. Skey, Director of the Christchurch Observatory, is gratefully acknowledged. Observations of visibility are made at 9 a.m. daily. The movement of medium and upper clouds is recorded as opportunity occurs. These latter observations are a very useful supplement to the pilot-balloon observations. They give information regarding the winds at heights to which the balloon is seldom followed, particularly at a place like Wellington, where low cloud is of frequent occurrence.

Publications.

There are published monthly in the Government *Gazette:* (1) Daily observations of pressure, temperature, &c., at the Kelburn Observatory, Wellington; (2) a note on the weather of the Dominion for the month; (3) a summary of the temperature observations at climatological stations other than Wellington; and (4) total rainfall and number of days' rain for all rainfall-stations. A table of the total rainfalls, differences from average, and greatest day's fall in the year is published annually.

The Meteorological Office publishes and annual volume of "Meteorological Observations" containing monthly and annual means of pressure, sunshine, wind, temperature, and other climatological data for upwards of forty stations.

Reprints of these publications are obtainable for the cost of postage.

The article of climate for the volume of "Land Utilization in New Zealand," to be published under the auspices of the Institute of Pacific Relations, has been completed, and, presumably, the volume will appear shortly.

The series of "Meteorological Office Notes" which have been appearing from time to time in the *Journal of Science and Technology* has been continued. The object of this series has been to summarize and thus make available to the public the results of the records which have been accumulated by the Service during past years and to treat of special problems and phenomena as they arise. In this way data regarding the climate and weather of the country are being accumulated in a readily accessible form. Without such sifting and co-ordination of data, theoretical advance is impossible. At the same time the information has numerous practical applications in the various professions. This year the following numbers have appeared:—

No. 11: Some Meteorological Data for 1930 and 1931.
No. 12: The Canterbury "Northwester."
No. 13: The Wairarapa Floods of August, 1932.

The first of these contains (*a*) tables of the total amount of bright sunshine recorded at the Kelburn Observatory for each hour of the day in each month in 1930 and 1931, (*b*) the average rainfall for each hour of the day throughout the year at Kelburn for 1930 and 1931, and (*c*) a map showing for the Dominion the differences between the rainfall recorded in 1931 and the average annual totals. The year 1931 was a wet one in western districts from Auckland southwards, parts of the ranges of the South Island having as much as 40 in. in excess of the average. In eastern districts it was very dry, large areas having a shortage of more than 10 in.

The Canterbury northwester, which is the subject of the second note, is the well-known Föhn wind of the Canterbury Plains. The reasons for the warmth and dryness of the wind and its erratic nature are explained. The Southern Alps have a profound effect on a current of air advancing from the north-west across the Tasman Sea, and the Canterbury northwester is only one of the manifestations of this. The flow in the lower levels is interrupted, and that at the higher levels correspondingly accelerated. The northwester is consequently not nearly so strong on the west coast as in the open ocean, while on the mountain-tops it is very strong and steady. It does not necessarily descend to the Plains on crossing the divide. The hotter the Plains are the more likely it is to descend. The northwester thus blows most frequently and strongly and covers a greater area on the Plains in the afternoon and evening hours than at other times of day. It is common for a north-easterly wind to prevail on the east coast when a northwester blows in the upper air. The air in the northeaster is cooler and denser than that in the northwester, which therefore rises over it. A weather-chart for a day on which a north-westerly gale occurred is reproduced in the paper, and various features described are clearly illustrated by it.

At the end of August, 1932, severe flooding occurred in the Wairarapa Valley. About Lake Wairarapa it was in some parts the highest flood on record, and losses of stock and damage to property were severe. In Note No. 13 the weather-conditions which led up to this flood are described. Weather-charts, drawn in accordance with modern ideas, are used to explain the developments which occurred. The very heavy rains on this occasion were due to the effect of the mountains of the Dominion on the movements of a mass of cold air advancing from the south-west. A bay was formed in the forward boundary of this air (the " cold front " as it is called) while it flowed over the Wellington Province. As this bay closed up the warm air flowing above the cold in the higher levels was forced rapidly upwards. The resulting cooling of this warm air caused much of its moisture to condense out as heavy rain.

In connection with the Pan-Pacific Science Congress at Vancouver, I was asked to prepare papers on,—

(1) " The Importance of Upper Air Observations in the Pacific especially with reference to Airships."

(2) " The Circulation of the Atmosphere in the Australia – New Zealand Region."

Airships are very much at the mercy of the weather, first, because of their limited speed through the air and the consequent effect of winds, and, second, because they have to depend on being more buoyant than the air. The total weight which can be lifted depends on the absolute temperature. For example, at a temperature of 27° C. or 300° absolute, a rise of temperature of 1° C. means a reduction of $\frac{1}{3}$ per cent. in the load which can be lifted. Now the weight of the vessel itself constitutes a very large fraction of the total load, and this, of course, cannot be altered. Any loss of lift, therefore, has to come off the useful load carried. Thus loss of a small percentage in the total lift may mean a large reduction in the useful load. An airship will therefore lose a large part of its efficiency on passing from the temperate regions into the tropics. On the other hand, in cold regions there is danger of trouble due to the formation of ice on the vessel. It thus becomes most important to choose airship-routes on which the winds are favourable and air-temperatures as steady as possible and neither too high nor too low. But perhaps the most serious factor airships have to contend with is vertical air-currents. Recent experience with the largest vessels suggests, indeed, that the dangers and disabilities due to vertical currents and a turbulent atmosphere generally have not been sufficiently overcome to permit the satisfactory development of transport by airship on a commercial scale.

The paper on the circulation of the atmosphere mentioned above presents ideas which have been gradually developing in my mind in the course of studies extending over the past twelve years. Any one who is at all familiar with Australian and New Zealand weather-charts cannot fail to be impressed with the regularity with which, for most of the time at any rate, anticyclones and, what we call in New Zealand, " westerly depressions " follow each other from west to east across the charts. This feature is obscured in the Northern Hemisphere owing to the effect of the contrast between ocean and land masses. Conditions in the Southern Hemisphere are much simpler. For the latter reason one may expect that it would be easier to solve some of the elusive problems of the general circulation in the Southern than in the Northern Hemisphere. From this point of view the regular progression of anticyclones and depressions or, as I prefer to call them, atmospheric waves, appears to be of particular interest. On the average, the waves pass at the rate of one for every six days, about, and their length and speed is such that there would normally be eight waves at any one time in the circuit of the hemisphere, and a wave would make the journey round in about six weeks. It is due to the regularity of these waves that weather of a similar type is frequently experienced on a number of successive week-ends and so attracts considerable attention. Many other interesting characteristics of the waves are described in the paper, but their interest is mainly theoretical and space will not permit of further reference here. Their study is being continued.

The normal weather sequence described above is, however, sometimes wholly or largely interrupted. A remarkable instance of this occurred in February, 1932, when, after a prolonged dry period, continuous and heavy rains occurred in the eastern districts of the North Island, ending in a general rain over the whole Dominion. From the 5th to the 22nd February the flow of air over New Zealand was almost continuously from a southerly or south-easterly direction, and the movement of depressions and anticyclones from the westward practically ceased. For a considerable time prior to this there had been signs of activity in the tropics, and the cause of the development described was due, in my opinion, to a great outpouring of warm air from the tropics and past the east coast of New Zealand. By means of reports received, partly by post, a detailed examination according to the Norwegian methods was made of the weather-charts for the period mentioned, and a paper on them is to be published in a European periodical. The series contains numbers of features of great theoretical interest.

Miscellaneous.

Observations of total solar radiation with an Angstrom pyrheliometer have been made at Kelburn by Mr. R. G. Simmers when weather-conditions were suitable. These will be published in the annual statistics. Mr. Simmers has also been making observations of soil-moisture and soil-temperatures at various depths. The problem of recording soil-moisture is a very difficult one, and much work remains to be done before it can be decided whether the method used, whereby the capillary attraction of the soil for moisture is measured, can be made of much practical value.

Hourly values of temperatures at Wellington and Alexandra for upwards of two years have been tabulated, mainly by Mr. A. G. C. Crust.

Mr. D. C. Meldrum has kept up-to-date tabulations of hourly values of sunshine, rainfall, and pressure at Wellington.

The temperature and rainfall tabulations have been made use of in connection with heating and other engineering problems.

Miss M. E. Ewart continued the tabulation of hourly observations of wind speed and direction at Auckland, Wellington, and Sockburn (near Christchurch).

In conclusion, I take pleasure in acknowledging once more the cordial co-operation of all members of my staff.

DOMINION OBSERVATORY.

REPORT OF THE DOMINION ASTRONOMER AND SEISMOLOGIST FOR THE YEAR ENDED 31ST DECEMBER, 1932.

Buildings and Equipment.

The buildings and equipment have been kept in good order and condition. The Observatory grounds have been kept in good order by the Wellington City Corporation.

Astronomy.

Astronomical Observations.

As in the previous year, the Observatory signal clock has been controlled mainly by means of radio time signals. It has not been possible to carry out sufficient meridian transit observations for these to be of use in controlling the time service.

Reception of Radio Time Signals.

The following radio time signals have been received for the purpose of checking the Observatory signal clock:—

Station.	Call Sign.	Hour (G.T.M.).	Number of Times received.	Greatest observed Error of Observatory Clock.
Nauen	DFY	00	286	0·85 seconds slow, December 16.
Malabar	PKX	01	142	0·50 seconds slow, April 14, May 27.
Honolulu	NPM	03	5	0·11 seconds fast, December 5.
Annapolis	NSS	05	17	*1·5 seconds fast, July 29.
Annapolis	NSS	08	18	0·33 seconds slow, February 23.
Bordeaux	FYL	08	99	0·32 seconds slow, November 1.
Rugby	GBR	10	4	0·12 seconds slow, August 9.
Nauen	DFY	12	2	0·14 seconds slow, May 17.
Bordeaux	FYL	20	416	†2·82 seconds slow, March 2.
Annapolis	NSS	21	106	0·75 seconds fast, August 20.

* Due to irregularities in clock-rate. † Due to breakdown in synchronizing circuit.

All the above radio signals are long-wave, except Honolulu at 3 hours, which is a short-wave signal.

The total number of signals received during the year was 1,095. This number includes both mean-time and rhythmic signals from Nauen, Bordeaux, and Rugby; Malabar, Honolulu, and Annapolis transmitting mean-time signals only. The daily-check signal from Bordeaux at 20 hours G.M.T. (7.30 a.m. N.Z.M.T.) was not available after October 15th. It is not possible to make regular use of the British time-signals transmitted by Rugby Radio owing to the very unsuitable times of transmission (5.30 a.m. and 9.30 p.m. N.Z.M.T.).

Time Signals sent out from the Observatory.

The time service has been maintained, and the regular signals have been transmitted daily. The present routine at the Observatory provides for the following time signals, most of which are sent automatically by the Observatory signal clock. The error of the signal clock seldom exceeds one-quarter of a second of time.

Automatic Time Signals—

(1) To the General Post Office and the Railway Department, Wellington, by telegraph daily, except on Government holidays and on Sundays.
(2) To ships and to the general public at Wellington, by electric lights at the Observatory daily.
(3) To the Auckland Harbour Board, by electric lights at Auckland, on Tuesdays and Fridays, except Government holidays.
(4) To the South Island telegraph offices, by telegraph, on Tuesdays and Fridays, except Government holidays.
(5) To the Lyttelton Harbour Board, by dropping the time-ball at Lyttelton, on Tuesdays and Fridays, except on Government holidays.
(6) Radio time signals through the Radio Broadcasting Station, 2YA at Wellington, daily at 4 hours and 8 hours G.M.T.
(7) Radio time signals through the Wellington Radio Station ZLW, on Tuesday and Friday evenings at 8.30 p.m. (9 hours G.M.T.), except on Government holidays.
(8) Radio time signals through the Wellington Radio Station ZLW, every day at 10.30 a.m. 23 hours G.M.T.).

In transmitting radio time signals the call sign of the Observatory is ZLY.

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 automatic 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 telegraph to 221 offices and by telephone to 257 stations.

The following list gives the number of time signals sent out during the year 1932:—

	Signals.
Radio time signals through Station ZLW	464
Radio time signals through Station 2YA	729
Time signals by telegraph	556
Time signals by lights at Wellington	365
Time signals by lights at Auckland	104
Time signals by time-ball at Lyttelton	102
Time signals by telephone	68
Total number of signals sent out in 1932	2,388

On October 16th the radio time signals through ZLW failed, on account of a faulty relay at the Observatory, and on December 2nd a partial failure of the signals resulted from the same cause.

The following table indicates the degree of accuracy of the radio time signals sent out from the Observatory, through station ZLW, during the year 1932.

Number of times correction did not exceed 0·25 sec.	424
Number of times correction between 0·26 and 0·50 sec.	35
Number of times correction between 0·51 and 1·00 sec.	4
Number of times correction exceeded 1·00 sec.	0
Total signals sent through ZLW	463

There was a considerable improvement in the accuracy of the ZLW signals as compared with 1931. This was mainly due to the fact that the check signal from Bordeaux at 20 hours G.M.T., and also the signal from Annapolis at 21 hours G.M.T., were available during the greater part of the year.

With the exception of January 15th, when a fault occurred at the Observatory, both afternoon and evening time signals were regularly supplied to station 2YA. As the actual broadcast of these signals is controlled by 2YA, the Observatory cannot be responsible for the regularity of the service. During the year 1932 the afternoon signals from 2YA were checked and the result showed that on fifteen occasions a partial failure in the broadcast occurred, while on twenty-one occasions a complete failure was noted.

Time signals by telephone included signals frequently given to Government House, to Trentham Military Camp, and to the Telegraph Office or Public Works Department for the purpose of setting Parliament clocks.

Government Buildings Clock.

The Government Buildings clock has been kept under fairly close control. A record is obtained at the Observatory each day, by direct circuit from the clock, and the adjusting weights on the pendulum are altered as occasion requires. The greatest errors of this clock were 26 seconds fast on August 18th and 58 seconds slow on December 7th.

General Post-office Clock.

The Post-office clock is checked by W/T at 3 p.m. daily, except Saturdays, Sundays, and Government holidays. The greatest errors observed during 1932 were 11 seconds fast on January 20th and 7 seconds slow on April 4th. This clock is not under the control of the Observatory.

Occultations.

The programme of observing occultations at Wellington with the 9 in. Wellington City telescope by the Dominion Observatory staff, and the 6 in. telescope at New Plymouth by the local astronomical society, has been continued. The Observatory is indebted in this work to a considerable amount of

voluntary assistance by members of the New Zealand Astronomical Society, and also to the predictions in the Handbook of the British Astronomical Association. During the year occultations were observed at Wellington on the following dates: January 19, March 22, August 9. At New Plymouth observations were made on January 12, 19, 20, 22; September 7; October 4; December 30. A total of sixteen observations was obtained, and these have been forwarded to Dr. L. J. Comrie, Superintendent of H.M. Nautical Almanac Office, London.

New Zealand observations were included in a compilation and discussion of 859 occultations observed in 1931 by Professors E. W. Brown and Dirk Brouwer (*Astronomical Journal*, Vol. 42, No. 20). Results for 1925, 1930, and 1931 published in the *Journal of the British Astronomical Association* (B.A. A. Journ. Vol 43, No. 3), also includes New Zealand observations.

Lunar Eclipse.

The partial lunar eclipse of 1932, March 22nd, was well observed photographically and visually with the 9 in. telescope by a member of the staff. Ten photographs were obtained of the eclipsed moon at the principal focus of the 9 in. photovisual lens, and the times of occultation of two faint stars during the eclipse were observed. A note appears in the *Journal of the British Astronomical Association*, Vol. 42, No. 10.

International Astronomical Union.

By courtesy of the Central Bureau at Copenhagen, arrangements have been made to receive advice of all important astronomical discoveries. The information is forwarded by the Bureau through the Melbourne Observatory. The following information was received in this way:—

(1) Discovery of a comet by Van Biesbroeck at Yerkes, March 6th.
(2) Discovery of a comet by Houghton at Cape Town, April 2nd.
(3) Discovery of a comet by Carrasco at Madrid on April 25th.
(4) Discovery of an object by Reinmuth at Heidelberg, April 27th.
(5) Observation of periodic comet Kopff, 1932, May 25th.
(6) Discovery of an object by Nakamura, Japan, June 8th.
(7) Discovery of a comet by Newman at Cartuja, June 20th.
(8) Discovery of a comet by Schmitt on June 25th.
(9) Discovery of a comet by Peltier and Whipple, August 8th.
(10) Discovery of a comet by Dodwell, Adelaide, December 17th.

Of these objects, Comets Houghton-Ensor and Dodwell-Forbes were observed by members of the New Zealand Astronomical Society and the results forwarded to the Dominion Observatory. Also Comet Ryves, discovered in 1931, was well observed. The results of the observations have been published in the *Monthly Notes of the New Zealand Astronomical Society.*

Comet Geddes (1932g.).

It is a pleasure to record the fact that an interesting comet of about the 8th magnitude was discovered by Mr. M. Geddes, at Otekura, Clutha County, South Otago, on 1932, June 22. The discovery was reported to the International Astronomical Union through the Melbourne Observatory, with the result that the Union Observatory in South Africa was able to obtain accurate photographic positions on June 23rd. It was well observed throughout New Zealand; by Baldwin at Melbourne; in South Africa; and South America (Cordoba). Owing to the fact that on discovery it was very near the south celestial pole, it was for a time observable from only the Southern Hemisphere. As it approached the equator, however, all the northern observatories concentrating on this class of work were able to obtain good positions. The appearance of the comet for many months after discovery was that of a round nebulous object, but later at Yerkes, Van Biesbroeck detected photographically a short, thin tail. A prediscovery position of the comet has been obtained by Whipple on a plate taken at Bloemfontein, South Africa, on 1931, August 14th. The magnitude then was 13.

From the observations made with the 9 in. at Wellington an orbit was computed. An orbit and ephemeris was received also from Dr. Bobone at Cordoba.

Mr. Geddes discovered this comet with the 5 in. telescope belonging to this Observatory. It is on loan to him so long as research work is being carried out.

New Zealand Astronomical Society.

The observatory is greatly indebted to the members of the New Zealand Astronomical Society who carry out systematic observations. Scattered over the whole of New Zealand, it is possible at times to secure continuous results, and the defects produced in a series of observations by weather-conditions, is minimized as much as possible. These workers continually keep the Observatory informed on the work they are doing.

The society has formed observing sections for special purposes, such as variable stars, sun-spots, planetary observations, comet-searching, star-colours, aurora and zodiacal light and meteors. All are producing valuable results, and it may be fairly said that New Zealand is producing, as a result of this systematic work, astronomical observations of world-wide interest. The southern latitude and the longitude nearly twelve hours different from Europe makes the country favourable for astronomical students.

"*New Zealand Nautical Almanac.*"

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

Summer Time Act.

The Summer Time Act, 1929, provided for the time in New Zealand being half an hour in advance of New Zealand standard time for the period beginning at 2 a.m. New Zealand standard time on Sunday, 1932, October 9th, and ending at 2 a.m. New Zealand standard time, on Sunday, 1933, March 19.

Seismology.

General.

During the year 1932 continuous seismological records were obtained at the Dominion Observatory, Wellington; the Magnetic Observatory, Christchurch; and from subsidiary stations at Suva, Arapuni, New Plymouth, Hastings, and Takaka.

On January 14th a consignment of Milne-Jaggar seismographs of the vertical boom type was received from Dr. T. A. Jaggar, Honolulu. One of these seismographs was immediately erected at this Observatory, and during the course of the year several new stations were established, and the older type Milne-Jaggar seismographs were replaced at some of the existing stations.

Special precautions have been taken at this Observatory to enable the seismographs to continue recording throughout a severe earthquake should such occur. All Milne-Jaggar seismographs are being fitted with devices to enable them to record a severe shock without being dismantled.

Seismological Stations.

New seismological stations were established at Chatham Islands, Tuai, Bunnythorpe, and Greymouth. The Milne seismograph at the Magnetic Observatory, Christchurch, was transferred to the Chatham Islands in January, and placed in charge of the Superintendent of the Chatham Islands Radio Station (Mr. L. J. Elliston). Owing to difficulties regarding the erection of the seismograph, regular records were not obtained until August. In September a Milne-Jaggar was erected at Tuai and placed in charge of the Resident Electrical Engineer (Mr. W. H. Gregory). In October another Milne-Jaggar was established at the Bunnythorpe substation, in charge of Mr. W. A. Waters, Chief Engineer of the Manawatu-Oroua Electric-power Board. In November a third Milne-Jaggar seismograph was erected at Greymouth in charge of Mr. T. A. Johnston, District Engineer, Public Works Department. The following is a complete list of seismological stations operating in New Zealand and surrounding islands on 31st December, 1932.

Station.	Position.		Instruments.	Person or Institution in Charge.
	Latitude.	Longitude.		
	° ′	° ′		
Apia	13 48 S.	171 47 W.	Wiechert, three components ..	Apia Observatory.
Suva	18 9 S.	178 26 E.	Milne, twin-boom	Miss Mune.
Arapuni ..	38 5 S.	175 39 E.	Milne, E.–W.	District Engineer, Public Works Department.
Tuai	38 48 S.	177 9 E.	Milne-Jaggar	Resident Electrical Engineer. Public Works Department.
New Plymouth ..	39 4 S.	174 4 E.	Wood-Anderson	H. W. Todd.
			Milne-Jaggar	C. E. Morshead.
Hastings ..	39 38 S.	176 53 E.	Milne-Jaggar	H. de Denne.
*Dannevirke ..	40 12 S.	176 7 E.	Milne-Jaggar	L. Bastings, M.Sc.
Bunnythorpe ..	40 17 S.	175 36 E.	Milne-Jaggar	W. A. Waters.
Takaka ..	40 17 S.	172 48 E.	Imamura, three components ..	W. J. Smith.
Wellington ..	41 17 S.	174 46 E.	Wood-Anderson	Dominion Observatory.
			Galitzin-Wilip	
			Milne-Shaw, two components ..	
			Milne-Jaggar	
			Ishimoto Clinograph	
*Seatoun ..	41 19 S.	174 48 E.	Inverted Pendulum	C. J. Westland, F.R.A.S.
Greymouth ..	42 25 S.	171 13 E.	Milne-Jaggar	T. A. Johnston.
*Glenmuick ..	42 54 S.	173 9 E.	Inverted Pendulum	A. S. Westland.
Christchurch ..	43 32 S.	172 37 E.	Wood-Anderson	Magnetic Observatory.
Chatham Islands	43 57 S.	176 31 W.	Galiztin-Wilip, three components	Magnetic Observatory.
			Milne	L. J. Elliston.

* Privately owned stations.

Thanks are again due to those officials and private persons who have assisted the Observatory in seismological work by operating instruments and forwarding records and reports. By the courtesy of the Government of Fiji the records of the Suva seismograph have been regularly forwarded to this Observatory for measurement. The Wood-Anderson seismograph belonging to this Observatory, and installed at the Magnetic Observatory, Christchurch, has continued recording throughout the year. The records have been forwarded regularly for measurement, and finally returned to the Magnetic Observatory. The following table gives the number of earthquakes recorded at various stations during the year 1932 :—

Station.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Suva	20	13	10	10	13	7	10	9	9	7	11	14	133
Arapuni	13	3	6	3	4	4	2	1	3	0	0	3	42
*Tuai	..	..	..	..	..	..	..	..	4	2	0	3	9
New Plymouth ..	4	1	9	10	20	7	5	9	61	13	10	11	160
Hastings	13	10	2	3	20	10	5	8	30	6	2	3	112
*Bunnythorpe ..	..	..	..	..	..	..	..	..	..	0	1	0	1
Takaka	4	1	5	5	4	2	1	3	3	1	0	1	30
Wellington ..	51	24	53	27	39	47	27	28	69	36	42	29	472
*Greymouth ..	..	..	..	..	..	..	..	..	..	..	0	0	0
†Christchurch ..	9	1	12	10	14	5	4	5	11	6	6	7	90
*Chatham Islands ..	..	..	..	..	..	..	..	1	0	0	0	4	5

* Seismograph recording for a portion of the year only. † From records of Wood-Anderson seismograph only.

Non-Instrumental Reports.

Officers of the Post and Telegraph Department and of the Marine Department, and private observers, have continued to furnish valuable reports of earthquakes as felt in various parts of New Zealand. The non-instrumental reports are always of great assistance in the determination of epicentres. The following summary includes all earthquakes reported felt in New Zealand in 1932 :—

Month.	Number of Earthquakes.			Reported felt.	Maximum Intensity (R.-F. Scale).	Locality of Maximum Intensity.
	North Island.	South Island.	Both Islands.	Total for New Zealand.		
1932.						
January	15	13	1	27	5	Napier.
February	9	2	0	11	5	Wairoa.
March	55	9	1	63	6–7	Coromandel.
April	7	15	0	22	6	Takaka.
May	15	3	1	17	8	Taradale.
June	12	1	0	13	7	Taradale.
July	5	5	1	9	8	Patea.
August	5	12	1	16	6	Hawera, Kahurangi.
September	88	1	1	88	9	Wairoa.
October	13	5	0	18	6	Wairoa.
November	16	2	0	18	5	Wanganui.
December	10	1	0	11	5	Wairoa, Waipawa.
Totals	250	70	6	313	9	Wairoa (September 16).

It will be seen that 313 earthquakes were felt in some part of New Zealand during the year 1932. The number felt in the North Island was over three times as great as the number felt in the South Island.

The following table gives the number of earthquakes in the year 1932, in which the maximum reached various degrees of the Rossi-Forel scale :—

Month.	Rossi-Forel Numbers.										Totals.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
1932.											
January	3	4	8	10	2	..	..	..	..	..	27
February	..	1	7	2	1	..	..	..	..	..	11
March	..	..	47	10	3	2	1	..	..	..	63
April	..	2	5	4	9	2	..	..	..	..	22
May	1	..	6	5	3	1	..	1	..	..	17
June	..	2	4	2	4	..	1	..	..	..	13
July	..	..	4	4	..	..	..	1	..	..	9
August	..	1	7	4	3	1	..	..	..	..	16
September	2	18	34	17	11	5	..	..	1	..	88
October	..	2	7	7	..	2	..	..	..	..	18
November	..	1	5	11	1	..	..	..	..	..	18
December	..	4	3	2	2	..	..	..	..	..	11
Totals	6	35	137	78	39	13	2	2	1	..	313

The maximum intensities (Rossi-Forel scale) experienced in each of the years from 1921 to 1932 (inclusive) was as follows: 1921, 8; 1922, 8; 1923, 6; 1924, 7; 1925, 8; 1926, 8; 1927, 8; 1928, 8; 1929, 10; 1930, 8; 1931, 10; 1932, 9.

Earthquakes in 1932.

The following is a list of all important New Zealand earthquakes during the year 1932. The summary includes (1) earthquakes of high intensity, (2) earthquakes felt over a wide area.

N.Z.M.T. of Shock.				Position of Epicentre.		Maximum Intensity as felt. (R.-F. Scale.)	Station or Locality reporting Maximum.
				South Latitude.	East Longitude.		
1932.	d.	h.	m.	°	°		
Jan.	3	15	13	40·5	175·3	5	Wanganui.
Mar.	3	9	55	42·3	172	6	Murchison.
	3	10	30	41·9	172	6	Murchison.
	5	13	12	36	179	6–7	Coromandel.
April	7	23	6	41·1	172·4	5–6	Takaka.
	8	3	9	39·9	175·7	5	Marton.
	17	21	14	41·8	171·9	5	Karamea, Reefton.
May	5	19	54	39·5	177·6	8	Taradale.
	5	23	1	39·6	177·6	5	Taradale.
June	8	8	53	38·2	177·8	5	Napier to Opotiki.
	16	1	24	40·4	174·5	5	Wanganui, Martin.
	18	2	8	39·6	176·6	7	Taradale.
July	20	16	22	40·0	174·0	8	Patea.
Aug.	3	1	17	40·7	173·5	6	Kahurangi Point.
	14	8	28	52	160	5	Stewart Island.
Sept.	11	5	18	38·3	178·4	6	Waipiro Bay.
	16	1	25	39·2	178·2	9	Wairoa.
	16	1	48	39·7	178·4	5	Motu.
	16	2	22	39·4	178·0	6	Opotiki
	29	7	44	39·7	178·8	6	Gisborne, Wairoa.
	30	22	49	38·9	177·9	5	Wairoa.
Oct.	31	9	29	39·7	176·7	5	Wairoa.
Dec.	11	2	23	39·7	176·7	5	Waipawa.
	17	4	39	39·5	177·5	5	Wairoa.

The East Coast Earthquake of 16th September, 1932.

The most important earthquake during the year 1932 was that which occurred in the Gisborne-Wairoa region on the 16th September at 1.25 a.m. N.Z.M.T. The shock was most severely felt at Gisborne and Wairoa and in the region lying between those towns. The intensity at Wairoa was slightly greater than R.-F. 9, and at Gisborne between R.-F. 8 and 9. Considerable damage was done to buildings in both towns. Fortunately there were no deaths as a result of this earthquake, although five persons received injury, one at Gisborne and four at Wairoa.

The earthquake was felt with decreasing intensity over the whole North Island, with the exception of the Auckland Peninsula. The most northern locality from which a report was received was Turua, a short distance from the mouth of the Thames River. The earthquake was not felt in Auckland. The most distant station at which the earthquake was felt was Blenheim, 270 miles south-west of the epicentre.

The epicentre, as determined from the records of the New Zealand seismological stations, was found to be situated a short distance off the coast, to eastward of Mahia Peninsula. The geographical position adopted was latitude, 39°·2 south; longitude, 178°·2 east. The resulting time at origin, as determined from the records of this Observatory was 1932, September, 16 d. 1 h. 24 m. 57 s., N.Z.M.T.

The main earthquake was followed by a series of after-shocks, which rapidly subsided in frequency and intensity. The approximate epicentres of the main shock and principal after-shocks are included in the map, together with other epicentres determined during the year 1932.

Publications.

The Observatory has continued to publish a preliminary earthquake report each month, giving sufficient data for the determination of the epicentres of the principle earthquakes. A preliminary seismological report from the Magnetic Observatory, Christchurch, has also been published, together with the report from this Observatory.

Besides the preliminary reports, the following complete seismological reports were published during the year 1932:—

E.–27—Seismological Reports for February, 1931.
E.–28—Seismological Report for March, 1931.
E.–29—Seismological Reports for April, May, June, 1931.
E.–30—Seismological Reports for July, August, September, 1931.

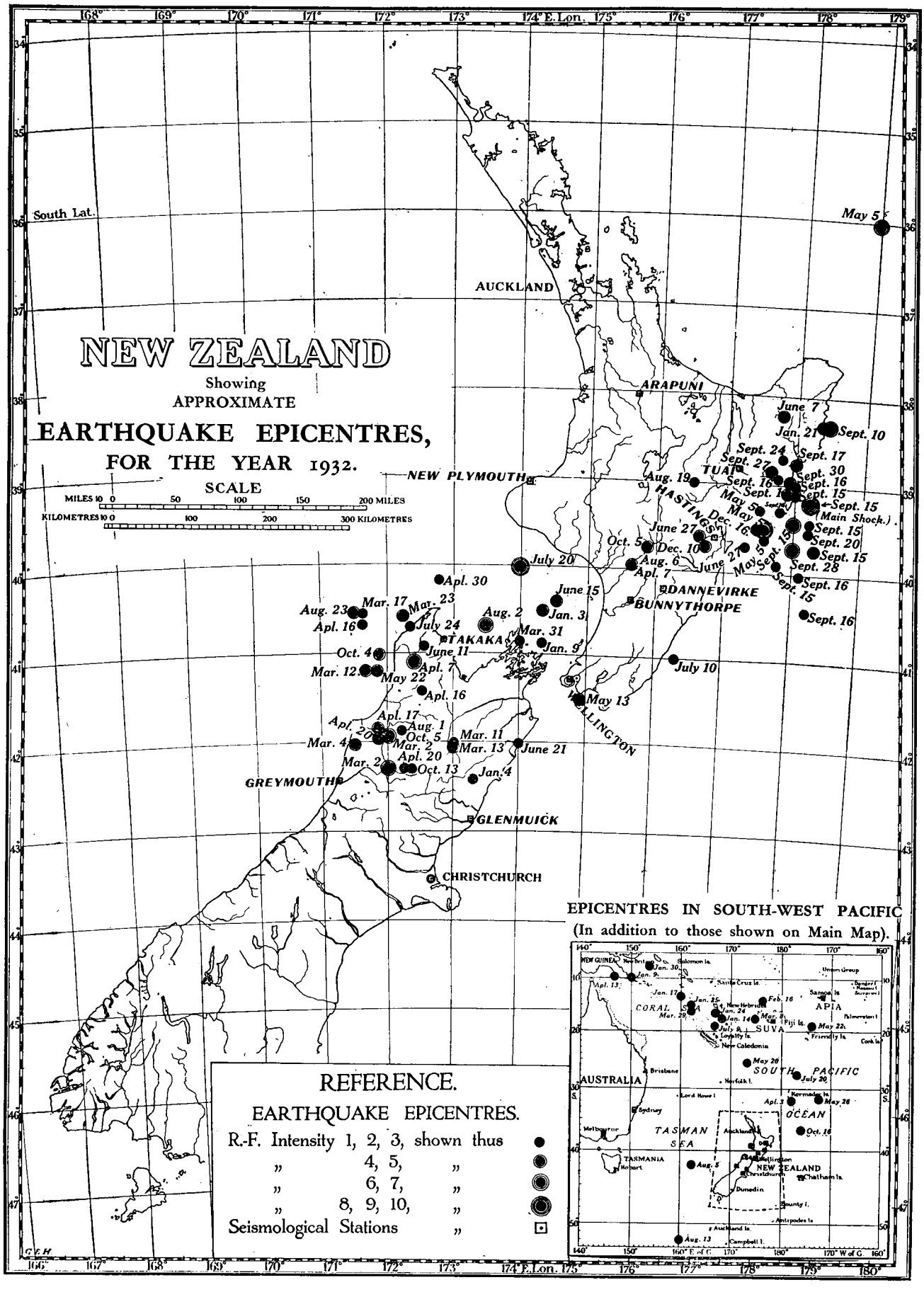
Also the following Bulletins:—

Bulletin No. 82—Report of the Dominion Astronomer and Seismologist for the Year ended 31st December, 1930.
Bulletin No. 83—Review: Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of all Integer Numbers up to 10,000.
Bulletin No. 84—Seismology in New Zealand.
Bulletin No. 85—Report of the Dominion Astronomer and Seismologist for the Year ended 31st December, 1931.

Staff.

The staff for 1932 was as follows: Mr. R. C. Hayes, Professional Assistant; Mr. I. L. Thomsen, Clerk. Occasional assistance has been given by Dr. M. A. F. Barnett in the work of the Observatory.

C. E. Adams,
Dominion Astronomer and Seismologist.



APIA OBSERVATORY, SAMOA.

Director: J. WADSWORTH, M.A. (Cantab.).

The programme of work in geophysical subjects was maintained during the year 1932–33 as in previous years.

TERRESTRIAL MAGNETISM.

Absolute measurements of the elements of the earth's magnetic field were made from time to time with the original Tesdorpf magnetometer and the Schulze earth inductor. Continuous records of declination and horizontal intensity were obtained by means of Eschenhagen variometers. There were no continuous records of the vertical intensity until a new Godhavn balance arrived in December, 1932. The Tesdorpf magnetometer was thoroughly overhauled in February, 1933, and the verniers were adjusted. An auxiliary reference-mark for the magnetometer was established on the wall of a small concrete-hut situated in the grounds of the Observatory.

Mean values of the magnetic elements for all days during the past three years are given in the table which follows :—

ANNUAL MEAN VALUES OF MAGNETIC ELEMENTS AT APIA.

—	1930 (Six Months).	1931.	1932.
Declination	E., 10° 34′·2	E., 10° 35′·2	E., 10° 36′·5
Horizontal intensity	35195 gamma	35171 gamma	35116 gamma.
Vertical intensity	20428 gamma	20434 gamma*	20460 gamma.*

* From absolute observations only.

SEISMOLOGY.

The seismographs are of Wiechert design. Both instruments have been overhauled during the year, the vertical seismograph in particular having been idle for some time owing to a defect in the driving-mechanism. A new time-marking unit was installed on the horizontal seismograph in November, 1932, which has much improved the registration.

The following analysis shows the character of the records of earthquakes obtained during the period 1st April, 1932, to 31st March, 1933 :—

The total number of shocks registered at the Observatory was 186. Of them, 3 originated at distances within 1° of Apia, 136 between 1° and 9°, 11 between 9° and 45°, and 5 at distances beyond 45°. The distances of origin of the remaining 31 shocks were indeterminate. The intensity of 23 of the recorded shocks was sufficiently great to be perceptible to ordinary residents in Samoa.

The epicentres of the more prominent earthquakes during the year are distributed as follows: Central America, 3; New Zealand, 3; Samoa, 2; Dutch East Indies, 1; Fiji Islands, 1; and Japan, 1.

METEOROLOGY.

The work in meteorology included surface observations twice a day, as in previous years, and some measurements of upper winds from time to time using pilot balloons. The tail method was generally used with the pilot balloons, but frequently, owing to unsuitable elevation of the balloon in light winds or bad visibility of the tail, the computation had to be performed assuming a constant rate of ascent.

A daily report of weather in the South Pacific has been displayed at the Post Office and customs-house since May, 1932, at the request of local traders.

New meteorological instruments brought into use during the year are as follows: An aspirator bottle providing a constant supply of slowly dripping water to the wet-bulb thermometer; a Snowdon type rain-gauge (Meteorological Office, London, pattern) as a check on the older German gauge; two Stevenson screens of standard pattern devoid of the auxiliary protection once considered to be essential in the tropics; a new hygrograph replacing the old one, which was worn out; a Gendle balance for filling pilot balloons; a Fineman nephoscope from the Meteorological Office, Wellington, for which a permanent wooden pillar was erected; a new Fortin barometer (by Casella), which arrived in November, 1932.

The number of local rainfall stations increased to about fourteen during the year. The value assumed for the height of the barometer cistern at Niue Island was found to be in error, and fresh measurements made in September, 1932, gave 65 ft. One of these measurements is due to the courtesy of the Commander of the "Maui Pomare." During the visit of H.M.S. "Laburnum" to the Tokelau Islands in July, 1932, the Officer Commanding kindly arranged an inspection of the meteorological instruments there. The afternoon reports from Tonga failed temporarily during the wet season, but were resumed in January. A tree fell on the Stevenson screen at Nassau Island and broke the thermometer and the thermograph.

Several cyclones occurred in the South Pacific during the wet season, and warnings were issued from Apia in January, February, and March, 1933.

Preliminary mean values of meteorological elements for the year 1932 are as follows:—

Month.	Pressure.	Temperature.	Rainfall.	Humidity.	Sunshine.	Wind.
	In.	°F.	In.	Per Cent. (9 a.m.)	Hours.	Miles per Hour.
January	29·743	79·8	21·34	82	157·5	3·4
February	29·780	79·8	13·70	78	193·1	3·7
March	29·783	79·7	14·20	77	210·6	3·4
April	29·770	79·2	12·81	83	158·8	2·7
May	29·856	80·6	3·80	76	251·1	4·2
June	29·867	78·3	1·31	76	239·1	2·3
July	29·836	79·2	2·42	76	247·7	3·4
August	29·880	78·8	5·99	77	254·4	3·4
September	29·865	78·6	6·27	74	231·1	3·5
October	29·857	79·7	6·77	73	248·1	4·6
November	29·800	79·6	20·09	79	191·6	3·0
December	29·756	80·2	15·24	79	215·8	2·8
Total ..	..	..	123·9	..	2,598·9	..
Mean ..	29·82	79·5	..	77	..	3·4

Atmospheric Electricity.

A continuous record of the potential of the air was made as in previous years by means of Benndorf self-recording electrometers at two stations—one in the lagoon and the other in the grounds of the Observatory. Owing to flooded ground at high tide it became necessary to raise the floor inside the hut at the land station. At the same time, owing to an invasion of ants, the electrometer had to be moved to a new concrete pillar erected for the purpose in the middle of the hut, where the insects could be better kept in check. The eaves of the Lagoon Hut were repaired and slight improvements were carried out at the platform in the lagoon, which is used for absolute determinations.

Time Service.

The standard clock by Strasser and Rohde continued to operate satisfactorily. Its indications were controlled from time to time by wireless signals from Annapolis, U.S.A., and by a few transit observations of the sun. A new Synchronome clock arrived in November, 1932, to replace the old clock, which had been used in the past for sending time signals to the seismographs and magnetic instruments. The installation of the new clock was completed in February, 1933.

Tides.

The tide gauge was in operation at the Lagoon Station throughout the year. Tabulations of its records were sent month by month to the Coast and Geodetic Survey at Washington, D.C., U.S.A.

Personnel, Building, and Equipment.

Mr. Wadsworth visited Niue Island and New Zealand during August and September, 1932. Two members of the clerical staff engaged locally—namely R. Lafitaga and F. N. Siaosi—left the Observatory at the end of February, 1933, to take up other work elsewhere. Their places were filled by Siaosi Sumeo and Sene Ne'emia, from Avele School.

A new covering of Malthoid cloth was put on the roof of the Gauss House, which had begun to leak. This was done in December, 1932, before installing the new Godhavn balance.

A card-index was completed in the course of the year for the library; and the manuscript of the annual report for 1931 was sent to the printer in December, 1932.

Grateful acknowledgment is due to the British Admiralty, the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and the Rockefeller Foundation of New York for very generous and substantial grants made during the year.

CHRISTCHURCH MAGNETIC OBSERVATORY.

REPORT BY THE DIRECTOR.

During the years 1931 and 1932 continuous recordings of the magnetic declination, the magnetic horizontal force, and the magnetic vertical force have been made as usual at the Amberley Substation on the set of Eschenhagen magnetographs. In addition, records of the magnetic declination and magnetic horizontal force have been obtained by the set of Adie magnetographs at Christchurch.

The mean hourly values for the years 1931 and 1932 have been measured and reduced, and the tabulations of these for these years are completed, and the typing for reproduction is just being finished.

The resulting mean annual values for Amberley (latitude 43° 10′ S., longitude 11 h. 30·9 m. E.) are for all days :—

——	D.	H.	Y.	X.	Z.
1931.. ..	17° 54′·4 E.	·22360	·06875	·21276	·55236
1932.. ..	17° 57′·3 E.	·22347	·06889	·21259	·55227

It is noteworthy that the unusually large annual change of mean yearly value in declination, experienced from 1924 to 1930 (during which time it was of the order of + 5′ to + 6′ every year), has since 1930 returned to the normal of about + 3′. From 1930 to 1931 it was + 3′·4, and from 1931–32 it has been only + 2′·9.

It is quite possible, in view of recent investigations by H. W. Fisk and others, that the diminution of this secular change in magnetic declination is not unconnected with release of strain in these regions by the major earthquake occurrences experienced in New Zealand from 1929 to 1931. It is also noteworthy that the usual annual $-\Delta$ H, which had been small from 1925–30, was in 1930 to 1931 replaced by a small $+\Delta$ H of 9γ, while from 1931 to 1932 the change was in the normal direction (-13γ).

In July–August, 1932, an underground chamber was constructed (under the superintendence of the Public Works Department) at the Amberley Substation to house a set of La Cour quick-speed magnetographs lent by the Polar Year Committee, and then on the way to New Zealand. Construction was much hampered by heavy rains, but these recorders were installed on arrival, and have been recording since the middle of September, 1932. Many valuable records of disturbances have been secured.

During the year 1932 246 pilot-balloon ascents were observed and reduced and made available for use.

The usual programme of meteorological and seismological observations has been continued. The seismological observations have been used in determining epicentres of local earthquakes, and are being put in tabular form for publication.

Magnetic Survey.

Recent investigations have demonstrated the necessity of the periodical reoccupation of a sufficient number of magnetic survey stations to obtain a knowledge of the variations of secular change over the area surveyed. This is a part of the geo-physics of a country that can not be long neglected if the country is to do its share in adding to world-knowledge. It is also a necessity for the revision of charts for navigational purposes. For this purpose a second absolute magnetometer and inclinometer are urgently needed by this observatory.

Henry F. Skey, Director.

Approximate Cost of Paper.—Preparation, not given; printing (910 copies, including maps and graphs), £132.

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Price 2s. 6d.]