

SESSION II.
1912.
NEW ZEALAND.

NEW ZEALAND GEOLOGICAL SURVEY
(SIXTH ANNUAL REPORT (NEW SERIES) OF THE).

Presented to both Houses of the General Assembly by Command of His Excellency.

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M A P .

Southern part of Ngakawau watershed At end.

REPORT.

LETTER OF TRANSMITTAL.

SIR,— Mines Department, Geological Survey Branch, Wellington, 16th July, 1912.

I have the honour to forward herewith the annual report of the Geological Survey Branch of the Mines Department for the twelve months ending 31st May, 1912.

I have, &c.,

P. G. MORGAN,

Director, Geological Survey.

The Hon. W. Fraser, Minister of Mines, Wellington.

INTRODUCTION.

THE present annual report, the sixth since the reorganization of the Geological Survey in 1905, deals with the twelve months from 1st June, 1911, to 31st May, 1912. During this period the work of the Survey has been in general conducted on the same lines as in former years.

STAFF.

In August, 1911, the staff was increased by the appointment of Mr. J. A. Bartrum, M.Sc., as Assistant Geologist. In May of this year Mr. J. C. M. Nutt, Geological cadet, was, at his own request, transferred to the Education Department. The *personnel* of the staff is therefore now as follows: Percy Gates Morgan, M.A., Director; John Henderson, M.A., D.Sc., Mining Geologist; James Allan Thomson, M.A., D.Sc., Palæontologist; John Arthur Bartrum, M.Sc., Assistant Geologist; George Edward Harris, Draughtsman; Henry Saxon Whitehorn, Assistant Topographer.

SUMMARY OF OPERATIONS.

During the twelve months ending 31st May, 1912, detailed field-work was under way in the Buller-Mokihinui and Aroha Subdivisions.

In the Buller-Mokihinui Subdivision field-work was conducted by the Director, with the assistance of Mr. H. S. Whitehorn as topographer. Owing to various reasons, such as the Director's frequent employment in other work, the difficulty of gaining access to the Mackley and Blackburn Valleys, and exceptionally bad weather, the survey of the subdivision could not be completed. It has been found necessary, for the sake of completeness, to add considerably to the area originally intended to be surveyed, and therefore the completion of the survey will occupy the greater part of another field season.

The survey of the Aroha Subdivision was intrusted to Dr. Henderson, with Mr. J. A. Bartrum as Assistant Geologist. Notwithstanding much bad weather, and the loss of a camp and effects by fire, the survey of the whole subdivision, together with an additional area to the south, was completed.

Dr. Allan Thomson, Palæontologist, immediately after joining the Survey, commenced work on the fossils collected by the old Geological Survey under Sir James Hector. Dr. Thomson has devoted himself mainly to those portions of the collections which come from late Cretaceous and Tertiary strata. Selections from the Palæozoic and Mesozoic fossils have been forwarded to various specialists who have kindly volunteered assistance in the work of description.

In order to furnish reports needed by the Mines Department, a number of short visits were made by the Director and other members of the staff to mining districts in various parts of New Zealand.

PUBLICATIONS.

During the past year two bulletins, Nos. 12 and 13 (New Series), and the fifth annual report have been issued.

Bulletin No. 12, entitled "The Geology of the Dun Mountain Subdivision, Nelson," was written by Dr. J. M. Bell, Mr. E. de C. Clarke, and Professor Marshall. After giving a general account of the geology of the district, the bulletin deals exhaustively with the copper, chromite, and other mineral resources. Another feature of the bulletin is the description of the ultra-basic igneous rocks of the area, one of which, named "rodingite" by the authors, is new to science.

Bulletin No. 13, "The Geology of the Greymouth Subdivision, North Westland," written by myself, describes an important mineral district, containing large deposits of coal and of alluvial gold. In addition, the area described includes the Kotuku Oilfield, concerning which all information available at the time of writing is given.

A bulletin (No. 14) by Mr. E. de C. Clarke, entitled "The Geology of the New Plymouth Subdivision, Taranaki," is now ready for distribution. It describes the New Plymouth Oilfield, and contains an account of the well-known Taranaki ironsand. Bulletin No. 15, "The Geology of the Waihi-Tairua Subdivision, Hauraki," written by Dr. J. M. Bell and Mr. C. Fraser, is in the press, and will shortly be published.

Dr. Allan Thomson has prepared a palæontological bulletin entitled "Materials for the Palæontology of New Zealand," which has been forwarded to the printer. Mr. Henry Suter has furnished a report entitled "A Revision of Captain F. W. Hutton's 'Catalogue of the Tertiary Mollusca of New Zealand, 1873,'" and this it is hoped to publish at an early date.

A manuscript index to the reports of the old Geological Survey (Vols. 1 to 22) has been prepared by Dr. Henderson. This it is proposed to publish as soon as a revision now under way can be completed.

LIBRARY.

A few books have been added by purchase to the library during the year. The usual journals and exchanges, many of a most valuable character, have been received.

FIELD-WORK IN THE BULLER-MOKIHINUI SUBDIVISION.

INTRODUCTION.

During the past year topographical work in the Buller-Mokihinui Subdivision was conducted from the middle of August, 1911, until the beginning of June, 1912. The country mapped was chiefly in the watersheds of the Blackburn River and St. Patrick's Stream (tributaries of the Ngakawau River) and in the valley of the Mackley or Orikaka River, a little-explored tributary of the Buller. Geological work began in October, and, with various interruptions, continued until the middle of May. It was spread over a much greater area than the topographical survey, the work done extending over a belt of country north of the Mokihinui River to Mount Rochfort, south of Denniston. The greater part of the area topographically surveyed was also examined.

GENERAL GEOLOGY.

A brief sketch of the general geology of the district was given in the last annual report. To this little need be added on the present occasion. Mention of a quartz-porphyry which occurs near Coalbrookdale, in Mount William Creek, and elsewhere, must be made. This rock intrudes argillites and grauwackes of possible Ordovician age, and is certainly antecedent to the coal-measures; but otherwise there is little to indicate its age. Possibly it may be contemporaneous, or nearly so, with the granitic intrusions of the district. The rock is distinguished by an abundance of quartz phenocrysts and of angular inclusions of altered argillite and grauwacke, which in places are so numerous as to give the rock the appearance of a breccia.

Some interesting data concerning faulting and tilting of the coal-measure strata in the Buller-Mokihinui Subdivision have been obtained, but presentation of these is deferred until a detailed report is written.

ECONOMIC GEOLOGY.

The main object in view throughout the season was the collection of data bearing on the chief mineral asset of the Westport district—its coal-resources. Alluvial gold has been found in many places. Quartz lodes, some of which carry gold, occur in various localities. Stream-tin has been reported from the Mackley Valley, but none was found by the Geological Survey party. The mineral doubtless occurs only in limited amount. Barite is found near Coalbrookdale in the quartz-porphyry mentioned above, but in such small quantity as to be of no economic value. The same mineral is reported as occurring in a small vein that penetrates coal-measure grits on the Westport-Stockton Company's ground.* The remarks which follow will be placed under the headings of (1) coal, (2) alluvial gold, and (3) auriferous-quartz lodes.

(1.) *Coal.*

The resurvey of the coal-bearing country explored by Cox and Denniston is incomplete, but has shown the general correctness of their results. It has to be stated, however, that exploratory work by the Westport-Stockton Company has shown that an area within their lease considered barren by Cox and Denniston is in great part coal-bearing. On the other hand, workable coal appears to be absent from a considerable area mapped as coal-bearing north-east of Millerton, although the coal-horizon is present.

The results of exploration of the country to the eastward of that already well known to be coal-bearing have not been altogether satisfactory. They will be stated under two heads—(a) Upper Blackburn and adjoining district, (b) Mackley or Orikaka district.

(a.) *Upper Blackburn and Adjoining District.*—The Blackburn, as shown by the accompanying map, is a tributary of the Upper Ngakawau, which has its sources on the north side of the low irregular ridge separating the Upper Ngakawau from the Mackley or Orikaka River. The Blackburn flows at first east, and then northward, till it joins the Ngakawau some six miles (in a straight line) from the mouth of the latter stream.

In the reports of Cox and Denniston the upper portion of the Blackburn is called the Tio,† and is erroneously stated to flow into the Orikaka. Hence their remarks under the heading of "Tio or Orikaka" refer to the Upper Blackburn, and not to the Mackley watershed. The error was probably discovered by Mr. W. M. Cooper, the surveyor to whom we owe an excellent topographical map of the greater part of the Buller Coalfield, for his pegs have been found some distance down the Blackburn, but was never publicly corrected.

* Information from Mr. Frank Reed, Inspecting Engineer, Mines Department.
originally been T 10, the number of one of W. M. Cooper's trigonometrical stations.

† The name may have

Coal outcrops in many places near the head of the Blackburn, and towards the western margin of a large flat “pakihi,” conveniently called the Blackburn Pakihi, through which that stream runs for some distance. The principal outcrops belong to one seam, which has a thickness of from at least 8 ft. to 25 ft., and possibly 40 ft., or even more. The coal, though in places friable, is everywhere clean and of good quality, as is shown by the following analyses, which, it should be noted, represent somewhat weathered coal, containing more moisture than will be found in coal from a solid face :—

	(1.)	(2.)
	Per Cent.	Per Cent.
Fixed carbon	56.99	53.05
Volatile hydrocarbon	36.77	40.50
Water	5.72	3.13
Ash	0.52	3.32
	100.00	100.00
Total sulphur	0.91	2.45

No. 2 cokes, whilst No. 1 is non-coking coal. Both burn to a dark-brown ash. No. 1, which is from a coal “island” at the north-west corner of the Blackburn Pakihi, represents 25 ft. of perfectly clean coal, whilst No. 2 is from a spot some distance to the eastward.

In general the coal dips to the north of east, and consequently it disappears under cover in that direction. A considerable area of the Upper Ngakawau watershed may therefore be expected to contain coal; but the notoriously inconstant nature of the Buller coal-seams renders it necessary that the area should be thoroughly proved by boring before positive statements can be made. Another reason for proceeding with great caution is furnished by the fact that both to the north and the south the coal-measures are found to rest upon ancient rocks without exposing coal. Eastward the coal-measures terminate against the great fault that forms the western side of the Mount Glasgow Range. Hence the Blackburn coal lies in a basin, the coal-bearing portion of which may be comparatively small.

West of the Blackburn Pakihi, and principally in the watershed of Erin Creek, is a series of ridges capped in places, but not continuously, by coal-measures. In all, three coal-seams are exposed, but only one of these was ever of workable thickness over any large area. This seam is doubtless the same as that seen outcropping on the Blackburn Pakihi, and is of similar quality. The following analysis represents a sample from the headwaters of Erin Creek :—

	Per Cent.
Fixed carbon	51.24
Volatile hydrocarbons	40.89
Water	4.82
Ash	3.05
	100.00
Total sulphur	4.62

The sample cokes, but does not swell. It burns to a dark-grey ash.

Unfortunately, the extent to which denudation has proceeded makes it practically impossible to work any of the remnants of coal remaining in the Erin Creek watershed.

(b.) *Mackley or Orikaka District.*—For many years persistent reports have been circulated to the effect that in the Mackley Valley there was a large and valuable coalfield. These reports probably originated in the first place through the error made by Cox and Denniston regarding the drainage of the Upper Blackburn district, but from time to time were strengthened by the discovery of various outcrops of coal in the real Mackley watershed. As yet the lower four miles of the Mackley River and the Pensini Creek have not been examined, but the detailed survey of the upper and middle portions of the Mackley Valley shows conclusively that the greater part of the coal once present has been removed by denudation, with the result that coal is now seen only in a few small isolated areas. It is therefore quite certain that the greater part of the Mackley Valley is of no commercial value as a coalfield. When the survey of the area near the Buller is made, possibly more satisfactory data may be obtained.

(2.) *Alluvial Gold.*

Alluvial gold has been obtained at many places within the Buller-Mokihinui Subdivision. Some of these were mentioned in the last annual report. A large amount of gold has been won from the Fairdown terraces, near Westport, but these were not examined during the past season, and therefore no account of them can at present be given. Old workings, none of great extent, were observed near Coalbrookdale, at the head of the Whareatea River; near Kiwi Compressor, and on the saddle at the head of Cedar Creek. The gold at all these places has been derived from argillites and grauwackes of the Greenland or Aorere Series. There is no possibility of alluvial gold being found in quantity in the area examined, but small patches of a few ounces may be discovered at any spot on or near exposures of the Greenland rocks.

(3.) *Auriferous-quartz Veins.*

Quartz veins are numerous in the argillites and grauwackes (“slates”) of the Greenland Series, but none hitherto discovered has been remarkable for its gold-content. The only quartz-mine at work in the Buller-Mokihinui Subdivision is the Britannia Mine, in Stony Creek, near Waimangaroa. This was not examined last season. The Banbury Mine, near Denniston, was worked many years ago for a short time. Veins in Todea or Cascade Creek were also worked a few years ago, without any real success.

REPORTS OF FIELD OFFICERS.

DR. J. HENDERSON, MINING GEOLOGIST.

Dr. Henderson, Mining Geologist, submits the following report on his work during the last twelve months :—

INTRODUCTION.

During the months of June and July, and also during part of August, 1911, I was engaged in the preparation of an index to the Geological Survey Reports (Old Series). Since leaving Wellington in August, field-work in the Aroha Subdivision engaged the whole of my attention until the end of May, 1912. In this work I had associated with me Mr. J. A. Bartrum, Assistant Geologist. Before my arrival in the field Mr. K. M. Graham, late of this Department, had completed a topographical survey of the Waitawheta River and its branches, and also of the Waiorongomai and several of the less-important streams near Te Aroha.

COUNTRY EXAMINED.

The area which constitutes the Aroha Subdivision of the Hauraki Division, comprises the Survey Districts of Waitoa, Aroha, Katikati North, Katikati, Matakana, Wairere, Aongatete, and Tauranga, and contains in all 672.6 square miles. Of this area 422.3 square miles are of low relief, and the whole country is readily accessible by numerous roads, tracks, and tramways.

PHYSIOGRAPHY.

The chief physiographical feature of the area under review is the southern continuation of the Cape Colville Range, which here runs in general in a N.N.W.—S.S.E. direction. The general appearance and structure of this range is most reasonably explained by considering it a block mountain-range separated from the lowlands on either side by powerful fault-complexes. The range is comparatively rugged and broken. The highest point in the subdivision—and, indeed, of the whole range—is Mount Te Aroha (3,126 ft.). North of this, within the subdivision, the most prominent peak, Karangahake Mountain (1,785 ft.), is conspicuous rather from its isolation than from its height. Connected with Te Aroha Mountain by the saddle between the Mangakino and Waiorongomai Streams is a large block of high country (about 2,700 ft.), in which the Waitawheta, Tuapiro, and Wharawhara have their sources. South of this, the range drops and narrows to a single ridge, but rises suddenly again in Ngatamahinerua (2,749 ft.). An approximation to this height is maintained for three miles, when a drop to the Whakamarama Plateau of half this height occurs. This plateau rises gradually to a height of 2,527 ft. in Te Weraiti, beyond the southern limits of the subdivision.

It would seem that the Whakamarama Plateau was, during elevation, tilted towards the east. The bulk of its drainage is in that direction. The Wairoa, Te Puna, Waipapa, Wainui, and Whatakao flow in relatively straight V-shaped valleys to Tauranga Harbour; while the Waiteariki and Wairere, branching streams, after short winding courses on the plateau, plunge over the western scarp by great falls (Waiteariki, 260 ft.; Wairere, 450 ft.), to continue their brief tempestuous way to the Hauraki Plains. North of the Whakamarama Plateau the tilt of the elevated region still seems to be eastward, though the western fault-scarp is more deeply incised, and the streams draining westward partake more of the nature of ordinary mountain torrents than do the Wairere and Waiteariki. Northward of the Wharawhara the character of the range changes; it ceases to consist of a single ridge with diverging streams. The great longitudinal valley of the Waitawheta and the smaller one of the Mangakino divide the range into parallel watersheds, which, dropping northward, diverge on either side of the Waihi Plain.

This hill-encircled plain presents some unusual features, of which the most reasonable explanation appears to be that the tilt to the E. and S.E., general over the whole of the Hauraki Division, has forced the antecedent Ohinemuri and Waitawheta Rivers to cut deep cañons along their lower courses.

The Katikati lowlands, to the east of the Cape Colville Range, attain a width of about five miles at Tauranga. They taper out towards the north at Waihi Beach, while three miles east of Tauranga rhyolitic hills reach the sea. These lowlands rise gradually from sea-level to a height of 1,000 ft. on the hill-border.

The Hauraki or Piako Plains to the west of the range occupy a well-marked *graben* ten miles in width. This great depression stretches far beyond the northern and southern limits of the subdivision.

GENERAL GEOLOGY.

The oldest rocks in the area under consideration are argillites and grauwackes, which form the western boundary of the Hauraki Plains. These rocks are of doubtful age, but are certainly not younger than the Jurassic. They are overlain, with great unconformity, by volcanic rocks of the Second Period (Beeson's Island Group).

The oldest rocks of the Cape Colville Range, as developed within the subdivision, are dacitic and andesitic volcanics occurring on the western flank of the range from Karangahake to Te Aroha. These are the rocks of the First Period of Fraser.

Overlying these unconformably is a great series of flow and fragmental rocks of andesitic facies. They form the bulk of the range in the subdivision, and are the volcanic rocks of the Second Period.

Rhyolitic rocks, or rocks of the Third Period, occur on the eastern flank of the range as isolated exposures at Hikurangi Mountain and Minden Peak. The edge of the great rhyolite plateau (which stretches as far as Rotorua) reaches the south-eastern corner of Tauranga Survey District, and its former greater extension is shown by the isolated fragments Maunganui and Te Karewa.

Rhyolitic tuffs, mudstones, &c., with occasional beds of poor lignite, form the Katikati lowlands. These beds are probably of Pleistocene age.

Towards Tauranga they are overlain by pumiceous deposits of somewhat later age. It is tempting to correlate these beds with the pumiceous sands, &c., of the Piako Plains.

ECONOMIC GEOLOGY.

The metalliferous deposits of the area are chiefly restricted to gold-silver quartz veins. These occur mainly in the flow and fragmental rocks of the First Period. The rocks enclosing the veins are always more or less altered from their original condition. This propylitic facies seems to have accompanied or perhaps preceded the formation of the original ore-deposits. In the detailed report now being written an effort will be made to show that such deposits as have economic value have been formed by the action of circulating meteoric waters upon lean primary deposits, and, further, that the distribution of the deposits of economic value is chiefly dependent upon the existing topography.

The veins occur in four groups:—

- (1.) Karangahake Group.
- (2.) Te Aroha Group.
- (3.) Owaharoa Group.
- (4.) Waitakohe Group.

The Karangahake area carries veins with a meridional strike and westward dip. They vary up to 16 ft. in width, and in general it may be said that the wider portions of the veins carry the higher values. The lodes of this area have been mined for many years, and some of them are still being successfully worked. In the Talisman Mine occurs a bonanza of sulphide ore that presents several features of great interest.

The Te Aroha area is traversed from end to end by a great siliceous lode, which varies up to 150 ft. in width. The strike of this "buck reef" is north and south, and the dip in general to the westward. Numerous lodes with a north-east-south-west strike and westerly dip cross this zone. It is these that carry the values. Another silicified zone striking N.E.-S.W. occurs on the western side of Te Aroha Mountain. It is crossed by siliceous lead and zinc lodes, which, however, are but an extreme phase of the ordinary gold-silver lode of the Hauraki Goldfields. Some of these lodes have been worked to a limited extent.

The lodes of the Owaharoa area are almost all without the limits of the Aroha Subdivision. They are fully treated of in Bulletin No. 15.

In the valley of the Waitakohe occurs a small area of propylitized and silicified volcanics of the Second Period. The values seem to be confined to a narrow shear-zone, and, so far, nothing of economic value has been found.

DR. J. ALLAN THOMSON, PALÆONTOLOGIST.

Dr. J. Allan Thomson, Palæontologist, reports as follows:—

Since my appointment on the 1st June, 1911, I have been almost continuously occupied with examination of the fossil collections. From the 5th February to the 29th March I was absent in the South Island, visiting the chief localities for Cretaceous fossils, reporting on a coal-indication at Cherwell Flats, Marlborough, and examining the fossil collections in the Otago and Canterbury Museums. I report as follows on my work during the period under review:—

OFFICE AND LABORATORY WORK.

Before attempting to determine and describe any parts of the fossil collections accumulated in Wellington it was necessary to gain an adequate idea of the nature and condition of the collection, the previous palæontological work that has to be taken into account, and the state of our stratigraphical knowledge of the localities from which the fossils were collected. This is necessary, because no single man could describe the whole of the collections in a lifetime, and it is desirable that the palæontological work attempted should have an immediate bearing on the broad questions of the geological history of New Zealand and on the economic problems which the Survey is constituted to solve.

This task, along with a considerable correspondence with palæontologists outside of New Zealand, occupied nearly the whole of my time until I left for the South Island in February. The results of this "spade-work" have been partly embodied in a bulletin now in the press, entitled "Materials for the Palæontology of New Zealand." The more important points may be briefly summarized here.

NATURE OF THE FOSSIL COLLECTIONS.

The collections now in the possession of the Geological Survey may be divided into three categories—(1) The type and show collections; (2) undescribed collections of the old Survey; (3) partly determined collections of the reorganized Survey.

(1.) *The Type and Show Collection.*—This includes the type specimens founded by Hutton, Hector, Tenison-Woods, T. W. Kirk, and J. W. Davis. Most of these specimens are exhibited in the show-cases of the Dominion Museum, but the conditions of mounting and labelling are far from satisfactory. Many of Hector's types are missing, but may yet be found packed away with the undescribed collections. The work of mounting and labelling these specimens is being carried on as fast as circumstances will allow. Mr. A. Hamilton, the Director of the Museum, has kindly put the services of the Museum printer at my disposal, so that permanent printed labels are being affixed to each specimen.

The accommodation in the Museum for the type collections is ample at present, but will be insufficient in a few years, as the type collections grow. As only a small proportion of the fossil species already known in New Zealand is represented by type specimens in the Survey collection, it will be necessary, for purposes of comparison, to add to the show collection good examples of the other species. I feel it my duty to urge that while plans for the rebuilding of the Museum are under consideration, better accommodation for the geological collections should be provided, and the permanent disposition of the type collections should be decided on.

(2.) *The Undescribed Collections of the Old Survey.*—This constitutes the bulk of the collections, and comprises over 120,000 specimens from 847 localities. Each specimen bears a locality-number, corresponding to an entry in a manuscript register. The fossils are wrapped in paper, and packed away in numbered boxes of uniform size, there being 463 of these boxes stored in limited space in the back rooms and passages of the Museum. It will be readily understood that the handling of the fossils from any given locality is a matter requiring much time and labour. Increased accommodation for these boxes, with slots to take each box separately, is very urgently required.

(3.) *The Collections made under the Reorganized Survey.*—These are also packed away in boxes, not uniform in size or numbered, and with no register, and stored in a small shed in the Museum grounds. Each specimen is wrapped in paper, with a locality-label on paper along with it. The total number of specimens is not large.

RELATION OF THE FOSSIL COLLECTIONS TO NEW ZEALAND STRATIGRAPHY.

The history of the New Zealand stratigraphy for the last forty years is the history of controversies between the leading exponents of New Zealand geology. Very many important questions are still unsettled, and must remain so until combined palæontological and stratigraphical researches are carried out in critical areas. In the description of the fossil collections it is therefore desirable to work under some definite plan by which the data for settling these points may be most speedily made available. The chief questions at issue are :—

- (1.) Are Carboniferous fossils present in the Wairoa Gorge, Nelson, as affirmed by Hector, McKay, and Park, and denied by Bell, Marshall, and Clarke ?
- (2.) Is there a sequence of formations and faunas from the Permian to the Jurassic, as affirmed by Hector, McKay, and Park ; or an indivisible Trias-Jura formation, as affirmed by Bell, Marshall, and Clarke ?
- (3.) Is there a conformable sequence from Cretaceous to Tertiary, as affirmed by Hector, McKay, Marshall, Speight, and Cotton ; or are there distinct Cretaceous and Tertiary systems, as affirmed by Hutton and Park ?
- (4.) Do the Cretaceous and succeeding rocks form one rock-series, as affirmed by Marshall, Speight, and Cotton ; or are they divisible into several systems, as affirmed by Hochstetter, Haast, Hector, Hutton, McKay, and Park ?

The last two questions, involving as they do the stratigraphy of the coalfields, are the most important from an economic point of view. After consultation with the Director, I decided to commence detailed work with the fossils of Amuri Bluff and the Waipara-Weka Pass district, where a succession of faunas is clear and undisputed. It is proposed to describe each fauna in the succession in detail, and to discuss the stratigraphical evidence in this district. Later, if necessary, other similar successions, such as those of the South Canterbury rivers, the Oamaru district, and the Kaipara district, can be similarly described, so that any faunal or stratigraphical gaps in the Waipara succession may be detected and filled up.

FIELD-WORK IN EAST MARLBOROUGH AND NORTH CANTERBURY.

A flying visit, in which Mr. C. A. Cotton, of Victoria College, accompanied me, was paid to the principal fossil localities of East Marlborough and North Canterbury, in order to decide upon the possibilities of zoning and correlating the Cretaceous and Tertiary rocks, and incidentally to collect further material.

General Account of the Succession.

The succession of the rocks in question in this area is not in dispute, although the presence or absence of unconformities has always been a matter of controversy. Certain correlations on lithological grounds have been always made without challenge, and appear to be perfectly justified. Over practically the whole area where these younger rocks occur in this part of the Island a white chalky limestone, known as the Amuri limestone, occupies a prominent place in the succession. The underlying rocks are, speaking generally, a middle series of sulphur-mudstones and glauconitic sands, with concretions bearing saurians in some localities, and a basal series of conglomerates and grits which are frequently fossiliferous. The principal variation from this type of deposition is found in the Coverham section of the Clarence Valley, where the lower part of the Amuri limestone is replaced by lenticular flint-beds, while the Saurian greensands are represented by a great thickness of black mudstones with calcareous concretions. In the Waipara district the Amuri limestone of typical facies is overlain by a glauconitic limestone known as the Weka Pass stone, but in its upper parts this rock again approaches the facies of the normal Amuri limestone. In the other localities a marked division of the limestone member cannot so easily be made, although glauconitic partings occur at more than one horizon at Amuri Bluff. The Amuri limestone, or Weka Pass stone, is overlain by the grey mudstones, known as the Grey Marls. North of the Conway River no higher beds are present in direct succession, but in the Waipara district there follow two series of sands with rubbly limestones and shelly conglomerates, known respectively as the Mount Brown beds and the Motunau or Greta beds.

The collections available for working out the succession of faunas in these rocks are very complete as regards the lower members, but contain little material from the beds above the Saurian beds. In part this corresponds to an actual paucity of fossils in the rocks themselves. The Amuri limestone has yielded at Amuri Bluff a few molluscs, elsewhere only *Foraminifera*. The Weka Pass stone is very poor in fossils, and so are the Grey Marls. On the other hand, the Mount Brown and the Motunau beds are locally very rich in shell-beds, but the existing collections do not represent this richness. It is in large measure due to the faunal gap between the Saurian beds and the Mount Brown beds that the difference of opinion as to the relations of the Cretaceous to the Tertiary has arisen, for it leaves a large range of rock-junctions available for the interposition of an unconformity.

Fresh Discoveries.

While our field-work was concerned mostly with the well-known and often-described sections of Amuri Bluff and the Waipara district, some new observations were made. The basal Cretaceous sandstones and conglomerates were found to be fossiliferous in the hills running from Monkeyface to the south-west of Cherwell Flats. The exact locality is in the cliffs overlooking a small lake situated on the south-west side of the Cherwell River, about 200 ft. above the river. Only two recognizable species were obtained—the one a *Trigonia*, the other an *Aucella*; and it is interesting to note that they do not occur at Amuri Bluff, but are found on the other side of the Kaikoura Mountains, at Bluff River, a tributary of the Middle Clarence. Neither species has yet been described or named.

A second discovery of great interest in elucidating the physiographical history of the district was made by Mr. Cotton in the Amuri Bluff district. Mr. Haine, schoolmaster at Hundalee, showed us apparently Recent shells which he had obtained from a slip in the Oaro Creek, and guided Mr. Cotton to the spot. It was then found that these shells came from a series of sandy beds resting on the basal Cretaceous beds at a height of approximately 900 ft. above sea-level. McKay had already described a raised beach 500 ft. high at Kai's Hill. A small collection was made and submitted to Mr. H. Suter, who stated that some of the species were extinct, and that the beds were probably of Pliocene age. The species determined were as follows:—

Cominella virgata H. & A. Ad.
 „ *zealandica* Reeve
Drillia aequistriata Hutton.
 „ *chordata* Suter.
Siphonalia sp. nov.
Turritella symmetrica Hutton.
Dentalium nanum Hutton.

Chione mesodesma Q. & G.
Glycymeris modesta Angus.
 „ *laticostata* Q. & G.
Pecten triphooki Zittel.
Venericardia difficilis Desh.
 „ *zealandica* Desh.
Terebratella sanguinea Leach.

As the Mount Brown beds are absent in the Amuri Bluff district, there can be no doubt that here at least an unconformity is present in the younger rock-series (Cretaceous to Pliocene).

A third discovery of some historical interest was made in the Waipara district. Towards the end of our visit two specimens of *Pecten huttoni* were found in the Weka Pass stone, about a foot above the junction of the Amuri limestone on the cuesta of these rocks lying between Mount Brown and Bobby's Creek. We had occasion to follow this junction later only from the Rams' Paddock down to the bed of the Waipara River, and discovered in all twenty-five specimens of *Pecten huttoni* and one of *Cirsotrema rugulosum lyratum*. The best places for fossils are where the Weka Pass stone overhangs in rounded bosses the hollowed-out Amuri limestone. I have little doubt that if the actual junction is examined across country from the Waipara River to the Weka Creek, many other specimens and possibly other species will be obtained. The interest of the discovery lies in the fact that Park had recently thrown doubt on the presence of Tertiary fossils in the Weka Pass stone, although it had never been a matter of doubt to Haast, Hutton, Hector, and McKay.

A slight unconformity was observed within the sandy beds between the Weka Pass stone and the lower calcareous horizon of the Mount Brown beds in a cliff of the Waipara River gorge, just above the junction with Bobby's Creek. It appears, however, to be a purely local accident of bedding. With this exception, there is apparent conformity in section throughout the Waipara district.

Correlation and Subdivision of the Cretaceous Beds.

It cannot be asserted on palæontological grounds that any beds above the Saurian beds are of Cretaceous age. The presence of ammonites, belemnites, *Inoceramus*, and *Aucella*, and the abundance of *Trigonia*, and of gasteropods belonging to the families of *Aporrhaidæ* and *Strombidæ* leave no doubt as to the age of the basal beds; and these peculiarities persist to some extent into the Saurian beds. Above them practically no fossils are found till the Weka Pass stone, with undoubted Tertiary forms, is reached.

It seems reasonable to hope that the Amuri limestone itself will somewhere prove fossiliferous. It occupies a very large extent of country between the Waipara River and Cape Campbell, as well as in the Clarence and Awatere Valleys, and can have been inspected only at a relatively few of the innumerable sections it presents. The same is true for the Toredon limestone and greensands between the Saurian horizon and the Amuri limestone.

The lithological similarity of the Saurian beds at Amuri Bluff, Monkeyface, and the Waipara district is so striking that the correlation of these beds cannot be held in doubt. Invertebrate fossils have been obtained from these beds only at Amuri Bluff, the Waipara Gorge, and the Malvern Hills. Below the Saurian beds there is only one fossiliferous horizon in the Malvern Hills, the Waipara Gorge and the Monkeyface section. At Amuri Bluff, however, Hector and McKay proposed several subdivisions. At the time of our visit, unfortunately, the more important sections on which they relied were obscured by slips. So far as I could judge, however, both by the sections that were available and the collections made by McKay, the Black Grit is a persistent horizon in this area, and has distinctive fossils; but the underlying *Aporrhais* beds, *Trigonia* beds, and *Belemnite* beds are not persistent stratigraphically, nor distinct faunally.

McKay has made extensive correlations with the Black Grit throughout the area between Cape Campbell and the Waipara River, but the available evidence seems insufficient to justify them at present.

In the Coverham section of the Clarence Valley, the succession of Cretaceous rocks presents a different facies to the rest of the area under consideration. The basal part of the Amuri limestone is entirely replaced by flint. Between it and the unfossiliferous basal conglomerates of the series there is an immense thickness of black mudstones with occasional calcareous lenticles or concretions,

alternating with beds of sandstone, which are mostly quite thin. In the cliffs of the Ouse, Cover, and Swale we found fossils, mainly *Inocerami*, at four distinct horizons; but the highest of these is still far below the base of the Amuri limestone, and the intervening beds are not exposed in the banks of the Swale. Probably they can be better explored in the Nidd, which we had not time to traverse. It is to the Coverham section that we must look for the subdivision of the Upper Cretaceous and the definition of its upper limits, unless Cretaceous forms should be discovered in the Amuri limestone itself.

Correlation of the Grey Marls.

The beds following the Amuri limestone at Amuri Bluff, Kaikoura Peninsula, and the country to the north, including the Clarence and Awatere Valleys, are light or dark grey mudstones, sometimes glauconitic at the base, and often micaceous. They are very poor in fossils at Amuri Bluff and Kaikoura Peninsula, but contain a fair number of fragmentary specimens in the Mead Gorge, Clarence Valley. Probably a satisfactory collection could be made at this point if the outcrop were followed across country. The thickness of these beds varies considerably, due in part to erosion and faulting of the upper part, but it is seldom less than 300 ft., and is estimated at 12,000 ft. in the Cape Campbell section by McKay.

Beds of the same facies are found in the Weka Pass, but are quite thin, and are followed by loose sands. In the Waipara Gorge it is doubtful if the typical Grey Marl facies is present, the section being poor just at the junction; but a great thickness of sands intervenes before the lowest calcareous horizon of the Mount Brown beds is reached. These sandy beds are generally also called Grey Marls, but it has yet to be shown that they are the real equivalents of the upper part of the Grey Marls of Amuri Bluff.

It was doubtless the persistence with which the series closes with the Grey Marls north of the Conway that influenced Hector and McKay to close the Cretaceous-Tertiary sequence with this member, and to postulate an unconformity above the Grey Marls in the Waipara section. While no unconformity has been described in section, it may still exist in plan, or there may be complete apparent conformity, but a non-sequence. The sketch-maps hitherto published of the Waipara - Weka Pass district have not been made with sufficient detail to settle this point.

So far we have but a fragmentary idea of the fauna of the Grey Marls, and further collecting is necessary. In particular it is desirable to examine in detail the 12,000 ft. of strata above the Amuri limestone in the Cape Campbell district which has not yet yielded fossils, and to exhaust the possibilities of collecting in the Mead and Dee sections of the Clarence Valley. It will then be possible to compare the fauna of the sands below the Mount Brown calcareous beds, and ascertain if these are correctly included in the Grey Marls.

The Mount Brown Beds and the Greta or Motunau Beds.

Very little material is available in the existing collections for describing the faunas of these beds. Fossils are abundant in both, but they are mostly fragmentary in the younger series, while in the Mount Brown beds few localities yield anything but brachiopods. It will therefore be necessary to traverse the outcrops of each important cuesta across country from the slopes of Mount Grey to Mount Donald before the complete fauna can be ascertained. The beds recently described by Speight* in the Lower Waipara Gorge have yielded a rich fauna, but a palæontological comparison with the Mount Brown and the Motunau beds of the Middle Waipara section must be made before confidence can be placed in his correlations.

DESCRIPTION OF FOSSILS.

The day has gone by when a palæontologist will attempt to name and describe fossils irrespective of their age and nature. Most modern palæontologists confine themselves to particular groups of organisms, and frequently again to groups of a given age. Any attempt to take a short cut and avoid specialization can only end in confusion. It is obvious, therefore, that the services of many specialists must be obtained to deal with the very varied collections in the possession of the Survey. I have entered into correspondence with many palæontologists to ascertain to what extent voluntary assistance may be forthcoming, and to what extent it will be necessary to engage the services of specialists by a suitable remuneration. Mr. D. G. Lillie, Ship Biologist to the 1910 British Antarctic Expedition; Dr. Henry Woodward, Editor of the Geological Magazine; Dr. A. Smith Woodward, lately Keeper of Geology in the British Museum; Dr. F. L. Kitchin, Palæontologist to the Geological Survey of Great Britain; Professor Sollas, University of Oxford; and Mr. W. S. Dun, Palæontologist to the Mines Department of New South Wales, have given much kind advice, and have been instrumental in obtaining offers of assistance from leading specialists, and as a result many parts of the collection have already been sent away to them. To the above-named gentlemen, and to those who are actually working on the collections, the thanks of the Survey are here gratefully recorded.

The collections that have been sent to voluntary workers outside New Zealand are as follows: Plant-fossils from Mount Potts and other Mesozoic localities, to Dr. E. A. Newell Arber, Demonstrator in Palæobotany, Cambridge (these are supplemented by specimens from the Canterbury Museum, and by fresh collections made by Mr. D. G. Lillie); graptolites from Collingwood, to Dr. E. Shakespear, Birmingham; fossil wood (Cretaceous), to Dr. Marie Stopes, British Museum; Cretaceous ammonites

* Speight, R., Trans. N.Z. Inst., vol. 44, pp. 221-33, 1912.

and belemnites, to Mr. H. Woods, Demonstrator in Palæontology, Cambridge; fossils of the Baton River and Reefton Series (Lower Palæozoic) to Mr. W. S. Dun, Sydney. In addition, several New Zealand geologists have signified their willingness to take parts of the Tertiary collections for study.

At the same time it must be pointed out that the specialist, like any other working-man, is worthy of his hire, and that many of those whose services it is necessary to secure before the collections can be worked out cannot afford, or object on principle, to give their services gratuitously. It will therefore be necessary to increase the funds at the disposal of the Survey for this purpose, if the collections are to be adequately described.

A revision of the Tertiary *Mollusca* being an immediate necessity, the services of Mr. H. Suter, of Christchurch, were secured for six months. His unrivalled knowledge of the Recent *Mollusca* of New Zealand renders him particularly qualified for this work. Mr. Suter has finished the revision of the types of Tertiary *Mollusca* in the possession of the Survey which illustrate Captain Hutton's Catalogue of 1873; and, in addition, has determined several hundred specimens from various Pliocene and Miocene localities. The results of his work are now awaiting publication.

As mentioned above, I have concentrated my efforts on establishing a succession of faunas from Cretaceous to Pliocene. The Cretaceous fossils from Amuri Bluff have been separated into genera and species, and I was about to commence their description when Mr. H. Woods, of Cambridge, who is so well known for his work on Cretaceous *Pelecypoda*, expressed his desire to describe the New Zealand material. Correspondence is proceeding with this end in view, and meanwhile I am now engaged with Mr. C. A. Cotton in revising the Tertiary *Brachiopoda*. It is desirable to have complete revisions of the Tertiary *Mollusca*, *Brachiopoda*, *Echinodermata*, *Bryozoa*, *Cirripedia*, and corals published as soon as possible, in order that New Zealand geologists may co-operate by work on other sections than the Waipara section, and thus assist in clearing up the disputed questions of stratigraphy.

THE MESOZOIC MARINE FAUNAS OF NEW ZEALAND.

As various specialists have made inquiries about the Triassic or Jurassic fossils of New Zealand, it will be well here to explain the present state of our knowledge. Hamilton* and Bœhm† have expressed the opinion that so far as the Mesozoic fossils are concerned, "there is little of permanent value on record except in the 'Voyage of the "Novara"' and one or two recent papers, and it will be necessary to make a fresh start in the description and correlation of the New Zealand species in the collection."

The fossils collected by Hochstetter, and described in the "Novara" records by Hauer, Zittel, and Suess, came from three localities—Waikato Heads; Kawhia Harbour, on the west coast of Auckland; and the neighbourhood of Richmond, near Nelson. The Waikato Heads and Kawhia beds were ascribed by Zittel to the Upper Jurassic or Lower Cretaceous, the Richmond sandstone to the Trias and probably Upper Trias.

After the inauguration of the Provincial and Colonial Surveys very many new localities for Mesozoic fossils were discovered, and a vigorous policy of collecting was carried out by Hector and his assistants, particularly McKay. A succession of faunas was described from many localities, of which the most important are: Nugget Point, Otago; the Hokanui‡ Hills, Southland; the Wairoa Gorge, Nelson; and Kawhia Harbour, Auckland. Many of the fossils collected were identified by Hector with European species, a few new species were described or figured, and many were given manuscript names. Haast relied chiefly on determinations by McCoy, while Hutton practically confined himself to the identification of the species described by Zittel. A complete list of the specific identifications published will be included in my forthcoming bulletin. It is to be regretted that few of the specimens determined by Hector or McCoy have been preserved with labels attached.

As a result of the different interpretations placed on the fossils by Hector and McCoy, and also of divergent views as to the stratigraphy, several controversies arose between Hector, Haast, and Hutton, and in consequence the literature on the beds is very diffuse, and not easy to follow. None of these controversies may be said to be settled yet, and fresh complications have arisen by the assumption of new positions by Park and Marshall. It is impossible to analyse these controversies in detail here, but the more important points may be noticed.

The most fundamental point at issue is the presence or absence of Carboniferous rocks in New Zealand. Hector and McKay, in 1878, recorded the occurrence of Carboniferous fossils in the Maitai limestone of the Nelson district. Elsewhere the only fossils found in supposed Carboniferous rocks are *Dentalium huttoni* and *Torlessia mackayi* (the "Mount Torlesse annelid"). These fossils have recently been described by Bather, who compares the latter with forms in the Lias of Alaska.§ In the last-published Bulletin of the Geological Survey (No. 12), Bell, Marshall, and Clarke, after a detailed survey of the Dun Mountain Subdivision, which includes the Maitai limestone and the Richmond sandstone of Hochstetter, have concluded that Carboniferous fossils are not there present, and that the Maitai limestone is an integral part of the Trias-Jura series. It should be remarked that the fossils on which Hector made his determinations were not examined in this recent survey, as the collections were then undergoing repacking. There is a fairly large collection of fossils from the Maitai limestone in the possession of the Survey, and the question of whether they are Carboniferous or Triassic is susceptible of a direct palæontological solution.

* Trans. N.Z. Inst., vol. 42, p. 55, 1910. † Neues Jahr. f. Min., &c., Jahrg., 1911, bd. i., p. 1. ‡ Also spelt Hokonui. Both are possible Maori place-names, but *Hokanui* is the more probable and has the advantage of priority in geological literature. Maori *hoka*, that which projects; *nui*, large. § Geol. Mag., Dec. 5, vol. 2, pp. 532-41, 1905; vol. 3, pp. 46-47, 1906. See also Bull. No. 6 (N.S.), N.Z.G.S., 1908, p. 20.

With the exception of these supposed Carboniferous rocks, Hector and McKay referred all the other fossiliferous beds in question to horizons between the Permian and Upper Jurassic. Their classification (of 1878) was as follows :—

Mataura Series (Plant Beds)	..	..	..	Upper Oolite.
Putataka Series	..	..	..	Middle Oolite.
Flag Hill Series	..	..	..	Lower Oolite.
Bastion Series	..	..	..	Lias.
Otapiri Series	..	..	..	Rhætic.
Wairoa Series	..	..	..	Middle Trias.
Oreti Series	..	..	..	Lower Trias.
Kaihiku Series	..	..	..	Permian.

In this classification the Richmond sandstone of Hochstetter is placed in the Wairoa Series, and the Ammonite beds of Kawhia in the Putataka Series, the age ascribed to each by Zittel being practically accepted, although in each case they are made a little older. The superposition of the series was worked out by Cox and McKay in the Hokanui Hills; and by a comparison of the fossils with those of other localities in New Zealand Hector was able to assign the beds at Nugget Point, the Kaihiku Ranges, Mount Potts, and the Wairoa Gorge to their various horizons in his classification. Subsequently McKay showed that the lower members of the sequence were present at Kawhia also. The ages ascribed to the different series were arrived at by Hector after a comparison with European forms. In this connection it is of interest to note that although Hector satisfied himself with bald statements as to the presence of European fossils, and gave no descriptive remarks and only a few unsatisfactory figures, Böhm and Diener have lately shown that he was correct in his identifications so far as they have been tested—e.g., *Lima (Plagiostoma) gigantea* Sow. and *Grypoceras mesodiscum* (Hauer).

Hector's classification was not adopted in its entirety by his contemporaries. Haast always contended for a Carboniferous or Upper Devonian age for the Mount Potts "Spirifer" beds (Permian of Hector). Hutton, while admitting the Carboniferous age of the Maitai Series, doubted the Permian age of the Kaihiku Series, and placed it with all the succeeding beds in one Trias-Jura system, the Hokanui System. Park also recognizes certain separate Maitai and Hokanui Systems, but considers the base of the latter Permian, and, while adopting and amplifying Hector's classification for the lower beds, has introduced some simplification in the upper members. Still more recently Marshall has stated, regarding more than one locality, that he is unable to make any subdivisions in the Trias-Jura rocks.

Recent palæontological work by Böhm and Diener, although of great value in increasing our knowledge of the fossils, has not had much effect in clearing up the question of classification or in defining the limits of age of the bottom and top fossiliferous horizons. Böhm's detailed work on Kawhia refers only to the Ammonite beds of Kawhia, already treated by Zittel, and his conclusions are substantially the same—viz., that the beds in question are about the junction of Jurassic and Cretaceous. The Upper Triassic *Cephalopoda* from the Hokanui Hills, originally named by Marshall and subsequently noticed by Böhm and Diener, do not appear to have been collected with sufficient details as to locality or horizon to show whether any other of the series than the Wairoa Series belongs to the Upper Trias.

Our exact knowledge, therefore, is confined to the certainty of Upper Trias in the Wairoa Series of Nelson, and in beds of unknown position in the Hokanui Hills, and of passage beds between Jurassic and Cretaceous in the Ammonite beds (Lower Putataka) of Kawhia. Probably the beds with *Belemnites canaliculatus aucklandicus* (Blainville) Hauer, which lie above the Ammonite beds at Kawhia, and were placed by McKay in the Mataura Series, are Lower Cretaceous. If McKay's description of the fossils may be followed, other probable Lower Cretaceous beds are to be found in the Catlin's River district opposite Bloody Jack Island. That Middle and Lower Triassic beds are present in the Hokanui Hills and elsewhere is also more than probable.

A very large number of fossils from this Trias-Jura or Permo-Mesozoic sequence is contained in the Survey collections, and in each case the locality-label gives the position of the beds in Hector's classification. Before any part of these collections from the lower beds is sent away to specialists for description it is desirable first of all to have a representative series of *Brachiopoda* described. The reasons for this course are twofold: In the first place, the persistence of *Brachiopoda* in the Lower Mesozoic of New Zealand is its most striking feature, and the collections consist predominately of this group: in the second place, Hector proposed three new genera or subgenera, and it has yet to be seen whether these are necessary. He failed to establish these genera, by neglecting to describe species that might serve as genotypes, but he has left behind chirotypes of several species; and it is obvious that his proposals should be tested by his chirotypes, and not by other examples of the same species in the main part of the collection or by fresh collections. Further details of these chirotypes, with figures of some of them which were printed by Hector for a paper that was never published, will appear in my forthcoming bulletin.

Approximate Cost of Paper.—Preparation, not given; printing (1,500 copies, including map), £12 10s.

By Authority: JOHN MACKAY, Government Printer, Wellington.—1912.

Price 6d.]



