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The following Lecture delivered by Dr. F. HOCHSTETTER on the Geology of the Province of Nelson is published for general information.

E. W. STAFFORD.

LECTURE ON THE GEOLOGY OF THE PROVINCE OF NELSON.

LADIES AND GENTLEMEN,—It is with much pleasure that I respond to the wish expressed by you, and at the same time fulfil my promise of communicating the results of my geological, explorations in a lecture, on the geology of this Province; and it is with a feeling of pride that I see so large and distinguished an assemblage met here this evening.

On my arrival in Nelson, in the beginning of the month of August, I hardly hoped to be able to extend my researches so far as to obtain an accurate idea of the geological features of the Province. The time allotted to me was very short: the geological field of the Middle Island, on which I was entering, was, in comparison with that of the Northern Island, an entirely new one. Entering into Blind Bay upon a bright morning, I saw all around me lofty snow-covered mountain chains. It was the middle of winter, and I doubted whether at this season of the year extended geological researches were possible. This doubt was soon removed: the glorious weather which favoured my excursions gave me full confidence in the far-famed and deservedly-praised Nelson climate. My first exploration opened up to me a field at once as interesting as regards scientific research, and at the same time of so great practical importance, from the existence of those very valuable substances, gold, coal, and copper, that in order to give greater value to the results of my observations, I willingly resolved to respond to the wish of the inhabitants, and to remain a month longer among you.

I feel myself in the highest degree obliged to the inhabitants of this Province, who, so soon as the Novara arrived in Auckland, invited the members of the expedition to visit Nelson, for the honourable and hospitable reception, and for the active assistance in the prosecution of my objects, which I have met with on all sides; and I wish to take this opportunity of expressing my thanks to the Provincial Government for the admirable arrangements which on its part were made, so as to extend to the utmost limit the sphere of my explorations, and enable me to occupy to the greatest advantage the limited time at my disposal.

Allow me, before proceeding further, to give you an account of my different journeys, and to detail to you the places which I have visited.

I began in the immediate neighbourhood of the town of Nelson, by a short excursion to Brook-street valley, and a visit to Mr. Jenkin's brown coal mine. I then proceeded in the Tasmanian Maid, which the Government had chartered for this extra trip, to Croixelles Harbour and Current Basin, and examined the veins of copper ore which show themselves there.

We proceeded up Current Basin as far as the French Pass, and on our return landed in the bight of Owhaua, on the south-eastern corner of D'Urville's Island, where copper ore is also found. From thence we steamed without loss of time, during the night, across to Golden Bay, where I went on shore at Collingwood, and visited the gold-fields and the bone-caves of the Aorere Valley. Thence I preceeded along the coast to Pakawau, and examined the coal-field there, and the graphite which is found in the hill at Taumatea. Returning overland from Golden Bay to Nelson, I visited, on the way, the Parapara gold-field, the brown coal deposit at Motupipi, followed the course of the Takaka Valley upwards, crossed the mountain range that divides the Takaka and Riwaka Valleys and passing through Motueka reached Nelson by the Moutere and the Waimea. Another day was devoted to an examination of the Boulder Bank and the Arrow Rock. I next proceeded by the valley of the Maitai to an examination of the Dun Mountain. I then visited the Wakapuaka District and the Happy Valley; and, at a later date, in an opposite direction, spent some time in examining the fossiliferous schists of Richmond and the Wairoa Valley.

After I had made myself acquainted with the geological relations of the nearer lying districts of Golden and Blind Bays, arrangements were made for a more distant excursion in a southerly direction, to the Wangapeka and the Lake country, and in an easterly direction towards the Pelorus, the Wairau, and the Awatere Valley. My time was too limited to enable me personally to undertake both these geological explorations. I therefore availed myself of the friendly co-operation of my friend and companion, Mr. T. Haast, who has hitherto accompanied me on all my journeys in New Zealand. My friend Haast proceeded by the Tasmanian Maid to Queen Charlotte Sound, landed in Maraetai bight, examined the coast as far as Waikawa, and proceeded overland to Waitohi; thence by the Waitohi pass along the Tua Marina to the Wairau plain; thence by the Taylor's pass, Mr. Haast proceeded to the Awatere, returning by Maxwell's pass to the Wairau. After an examination of the Waihopai Valley, he proceeded through the Kaituna to the Pelorus, and returned by the Pelorus road to Nelson. I am indebted in the highest degree to my friend Haast for the interesting and important information which he has communicated to me concerning this region, and for the disinterested zeal and the ability with which he carried out his task of contributing to a knowledge of the geological relations of the country visited, and also for a valuable addition to my collections.

I myself took my way in a southerly direction towards the Motueka and Wangapeka valleys; crossed the chain of hills to the Buller river; followed this upwards to the Rotoiti lake; from thence made my way to the Top House, in the Wairau valley, and returned by the Big Bush to Nelson.

I am thus enabled to say, that it has been possible for me to obtain a general geological view over the whole of the northern half of the Province of Nelson, from the Awatere valley, on the east, to the Aorere valley, on the west; while the cross valley of the Buller river, between the Rotoiti lake and the gorge of the western mountain chain, indicates the southerly limit of the district explored.

I have much to thank my Nelson friends for, both in the way of information and contribution to my collections, and am at the same time indebted to the various gentlemen who, in a spirit of friendship, accompanied me on my journeys.

My best thanks are also due to the various settlers, in whose houses I have found such hospitable quarters. May I be allowed, without mentioning individual names, to express my most sincere thanks to all these gentlemen for their active assistance and valuable contributions to the Novara collections.

I have begun to put together on a map the results of my observations, with the view of laying the foundation of a Geological Map of the Province of Nelson. So soon as time will allow me to complete this map, I will hand over to you a copy of it with pleasure; at the same time expressing a wish that the numerous friends of geology among you, and if they will allow me to say it, my geological scholars here, may continue it and improve it, where I, either from want of time or inaccessibility of the district, have not been able to fill in the details.

I will now come to the subject matter of my lecture.

I.—Physical Features.

The character of the surface is always more or less indicative of the geological structure of a country. Even to those who have not deeply studied the science, the

different forms which mountain ranges show, will indicate a different geological formation. The difference in these external appearances of the country is very striking, if you come from the Northern to the Southern Island.

In contrast with the comparatively low plateaus extending over the largest part of the Northern Island, and broken only by high volcanic peaks, you find on the Middle Island lofty and abrupt mountain ranges, striking in long parallel chains, divided by deep longtitudinal valleys, and broken at right angles by rocky gorges. This complication of rock and gorge runs as the great backbone of the island from north-north-east to south-south-west, and from strait to strait. Well do you name it your "Southern Alps." Amongst them rises in grandeur a mountain named after the great discoverer of the South Sea, Mount Cook, of a height equal to Mont Blanc. It towers above the rest, crowned with perpetual snow, with ravines glistening with glacier ice. To the steep perpendicular cliffs with which the Southern Alps breast the stormy sea on the west coast, are opposed fertile plains extending along the eastern shore.

From a central point, which (near the boundary line of the two Provinces of Canterbury and Nelson,) gives rise to the Hurunui and Waiau-ua rivers, flowing to the eastward, and to the Grey and Enungahua flowing to the westward, the Southern Alps send forth two arms through the Province of Nelson, the extremities of which are washed by the waters of Cook Strait. These arms are again subdivided by longitudinal valleys into numerous ranges, with peaks from five to six thousand feet high. I will distinguish between the two arms by giving the name of the "Western Ranges" to those which, with a northerly strike, terminate in Massacre Bay, between Separation Point and Cape Farewell; and the name of the "Eastern Ranges" to those which, running in a north-easterly direction, terminate in the Pelorus and Queen Charlotte Sound.

In the acute angle between the two ranges are situated the Lakes Rotoiti and Rotorua, from which, undulating hills, intersected by numerous streams, gradually slope from an altitude of two thousand feet to the plains of the Waimea, and the shores of Blind Bay.

I can hardly remember a more beautiful and more striking scene than when I first looked, on a clear winter day, from a high point on the Richmond hills over the fertile Waimea plains, lying like a map beneath my feet, studded with homesteads and covered with cultivations, towards that triangle of snow-capped ranges.

It is, without doubt, in consequence of the peculiar configuration of the mountain ranges, that Blind Bay is favoured with an extraordinarily temperate climate. The western and the eastern ranges of Nelson, converging towards the south, form a regular wedge which diverts on the one side the force of the south-westerly winds, and on the other side the force of the south-easterly winds. Those parts of the Province of Nelson which are not enclosed between the legs of the triangle, do not enjoy the same serenity of climate. In Golden Bay and in the Wairau country, which lie respectively to the west and to the east in the line of the bounding ranges, gales of wind and bad weather generally are much more frequent than in Blind Bay.

The "spout wind," blowing with considerable violence during the summer from the south, is a local wind of Blind Bay, due to the same physical configuration of the country. The calm heated air of the Waimea plains and of the low hills rising in obedience to physical laws into the higher levels of the atmosphere, is suddenly replaced by volumes of colder and denser air, which rush down towards the plains from the mountain ranges behind.

I have made these remarks in order to offer an explanation of some of the most striking peculiarities of the Nelson climate, the Montpellier of New Zealand.

II.—Geological Features.

The western and the eastern ranges of Nelson are totally different in their geological character. The western ranges consist of primitive formation, being built up of old crystalline schists, or metamorphic rocks. The eastern ranges are the oldest sedimentary strata, primary formation, broken through in places by masses of plutonic rocks. The lower undulating hills lying in the angle between the two ranges are nothing but an immense accumulation of *debris* from the mountain ranges on either side, rolled together by the action of the sea, which, in former ages, washed the bases of the mountains.

When I say, *Gold* in the western ranges, *Copper* in the eastern ranges, *Coal* in the basins between them, I have indicated the chief mineral characteristics of the region referred to. I will now speak more in detail of the

1.—Primitive Formation of the Western Ranges.

Taking a cross section from east to west, through the western ranges, we find the subdivisions of the primitive formation succeeding to one another in their normal geological order.

a. *Gneiss and Granite Zone.*—The western shores of Blind Bay, from Separation Point to Riwaka, consist of granite, bordered on the eastern side opposite to the Tata Islands by gneiss. This same zone of granite and gneiss may be traced in a southerly direction up the Motueka river to the confluence of the Wangapeka, and is cut through by the Buller river, where it enters the gorge of the Devil's Grip on the western ranges, and extends all along the eastern slope of the mountains as far as the Rotorua lake.

b. *Zone of Hornblende-schist and Crystalline Limestone (Urkalk).*—Proceeding from the granite and gneiss towards the west, we next meet, on the top of the Pikikerunga range, between Riwaka and Takaka, a broad zone, on which hornblende-schists, quartz-schists, and crystalline limestone succeed one another in regular and numerous alternating strata, with a vertical dip, and a strike nearly due north and south. This formation continues in a westerly direction to the opposite side of the Takaka valley, where it is broken through by erupted masses of diorite-porphyry and serpentine, which show themselves in the Stony creek and Waingaroa. The same zone of crystalline schists exhibits itself in the steep escarpments of the gorge of the Wangapeka. A characteristic feature of this limestone formation is the existence of numerous funnel-shaped pits, which have been hollowed out by the action of water, which has dissolved the limestone.

The interesting phenomenon of the Waikaromumu springs in the Takaka valley, where whole rivers suddenly appear on the surface with the water bubbling, is readily explained by a subterranean passage of the water through the limestone from the ranges. This crystalline limestone on the ranges must not be confounded with the other limestone in the Takaka valley, which belongs to the tertiary period.

c. *Mica-schist and Quartz-schist.*—The crest of the western ranges, with peaks rising to an altitude of about 6,000 feet, the Anatoki mountains, Mount Arthur, and the chain lying between the source of the Wangapeka river and the Buller river gorge, consists of mica-schist containing garnets, alternating with quartz-schists.

d. *Zone of Clay-slate.*—Still proceeding towards the west, the mica-schists pass by insensible gradations into clay-slates, which, however, still exhibit the same alternating strata of quartz-schist. The Aorere valley and the lofty peaks on its eastern side, as the Slate-river peak, Lead Hill, Mount Olympus, and the Haupiri range, generally belong to the clay-slate zone. In all those ranges the strata are more or less vertical, and exhibit unmistakeable signs of great disturbance at former geological periods. For instance, Mount Olympus presents the peculiar appearance of strata diverging from below towards the serrated edge of the mountain like the folds of a fan. A similar disposition of strata is observed on the loftiest summit of Europe, namely, on Mont Blanc.

Gold.

In the mica-slate and clay-slate zone of the western ranges, we have the matrix of the gold. From the interest attaching to this subject, I may be allowed to repeat the limits of these gold-bearing formations. On the east these formations are bounded by the Takaka valley; on the west by the Aorere valley, so that its breadth is from fifteen to twenty miles, and includes the Anatoki and Haupiri ranges. In a southerly direction the same formations can be traced to the gorge of the Buller river. How much further it extends in that direction has not yet been ascertained; but, inasmuch as gold has been found at the northern extremity of the Southern Alps, and also in the gravels of the Mataura, in the Province of Otago, towards the southern extremity of the backbone, it is not unreasonable to infer that the same gold-bearing zone may extend continuously throughout the whole length of the Middle Island.

Before speaking more specially of the gold-fields, I wish to correct some of the theories popularly current among the diggers, according to which gold is to be traced to the action of fire. The gold, in its original position, is in larger or smaller particles dispersed throughout the quartzose constituents of the mica and clay-slate formations. By the gradual wearing away of these rocks, through the action of the elements, extending over immense periods of time, large masses of debris have been formed, and nature itself has executed an operation of goldwashing, by collecting the heavier particles and depositing them in the gullies of the streams, or in the conglomerates covering the slopes of the hills.

There are, therefore, two principal descriptions of diggings: either "river diggings," in the beds of the streams, or "dry diggings," in the conglomerate and gravel accumulated on the slopes of the mountains.

I will first describe the best known and most worked of your gold-fields, namely, the Aorere and Parapara gold-field.

The Aorere and Parapara Gold-field.—You are all aware that the gold in the Aorere valley is confined to the eastern side of the valley; the only traces of gold found on the western side are on the Kaituna stream, but

not indicating any rich deposit on that side, which, as fertile agricultural land, must be left to the farmer. You know that all the tributaries of the Aorere river proceeding from the Haupiri range, as, for instance, Appoo's river, the Slate river with its different branches, the Boulder rivers, Salisbury creek, and also the Parapara river, which proceed northwards from the same range, have been more or less successfully worked by various parties of diggers. The rounded nature of the gold particles shows that the gold has been brought down by water; and the fact that the heaviest gold is found in the upper parts of the streams, points clearly to the mountains as the source of the metal.

But it would be improper to speak about an Aorere gold-field, if the gold were confined to the deep and narrow gorges of the streams, cut down into the clay-slate rocks.

The whole region of the eastern side of the Aorere valley, rising from the river bed towards the steep sides of the mountains at an inclination of about eight degrees, and occupying from the Clarke river towards the south, to the Parapara on the north, a superficial extent of about forty English miles, is a gold-field. Throughout this whole district, on the foot of the range, we find a conglomerate deposited on the top of the slate rocks, reaching, in some places, to a thickness of twenty feet. Pieces of driftwood changed into brown coal indicate a probably tertiary age of this conglomerate formation. Where a ferruginous cement binds the boulders and the gravel together, this conglomerate is compact; in other places only fine sand lies between the larger stones. Quartz and clay-slate boulders are the most commonly met with. This conglomerate formation is not only cut through by the deep gullies of the larger streams, but in some places washed by the more superficial action of occasional water, and so divided into parallel and rounded ridges, of which that portion of the district called the Quartz Ranges is a characteristic example. This conglomerate formation must be regarded as the real gold-field, prepared in a gigantic manner by the hand of nature, from the detritus of the mountains, for the more detailed and minute operations of man.

While the less extensive, but generally richer, river-diggings afford better prospect of gain to the individual digger, the dry diggings in the conglomerate will afford remunerative returns to associations of individuals who will work with a combination of labour and capital. The intelligent and energetic gold-digger, Mr. Washbourn, is the first person who has proved the value of the dry diggings in the Quartz Ranges, and has demonstrated the fact that gold exists in remunerative quantities in the conglomerate. I am indebted to Mr. Washbourn for the following interesting details. He writes to me as follows:—"In the drives into the conglomerate of the Quartz Ranges, the average thickness of dirt washed is about two feet from the base rock; and the gold produced from one cubic yard of such earth would be, as nearly as I can calculate, worth from twenty-five to thirty shillings. This includes large boulders; so that a cubic yard of earth, as it goes through the sluice, is of course worth more, as the boulders form a large proportion of the whole. Where the earth is washed from the surface to the rock, the value per cubic yard is much less; not worth more, perhaps, than from three shillings to six shillings per yard, and it would generally pay very well at that."

With this *data*, the following calculation may be made. We will reckon the superficial extent of the Aorere and Parapara gold-fields at thirty English square miles, the average thickness of the gold-bearing conglomerate at a very low rate at one yard, and the value of gold in one cubic yard at five shillings. Upon this *data* the value of the Aorere gold-field is £22,500,000, or £750,000 for one square mile.

I am not a practical gold-digger myself, but I will leave it to those who are more versed in that pursuit to contrive the means by which this wealth may be best extracted from the soil. Considering that Mr. Washbourn was able to pay his men wages from ten to twelve shillings a-day, and still to make a considerable profit, the richness of the deposit of gold in the conglomerate is clearly proved.

You may allow me to add, from inquiries I made on the spot, the number of diggers working on the Aorere and Parapara diggings is not more than about 250. Although the diggers cannot be at work continually, a large portion of time being occupied in bringing their provisions across a rugged country, ill-provided with roads, and occasionally stopped by floods in the rivers, it is considered that a digger earns on an average twelve shillings a-day.

The history of the gold-field does not record any large fortunes made by single diggers, but steady average gains. The largest nugget found was in the Rocky river, a nugget of 9 ozs. 18 dwts.

The whole produce of the gold-field, from the beginning, in 1857, up to the middle of August, is recorded in the *General Government Gazette*, as about £150,000.

I may add that, looking to the position of the gold-field generally, and its proximity to the sea, there is probably no other gold-field which, with moderate outlay upon roads, could be made more easily accessible or might afford greater facilities for being worked. I

have very little hope that quartz reefs will be found in this district rich enough to pay for crushing.

The country on the western side of the gold-bearing ranges, further south than the Clarke river, has not yet been perfectly explored with regard to probable gold-fields, and I proceed, therefore, to the eastern side of the gold-bearing formations.

I may remark that there is no foundation for the belief, so generally entertained amongst diggers, that gold-fields are only found on the western side of ranges, and not on the eastern.

The Anatoki and Takaka Diggings.—From the same mica-slate and clay-slate zone, from which on the western side the gold-bearing branches of the Aorere valley run, on the eastern side the Takaka river with its branches takes its rise. It is therefore not surprising that gold is also found on those rivers. If the farmer, settled on the rich alluvial plains of the Takaka, finds markets bad, he has but to ascend to the higher parts and branches of the river to fill his pocket. Gold is found in sufficient quantity to pay river diggings in the upper Anatoki, Waingaro, and Takaka, the heaviest nuggets in the Waitui river, which takes its rise from the Mount Arthur range. In the Anatoki valley a quartz reef is spoken of, which promises well. The interesting metal, *osmiridium*, as has been proved by specimens forwarded for analysis to Mr. Clarke, of Melbourne, is a peculiar accompaniment of the Takaka gold. Titaniferous iron, magnetic iron, and garnets —not rubies as generally thought—are everywhere found on the river diggings of the province. It must be left to the energy of future explorers, to determine if there be not, as it is most probable there is, a similar gold field as the Aorere gold-field, hidden under the dense forests on the eastern slope of the ranges.

Wangapeka.—With a view to exploring the country lying to the south of the Takaka, on the eastern side of the gold-bearing formations, I made a journey to the Wangapeka. My guide to that country, most difficult of access, was Mr. Clarke, who had formerly been prospecting there for gold. On this occasion I had the pleasure of the company of the Superintendent. The Wangapeka, as large if not larger than the Motueka, near its junction with the Sherry river, runs through a wide terraced valley.

The hills bordering the valley, are composed of tertiary strata, marl, sandstone, and limestone. At places on the sides of the valley, granitic rocks show themselves as the foundation of the tertiary strata. The boulders and shingle brought by the river from the deep gorge, through which it enters the broad valley, prove, on examination, that river takes its origin in a zone of hornblende-schists, and crystalline limestone, the continuation of the formations between Takaka and Riwaka. There is therefore no reason to expect an auriferous river bed. I might here mention that this valley seems the peculiar home of wild pigs, the immense number of which have rooted up the whole surface. The wet weather we experienced prevented my exploring those rivers which take their rise further westward, in the mica-slate and clay-slate ranges as I expect, as, for instance, the Battea river and its branches. It was here that Mr. Clarke found the best result of his prospecting expedition. He found not only gold, but, on the edges of the tertiary formation towards the crystalline ranges, large seams of coal cropping out.

As a very probable gold country, I should recommend the exploring of the high range situated between the sources of the Wangapeka and the gorge of the Buller. That range is, so far as I can judge, the continuation of the Mount Arthur, Anatoki, and Haupiri ranges.

I shall hereafter find an opportunity to remark upon the Motueka diggings, and will conclude this portion of my lecture by stating that the Nelson gold-fields are a fact, and that which is at present known is but the beginning of a series of discoveries which time will bring to light.

With regard to other minerals in the western ranges, there are no indications of quicksilver, as it was supposed. But Mr. Skeet informed me, that pieces of lead ore are found in the Waingaroa river, and large masses of brown iron ore, which has been mistaken, from the somewhat similar appearance, for scoria, are deposited at the Parapara. This has given rise to the idea of the Parapara being volcanic.

2.—Primary Formations in the Eastern Ranges.

The eastern ranges are of an entirely different geological formation to those just described in the west; old primary slates and sandstones, of very various character, form lofty ridges, intersected by parallel longitudinal valleys. The strata are all, more or less, vertical, and the parallelism of their strike from north-east to south-west continues with remarkable regularity. One and the same stratum can be traced from Cook Strait to the far interior in the south.

In the central ridge, which has its northern termination in Mount Stokes, between the waters of the Pelorus and Queen Charlotte Sound, the slates exhibit a more crystalline character. At Ship's Cove and Shakspeare Bay in Queen Charlotte Sound, in the Kaituna Pass, and other places, almost

crystalline micaceous clay-slates, with quartz layers and veins, occur.

On either side of this central ridge, the slates exhibit a more sedimentary character, alternating with dioritic schists, with amygdaloids, with very compact sandstones, approaching the character of graywacke. As no fossils have yet been found in those oldest sedimentary New Zealand schists, it is impossible to assign to them their geological place in a European classification of strata.

The slate and sandstone ridges are flanked by serpentine.

Below the confluence of the Blarich river with the Awatere, where the side of the mountain has slipped with an earthquake rent, serpentine appears. The Grey Mare's Tail is a waterfall over a serpentine cliff. The serpentine extends, in a south-westerly direction, through the Blarich valley towards Mount Mowatt, whose south-eastern slope to a height of about 2000 feet is composed of serpentine. In the bed of the Blarich river, Mr. Haast found a piece of copper ore of the same description as the Dun Mountain ores.

On the western side, the serpentine occurs developed to a much greater extent. An immense serpentine dyke of a thicknesss of several miles, stretches from the northern extremity of D'Urville's Island, across the French Pass, through the Croixelles, by the Dun Mountain, Upper Wairoa, and is met with again, on a continuation of the same straight line, on the red hills, near the Top-house, on the northern side of the Wairau Valley. This dyke can thus be traced from north-east to south-west for a distance of eighty miles. The strike of the serpentine dyke is perfectly parallel to that of the slates, but its eruptive origin is proved by the occurrence of a breccia of friction (Reibungs breccia) at the line of contact; and the fact of beds of slate enclosed in it being converted into hard and semi-vitrified cherts. The serpentine, in its turn, has been broken through by eruptive dykes of hypersthenite and gabbro. The rock of the Dun Mountain proper is a variety of serpentine, of so novel and peculiar a character, that I am obliged to apply to it a new term, and call it "Dunnite." The Dun Mountain district offers to the scientific geologist a field of unbounded interest; but I shall perhaps best respond to the wishes of my audience by telling them something about the ores of copper and chromate of iron, which are the characteristic metals of that serpentine dyke.

COPPER.

The occurrence of native copper, red oxide of copper, and copper pyrites, the principal copper ores of the Dun Mountain, is by no means peculiar to the serpentine of New Zealand. In the serpentine district of Cornwall, for instance, native copper is found. The Monte Ramazzo, near Genoa, contains copper ores in serpentine; and in North America, the same thing occurs.

I have visited (accompanied by Mr. Hacket and Mr. Wrey) all the workings of the Dun Mountain. I could not convince myself of the existence of a number of parallel lodes, so as to justify the various names which have been given, and which appear to designate different lodes. The Dun Mountain copper ore does not occur in a regular lode; by which I mean a metaliferous dyke of different mineral composition from that of the rock of the Mountain. As is usual in serpentine, the copper ore occurs only in nests and bunches. The richer deposits of copper ore, form lenticular shaped masses, which, when followed, may increase to a certain distance, but then disappear again in a thin wedge. Where these nests are large and rich, one alone may sometimes make the fortune of a mine. The richest found on the Dun Mountain appears to have been that of the Windtrap Gully, from which pieces of native copper (some of them weighing as much as eight pounds) were extracted. These nests of copper ore occur in the Dun Mountain in one continuous line, as if a rent had taken place in the serpentine rock, into which copper had either been injected from beneath, or deposited there by the operation of some causes which science is unable to explain. The green and blue silicates of copper are surface minerals, which are only of value by showing the direction of the fissure in which the real ore may be looked for at a greater depth. At a certain distance below the surface, they disappear entirely, and it is only by the broken and softened character of the serpentine that the miner is enabled to follow the fissure from one deposit of metal to the other. The occurrence of the best indications of copper ore on the surface, over a continuous line of about two miles, affords good ground for supposing that considerable quantities of ore are contained in the mountain; but, on the other hand, owing to the manner in which the ores occur in isolated bunches, mining operations in such a region are always attended by less certain profits than where the metal is deposited in a regular lode; and I may be allowed to express a hope that the Dun Mountain may prove to be all that the Nelson people could wish.

In Croixelles and in Current basin, where copper-mining operations have been carried on, the indications were very obscure, and the result has proved that there is no reasonable ground to expect a profitable copper mine there. More promising specimens of copper ore have been obtained from D'Ur-

ville's Island. The character of the ores met with there is quite the same as in the Dun Mountain.

I will add a few words about chromate of iron. This mineral is an ordinary accompaniment of serpentine rock, and occurs in the Dun Mountain in great force. Of its commercial value I do not feel myself qualified to speak; but, should its value be considerable, the abundance of it is so great that it must prove a source of much wealth to the mine.

Having described the central parts of the western ranges, and the serpentine which flanks it, there still remains to me to describe a zone of old sedimentary rock, which lies between the serpentine on the east, and Blind Bay and the Waimea plain on the west. The best section of this zone is obtained by following up the course of the Maitai to the Dun Mountain. Immediately to the west of the serpentine we meet a belt of calcareous schists, which attains its highest elevation on the summit known as the Wooded Peak, and continues on its strike parallel with the serpentine dyke. Proceeding to the westward, we pass over a band of greenish and reddish coloured slates of a thickness of about five English miles. The same description of slates continues all along the ranges, as far as the Big Bush road to the Wairau. The absence of any fossil remains in the calcareous schists and in the slates prevents me from assigning to them with confidence their geological age. I give them, therefore, a local name, and call them the Green and Red Maiti Slates. In places these slates are broken through and altered by eruptive rocks, as, for instance, in Book-street-valley by diabase, and near Wakapuaka by syenite.

3.—Secondary Formations.

Between Nelson and Wakapuaka, black slates and shales are found close to the edge of the water. In these we find the first indications of organic remains. Of the nature of these organic remains I have not been able perfectly to satisfy myself; they appear, however, to belong to the vegetable kingdom, and have more resemblance to seaweeds than anything else.

In the same line, further south, the Richmond sandstones form the boundary of the western ranges. No less interest attaches to these sandstones, which contain many and perfect fossil molluscs, and are, so far as I know, the oldest fossiliferous strata in the province. The fossils belong to the genera *Mytilus, Monotis, Avicula, Spirifer, Terebratula,* which seem to indicate a secondary age for the formations. If I were to trace any analogy between these strata and any European formation, I should say that they occupied in New Zealand the place filled by the muschelkalk in Europe.

I have described now the formations of the higher ranges of the province. Before leaving them, I will observe that they possess an extraordinary interest for the botanist. Dr. Monro and Dr. Sinclair have brought from those regions specimens of the greatest interest, and new to science. And a large field is still open for those who will follow in their steps.

Zoologists may be surprised to hear that on the top of limestone ranges between 3000 and 4000 feet high, at the Pikikerunga and the Maunga-tapu, a large land snail, or helix, is found as large as the Helix Busbyi of the Northern Island. Mr. Skeet found a live specimen on the Anatoki mountains; and to Mr. W. Askew, at Riwaka, I am indebted for a perfect specimen of that new and rare shell.

Pakawau Coal Field.

I come now to speak about the Pakawau coal-field, as probably belonging to the secondary period. The Pakawau coal-field overlies the mica and clay-slate formations of the western ranges. The Pakawau stream exposes various strata of the coal-field, its conglomerate, sandstone, shales, and seams of coal. There have been workings on the exposed seams on both sides of the stream. A quantity of coal extracted from a seam of four feet thickness on the north side, which has lain exposed to the weather for two years, and still remains in the condition in which it was extracted, at once convinced me of the difference existing between this coal and the other New Zealand coals which I have seen. The coal is a dense, heavy, black coal, of a laminated structure, breaking in large pieces, which do not crumble. In the evening I burnt the coal in a fireplace, and was pleased with the large amount of flame and heat given out by it, without sulphureous or other disagreeable smell. It burnt away to a clean white ash. Mr. Curtis has kindly forwarded to me an analysis of this coal, made in the year 1853, by Mr. Theoph. Heale, at Auckland. Mr. Heale proved the excellent qualities of the coal as a gas coal; the quantity of carbon (not more than 53 per cent.) would not confer upon this coal a high character as fuel; but this low percentage probably arose from the piece submitted to analysis being mixed with shale. To me it appears that the coal must contain at least 70 per cent. of carbon, and that it will be found a very excellent coal for steam purposes.

On the southern side of the stream, the old workings exhibited the following section:—

Shale.			
Coal . .	0 ft.	5 in.	Coal, in all, 2 feet.
Shale . .	0	3½	
Coal . .	0	4½	
Sandstone .	0	2	
Coal . .	1	2	
Shale.			

Thus, the natural sections and the old workings show various seams, but none of them of great thickness, and in all of them more or less bands of shale.

The dip of the seam is toward south-west, that is, towards the West Wanganui harbour, at an angle of twenty degrees, and the coal-field reaches, undoubtedly, from Pakawau to West Wanganui. In a coal-field of such extent, it may be with confidence affirmed, that seams of much greater thickness exist, and the way to ascertain their existence, is to make borings. That is the first thing for the company to do, which undertakes to work this very valuable coal-field. My reason for assigning to this coal-field a secondary age, is the existence of impressions of fossil plants, referable to calamites, ferns, and dicotyledones. Although the Pakawau coal-field does not belong to the carboniferous period, experience will show that the coal will rank in quality with the black coals of older date.

I proceed from these older coals to the tertiary period and the brown coal formation.

4.—Tertiary Formations.

The tertiary formations which I observed in the districts of Golden and Blind Bays, belong to that group which I mentioned in my Auckland lecture as the older one. All the wide valleys and basins, which from the shores of Cook Strait run inland between the high primitive and primary ranges, are filled with tertiary strata, which at some places attain an altitude of 2,000 feet.

This formation is divided into two parts: the lower, or a brown coal formation, the upper, fossiliferous marl, sandstone, and limestone.

I will give a short description of these strata, from Cape Farewell to Awatere.

It is a remarkable fact, that at Cape Farewell, the north-westernmost point of the Middle Island, where the sea swarms with echinides, commonly called sea-eggs, the tertiary sandstone cliffs are also found full of fossil remains of the same family, but differing in species.

In the Aorere valley the original tertiary strata are by later action for the most part destroyed. On the western side of the valley indications of brown coal have been found. On the cliffs of Collingwood, marls containing few fossils, are the representatives of the formation.

Higher up the valley large isolated masses of a fossiliferous calcareous sandstone, or, if you will, of a sandy limestone, penetrated by numerous caves, are the remains of a once continuous tertiary stratum.

The caves above Washbourn's flat, in these isolated limestone blocks, have lately become famed as bone caves, the cemeteries of gigantic birds, which, in the traditions of the Maories, are remembered as the frightful Moas, and which to science are known as the Genera of *Dinornis, Notornis,* and *Palapterix.*

When in, 1857, I saw in the British Museum, the skeletons of *Dinornis elephantopus,* and *Dinornis robustus,* I little thought that I should so soon be in possession of the same treasures.

Before my arrival at Collingwood I had heard of the late discovery of Moa bones in those caves, and I was anxious to procure those specimens which I had had so little success in obtaining in the Northern Island.

In the first cave which I entered—my friend Haast has since given it my name—after a short search, I dug out fragments of bones from the loam on the bottom of the cave. I was convinced that the treasures had not all been carried away, as from the caves in the Northern Island; and on the same day the finding of a Moa skull—so far as I know the most perfect yet found in New Zealand—was the reward of further researches.

Being obliged myself to leave for the Pakawau coal-field, my friend Haast remained behind in company with the young surveyor, Mr. Maling, to make more extensive researches. The bottom of a second cave, the Stafford's cave, was turned up, and the bottom of a third one, the Moa Cave. The excitement of the moa-diggers was great, and increased; for the deeper they went below the stalagmite crusts covering the floor, the larger were the bones they found, and whole legs, from the hip-bone to the claws of the toes, were exposed. They dug and washed three days and three nights, and on the fourth day they returned in triumph to Collingwood, followed by two pack-bullocks loaded with moa bones.

I must confess that not only was it a cause of great excitement to the people of Collingwood, but also to myself, as the gigantic bones were laid before our view. A Maori bringing me two living kiwis from Rocky river, gave us an opportunity to compare the remains of the extinct species of the family with the living *Apterix.*

It gives me much pleasure to acknowledge the zeal and exertions of my countryman and friend, Haast, in adding such valuable specimens to the collections of the Novara expedition. The observations of M. Haast, made during this search, throw a new light upon this great family of extinct birds. He

found that, according to the depth so was the size of the remains, thus proving that the greater the antiquity the larger the species. The bones of *Dinornis grassus* and *ingens* (a bird standing the height of nine feet) were always found at a lower level than the bones of *Dinornis didiformis* (Owen), of only four feet high.

I have the pleasure of showing you, here, a leg of *Dinornis grassus*.*

I have since had my collection of bones increased by various contributions from Messrs. Wells, Haycock, and Ogg, and a nearly perfect skeleton of *Dinornis ingens* presented by the Nelson Museum to the Imperial Geological Institution of Vienna.

These gigantic birds belong to an era prior to the human race, to a post-tertiary period. And it is a remarkable incomprehensible fact of the creation, that whilst at the very same period in the old world, elephants, rhinoceroses, hippopotami; in South America, gigantic sloths and armadillos; in Australia, gigantic kangaroos, wombats, and dasyures were living; the colossal forms of animal life were represented in New Zealand by gigantic birds, who walked the shores then untrod by the foot of any quadruped.

A characteristic of the tertiary formation of the Takaka Valley is large masses of fossiliferous limestone, beginning at the Tata Islands, and extending far up the valley. Under the limestone lies the Motupipi brown coal formation, which can be traced up the valley as far as Mr. Skeet's. I am indebted to Mr. James Burnett for carefully drawn and instructive plans and sections of the Motupipi working, which at once placed before me the character of the coal-field and the succession of the strata.† I need not here repeat what I have so recently said at Auckland with regard to the quality and economical uses of this coal. The Motupipi coal is of the same geological age, and of the same description, as the Drury coal at Auckland. It is to be regretted that works commenced with so much judgment and regularity, and which might easily be continued, should be no longer carried on, in consequence of the high price of the fuel, and the difficulty of putting it on board the ship. To obviate the last difficulty, Mr. Burnett proposes a coal depot at the Tata Islands, where vessels could easily take it in.

	Long.	Circumference of the Shaft.
*Tarsus	9½ in.	6 9 in.
Tibia	22	6 6
Femur	13	8 0
Spread of the claws	15	

†SECTION OF STRATA AT MOTUPIPI, MASSACRE BAY.
No. 1 SHAFT.

	ft.	in.
Surface Clay	1	9
Coal	2	0
Shale		
Coal (2 4) / Band of Shale (0 5) / Coal (2 4) — Working seam	5	1
Shale of a sandy nature	3	5
Coal	1	3
Soft sandstone, composed of very rough sand, like crushed quartz, with thin beds of shale; this stone falls away to loose sand under the pick, but stands very well in the shaft	7	0
Shale (pretty good roof)	2	0

TERTIARY FORMATION OF BLIND BAY.

That the waters of Blind Bay at one time extended much further to the south, and covered a larger area, than they do now, is proved by the fact of a tertiary formation filling up the space inclosed between the eastern and western ranges from the lake country to the shores of the Waimea; but for the most part this formation is again covered by a more recent deposit of rolled stones, gravels, and diluvium, which at some places attains a thickness of from 1,200 to 1,500 feet. So that the tertiary formation comes to the surface only just at the foot of the ranges, or where the rivers have cut through the diluvium and exposed the tertiary marls beneath.

I have before mentioned the fossiliferous marls, sandstones, and the coal seams of the Wangapeka district; in the hills between the Buller river and the Rotorua lake the same fossiliferous marls are met with. On the eastern side, near Nelson, the marine

		ft.	in.
Dip to the east 1 in 17.	Coal, with a great deal of water, sunk 2 ft. 7 in., and bored 2 ft. more to the bottom of this seam	4	7
		27	1
	Bored 1 ft. further in shale	1	0
		28	1

SECTION OF STRATA AT MOTUPIPI, MASSACRE BAY.
No. 2 SHAFT.

		ft.	in.
	Sea sand	4	6
	Clay	1	0
	Soft sandstone	10	8
	Sandstone (very hard)	1	0
Full dip, about S. 75° E., 1 in 5.	Shale (good roof)	4	7
	Coal (hard and good, but at this place mixed with a little hard slaty shale, which decreases towards the south-west, and almost disappears at a distance of 7 feet from the shaft)	4	4
Dip decreases with increased depth; and at bottom not more than 1 in 7.	Soft sandstone	5	0
	Dark shale (almost black)	1	0
	Soft sandstone	8	6
	Sandstone (very hard)	0	6
	Sandy shale	2	8
	Dark shale	1	4
	Slaty shale, mixed with coal	1	2
	Bored through soft sandstone	3	6
		49	9

This shaft was abandoned on account of the large quantity of water; had this not taken place, it was intended to sink to a seam known to exist about low-water mark.

JAMES BURNETT

strata of the tertiary formation form the cliffs from Greenpoint to the Waimea plains, and in a line between the town and the village of Richmond, the brown coal formation extends, opened up at Mr. Jenkins' coal mine.

The first excursion which I made after visiting Nelson, was by the cliffs to this coal mine, and it was with great surprise that I saw the extraordinary disturbances which must have taken place in the stratification. The dip of the strata is towards the east, at an angle of about sixty degrees. As it is geologically impossible that a newer tertiary stratum can underlie the older slate formations of the ranges, it follows that the strata about Mr. Jenkins's coal mine, by an immense force from the eastward, must have been completely turned over; and in the mine itself there is abundant proof of this. The strata there, show unmistakable evidences that they have been rubbed and pressed together. Under these circumstances it is very doubtful whether a mine in that particular place could be successfully worked. To Mr. Jenkins the people of Nelson are indebted for proving to them that they have coal in the immediate vicinity of the town, and I think it not improbable that in the same line of stratification between Nelson and Richmond, a place may be found where, perhaps, at a greater depth, the coal seams lie in their natural position, and workings may be carried on with success.

The diluvial formation, which constitutes what is commonly known as the Moutere, and Wai-iti hills, extending over an immense tract of country towards the south, so far as to the Rotorua lake, is nothing else than the detritus of the eastern and western ranges accumulated during a long period. It is not surprising, therefore, seeing that a portion comes from the auriferous rocks of the western ranges, that prospecting parties of diggers should have found gold at various spots between those hills. And it is a fact that the first gold in this province was discovered in a stream which cuts through this diluvium. I refer to the Motueka diggings in Pig Valley, at the foot of the western ranges. I have heard that quite recently these diggings have been resumed with some success. Bearing in mind the source from which the gold is derived, I think it likely that the nearer to the western ranges the richer will be the diluvium, but it is at the same time doubtful if it is rich enough, for any extent, to be of much consequence.

I have had many questions put to me with regard to the origin and character of the Nelson Boulderbank: I have not time to give such an explanation of it as I should wish to present to you. The boulders of which it consists are entirely syenite, and the same rock is found on the precipitous bluff which abuts upon the sea beyond Drumduan. The source is thus explained:—Fragments are constantly falling from the cliffs, and the action of the heavy northerly swell, combined with a strong current, takes them towards the south. The reason of their their being deposited on the existing line is, that in all probability a submarine reef underlies them, of which the Arrow Rock in the entrance of the Nelson harbour, may be regarded as the southern termination. This supposition is strengthened by the fact of the Arrow Rock being of the same altered schists as occur immediately to the south of the syenite. Before concluding, I wish to make a few remarks upon Volcanic Formations in the Province, and upon some general matters.

5.—Volcanic Formations.

Although there are no signs of a volcanic action still going on in the Middle Island, as far as regards active volcanoes, solfataras, and fumaroles, like those in the Northern Island, we have at the same time plenty of proof that volcanic action has not been less powerful in the Middle Island than in the Northern.

I have not had an opportunity of visiting the volcanic districts of this island; but still feeling that I should make some remarks upon this subject, I will endeavour to explain the opinion which I have formed from specimens and communications.

It is well known that the high peaks of the Kaikoras, covered with perpetual snow, are of volcanic origin. My friend Haast describes the aspect of the three gigantic cones visible from the Awatere valley as most magnificent; three Mount Egmonts, one behind the other: the first one, Tapauenuka (or Mount Odin), 9,700 feet high, a closed and rounded dome, similar in shape to a cupola; the second one, further to the south, a truncated-bifurcated cone, the bifurcation undoubtedly the indication of a crater on the summit. From that peculiar form it has acquired the common name of the "nest mountain;" and the third gigantic peak, pyramydical in form, like Mount Egmont. Almost equal in height to those landward Kaikoras, is the lofty range which rises on the seaward side of the Clarence river, the principal points of which have been named Mount Thor, and Mount Freya. Around these just mentioned Scandinavian monarchs of the mass, are ranged several smaller volcanic mountains, which I hope may have the right to maintain their *Maori names*.

It is not all surprising that accounts have been received of newly-discovered hot springs

in this volcanic region in the Hanmer Plains,* at the foot of the Kaikoras.

Specimens forwarded to me by gentlemen, some from the Kaikoras, and some boulders from the Awatere, prove that the principal rocks in this district are basaltic and trachytic lavas.

Following the southerly direction indicated by the relative position of the two Kaikora groups, we come next to Banks' Peninsula, undoubtedly an extinct volcanic system, rising like an island out from the sea and level plains.

In the same line farther south, lies a third group of volcanic hills, forming the peninsula at Otago.

These three points doubtless indicate a line of volcanic action, running parallel to the great middle range or backbone of the Middle Island, on the eastern side of it. A closer examination, especially of the Otago province, would no doubt furnish us with more and similar examples of volcanic hills on that line. It is remarkable that, whilst the parallel zones of volcanic action on the Northern Island—the Tongariro zone, the Auckland and the Bay of Islands zone—all run on the western side of the backbone range between Wellington and the East Cape; the great volcanic line of the Middle Island takes the eastern side.

Many peculiarities in the physical features of the Middle Island, and also many interesting facts respecting the earthquakes in New Zealand, can be explained by the different position of the line of volcanic action in the two islands.

Reserving, however, for my future publications this interesting subject, which, I regret, I have not time now to enter upon, I will, in conclusion, offer a few

General Remarks.

In the earlier geological era of New Zealand, we may assume that both islands were connected, and that one backbone ran continuously from the S. Cape to the E. Cape. In the present map of New Zealand the integrity of this backbone is broken at Cook Strait, and a closer inspection will show that there has been not only a simple break of continuity, but, a lateral dislocation. Cook Strait is, to use a miner's expression, a bone fault. It is evident from the rocks being of the same geological formation, that at one period the Pelorus ranges were a continuation of the Wellington ranges. The position of the strata in the eastern ranges of Nelson prove, that whilst the Northern Island seems to have remained stationary, some gigantic force has pressed the great mass of the Middle Island to the westward. The given description of the tertiary formation, extending between the ranges far up the valleys, sounds and bays leading towards Cook Strait on both sides, farther proves that the first act of this great convulsion of nature took place prior to the tertiary period, and the second, and subsequent acts, may be coeval with the period of volcanic action in the Islands.

While the tertiary sea was depositing in the strata which now fill the valleys, and which rise in some parts to an altitude of 2000 feet, the higher ranges of New Zealand only were above water.

Since the tertiary period, these Islands have been gradually rising, and that rising has been coeval with the volcanic action, and developed to the greatest amount along the zones of volcanic action. It was in this time that the extensive plains on the east coast of the middle Island, and the plateaus on the western side of the northern backbone, were raised above the sea. The best proof of this rising of the land is to be found in the river terraces, which strike the eye of every traveller in the valleys of the Wairau, Awatere, Clarence, Motueka, Wangapeka, Buller, Takaka, and Aorere, and also in the lines of the sandy downs on the Port Cooper Plains, which now, miles inland, mark the former limit of the sea.

These terraces are formed by the gradual rise of the land. If we suppose that, while the rivers are shaping out their beds, the upheaving movement is intermittent, so that long pauses occur, during which the stream will have time to encroach upon one of its banks, so as to clear away and flatten a large space, this operation being repeated at lower levels, there will be several successive cliffs and terraces. It is remarkable that in all the valleys the cliffs of the higher terraces are of a greater altitude than the lower. At the Buller River, for example, near its outlet from the Rotoiti lake, the uppermost cliff is 100 feet in height, and there can be distinguished

*At this house (Top house) I met some gentlemen newly arrived and stopped on their road by the river. One had made the journey from Port Cooper, and he gave me an account of hot springs which he had discovered on the Hanmer Plains, under the shelter of a range of snow hills. He observed what seemed to him a remarkable fog, and upon leaving his track to examine, he discovered some holes, which were filled with water of a temperature varying from milk warm to almost boiling. The largest of them contained the hottest spring, and although he attempted to sound the depth with all the rope he could procure, he was unable to find the bottom. The circumference of the largest was about fifteen or eighteen yards. This is I believe, the only instance of hot-springs yet discovered in the Middle Island, and, if corroborated, may tend to throw some light on the volcanic connection between this district and the Northern Island.—"A Walk from the Wairau," from the *Nelson Examiner*, May 25, 1859.

in one portion of the valley not less than eight terraces. The character of the terraces shows, that the upheaving force has been decreasing towards the present time, either in power or period. The extreme height of these terraces, being not more than about 2000 feet up the valleys, shows the whole amount of rise in these islands, since the tertiary period, to be about 2000 feet.

Even at the present day there are facts which prove that the land of these islands is not stationary, but that the relative levels of water, and dry land, are undergoing constant modifications. The rise of land at Wellington in 1855, to an average height of three or four feet, over a great extent of coast is familiar to every colonist. This rise of land, however, is not general over New Zealand; for there are many proofs that, while on the eastern side of the islands the level of the land is being raised, on the western side the land is sinking. An axis of equilibrium passes through the islands, on the western side of which the movement is downward, on the eastern side upwards. The same axis, curving round parallel to the Australian coastline, crosses the Pacific between New Caledonia and the Loyalty group, and can be traced through the Solomon Islands to New Guinea.

Ladies and Gentlemen,—It now only remains for me to express my thanks to you for the attention with which you have followed my geological explanations. Much more still remains that I would wish to say, but I must now conclude.

I feel well assured that the mineral wealth of Nelson is not confined to what I have to-day mentioned, but believe that in addition to gold, copper, and coal, future times will develop other valuable substances among your mountains and forests, which cannot fail to prove a source of wealth and prosperity to the Province of Nelson.

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