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Contents

Front Cover

Te Puna Wai Ora (*Spring of Life*), an urn-like sculpture of a free-flowing fountain and drinking water outlets supplied from the Hutt Artesian System at Petone, lower Hutt Valley, and opened in 2003. The photo (Editor: 2/3/2014) relates to the article on "The trials and tribulations of the Hutt artesian system" by Graeme Stevens in this issue.

The trials and tribulations of the Hutt Artesian System

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The Hutt Artesian System lies beneath the surface of the lower part of the Hutt Valley (Fig. 1). The System is fed by water derived from the Hutt River. As the river passes southwards towards Wellington Harbour from its sources in the Tararua Range it flows through the Taita Gorge. This gorge forms a natural division between the upper and lower parts of the valley (now occupied by the cities of Lower Hutt and Upper Hutt). Cotton (1914, 1921, 1951) described the overall topographic feature as an example of transverse deformation – warping along the line of a large transcurrent fault (the Wellington Fault; cf. Stevens 1958).

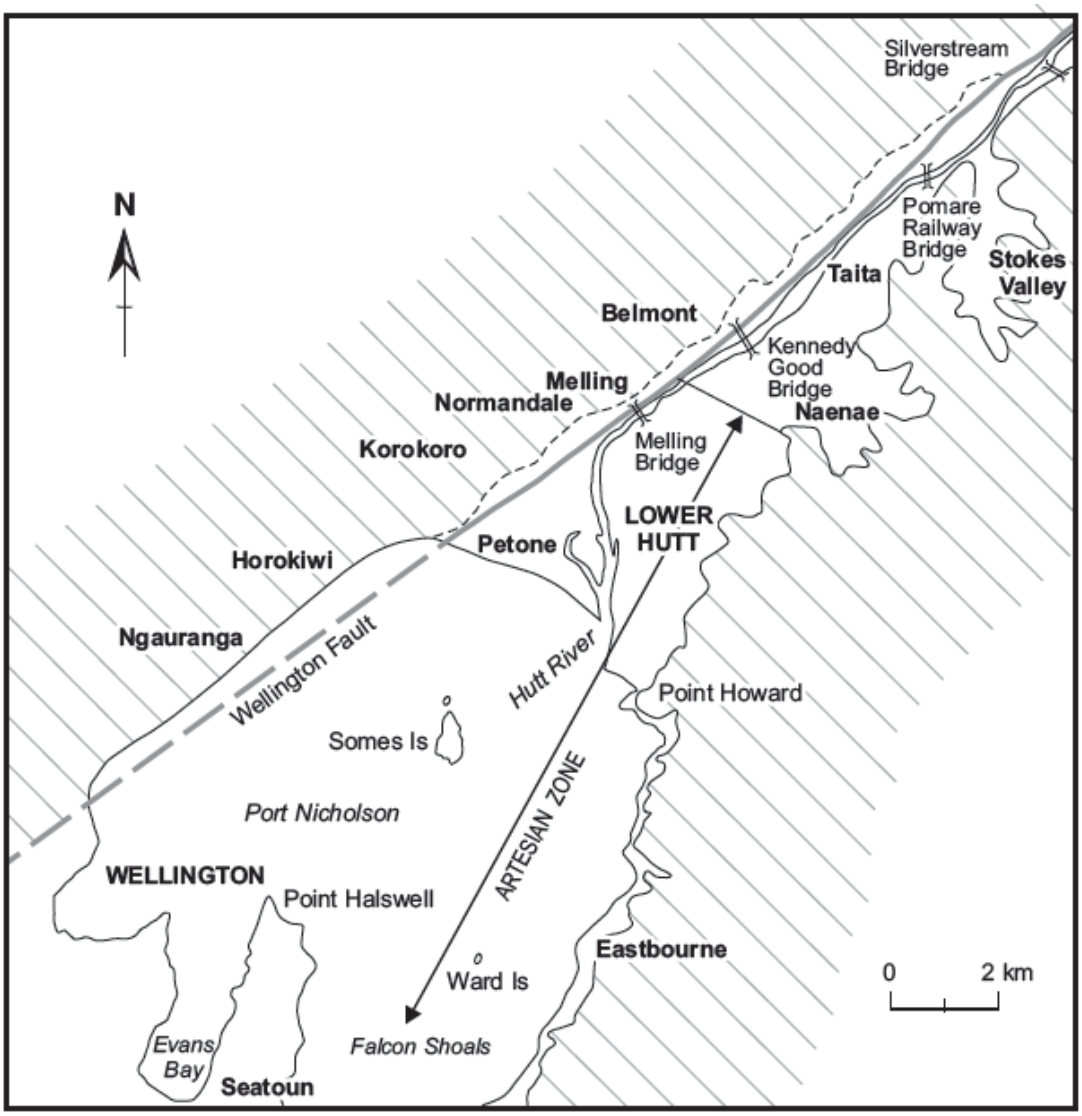

Fig.1. *Locality Map of the Wellington region showing place-names and the extent of the Hutt Artesian system.*

As the flow of the river passes across the flood plain gravels south of the Taita Gorge almost one-half of its total volume of water sinks into permeable layers within the gravels. The typical total normal flow of the Hutt River amounts to 225 000 cubic metres per day of which 125 000 cu. metres per day sinks into the gravels and is eventually added to the artesian system. The underground water continues to flow southwards, roughly matching the flow of the Hutt River on the surface. The area extending south from the Taita Gorge to a point between the Melling and Kennedy-Good bridges forms the infiltration (or recharge) zone for the Hutt Artesian System (Fig. 2).

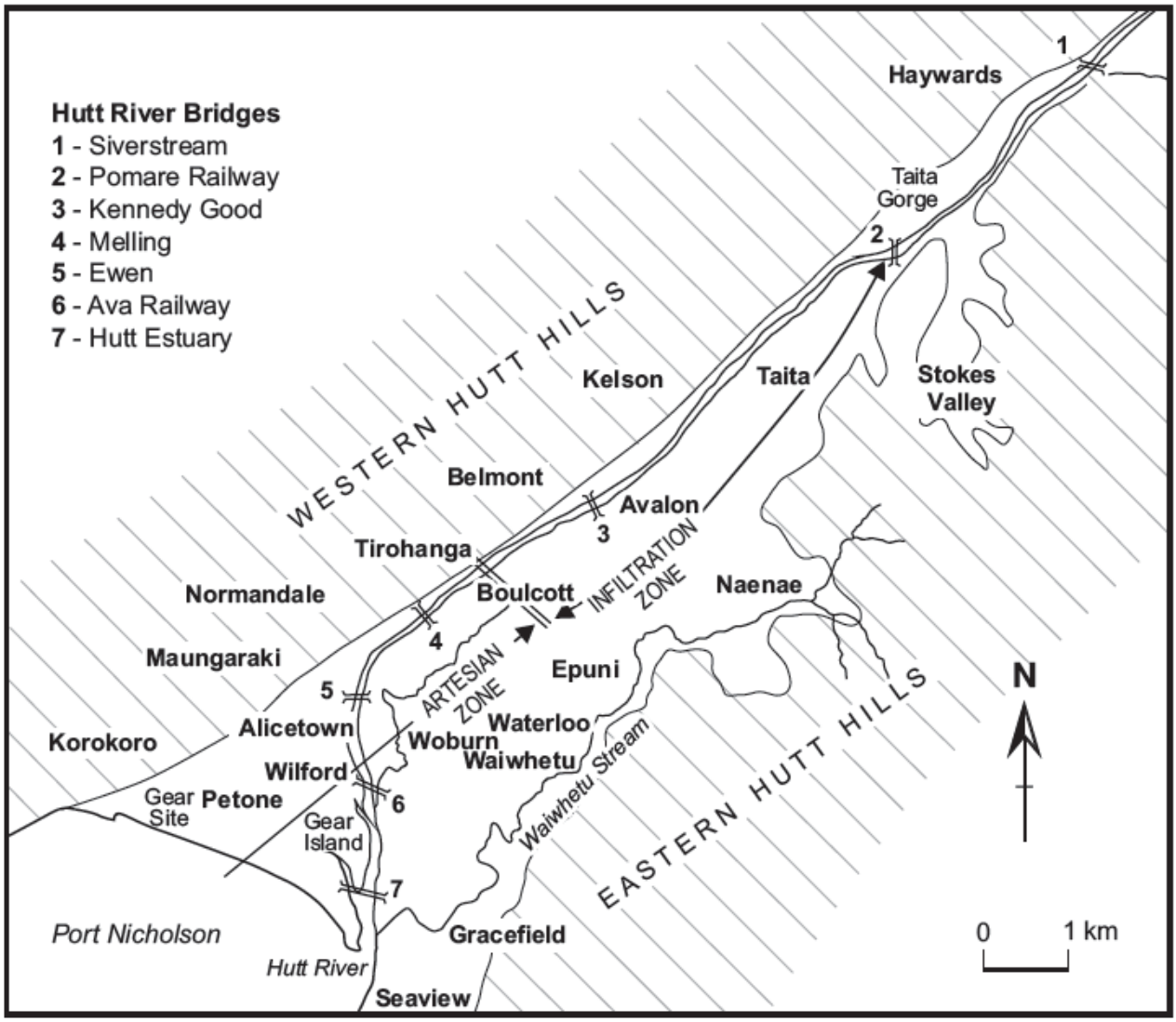

Fig.2. *Locality Map of the Lower Hutt Valley showing place-names mentioned in the text and the geographic extent of the artesian and infiltration zones of the Hutt Artesian System.*

In an area some 0.6-0.8 km north of the Melling bridge the outcrop of the Melling Peat Bed is encountered and is marked by a zone of rapids produced by fossil tree trunks in position of growth embedded in the peat formation (swamp deposits and debris from the old forest floor) (Stevens 1955, Plates 13-15; 1956a, Figs. 14-15). The fossil forest and associated peat beds extend under the Hutt City CBD and large trees are frequently encountered in foundation

excavations for many of the large buildings. Further south the Melling Peat Bed grades into the Petone Marine Beds. Both of these units dip towards Wellington Harbour and as they contain highly impermeable clays and fine silts, form a capping layer to the artesian system. The flow of water from the infiltration zone is confined under the capping layer and artesian pressures are developed. The artesian system is developed in the permeable gravels of the Waiwhetu Artesian Gravels, deltaic deposits of late Quaternary age (Figs.3, 4). The gravels were laid down primarily during low sea levels of glacial periods, when the harbour entrance was in the Rongotai area (Stevens 1956a). Less permeable marine sediments, including beach, estuary and lagoonal sands and silts were deposited during high sea levels in the interglacial periods. The Melling Peat Bed and the Petone Marine Beds date back to the post- glacial Flandrian Transgression, ca. 4000 years ago, when sea level rose to levels 2.5-3.6 m above mean sea level. At this time the sea flooded across the seaward edge of the Hutt delta, depositing the Petone Marine Beds and drowning the forest growing on the delta to form the Melling Peat Bed, with trees preserved in positions of growth. Some 25-30% of the water supplied in the Greater Wellington region comes from the Hutt Artesian System. Most of the water is obtained from aquifers at depths of 20-40 m in the Waiwhetu Artesian Gravels but deeper aquifers are also present up to 120 m below the surface, in the Moera Basal Gravels (Stevens 1956a).

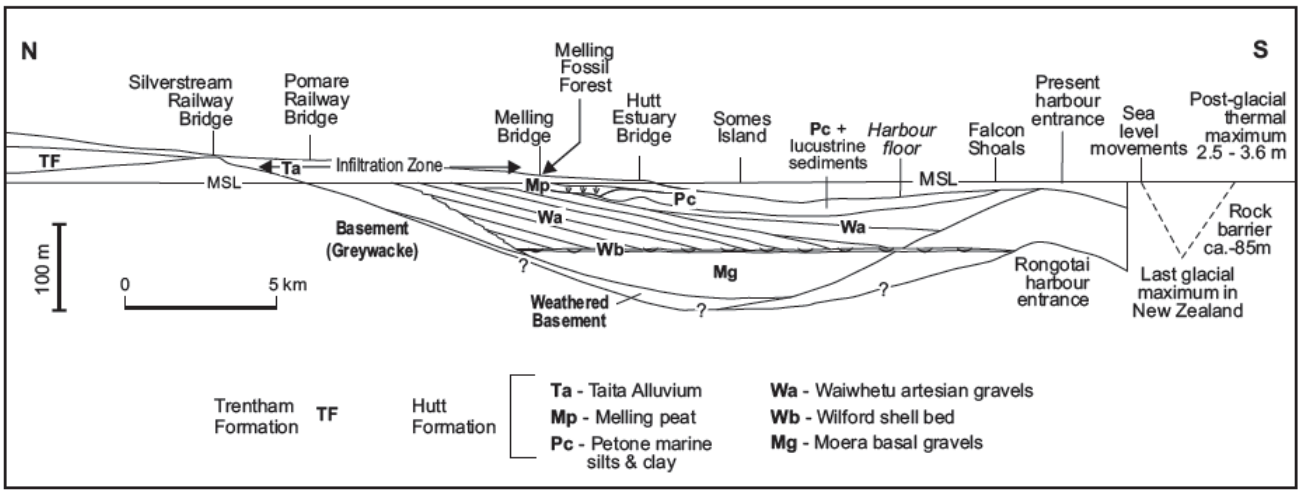

Fig.3. *Generalised longitudinal section of the Lower Hutt Valley, extending from the Taita Gorge to the entrance of Wellington Harbour. Simplified from Stevens (1956a, Fig. 10). This figure should be consulted to obtain greater detail, if required. In both Fig.3 and Fig.4 the stratigraphic succession is diagrammatic and based on widely spaced test bores.*

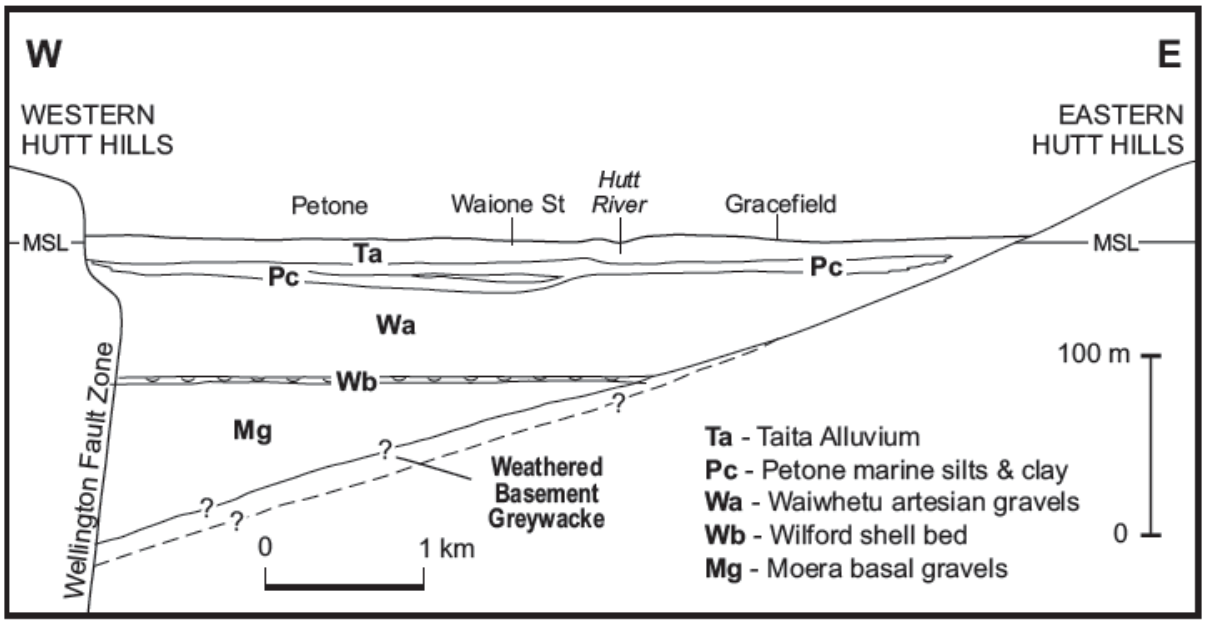

Fig.4. *Generalised cross-section of the southern margin of the Lower Hutt Valley, extending from the western part of Petone across to the Gracefield-Seaview area. Simplified from Stevens (1956a, Fig.11). This figure should be consulted to obtain greater detail, if required. The scarp of the Wellington Fault has been cut back over time by the lateral swinging of the meander belt of the Hutt River (Stevens 1958).*

As the lower valley was developed for farming the early settlers (post-1840) encountered a number of free-flowing artesian springs. As the water in the lower reaches of the Hutt River was of varying quality because of tidal influences the settlers soon recognized the superior quality of the artesian water and water from the springs was turned to good use for drinking water and for irrigation. The earliest record of an actual bore hole being sunk to tap artesian water was in 1883 at Mr C. Trevethick's residence at the corner of White's Line and Randwick Road (Hall 1941; Brown and Zucchetto in Begg and Mazengarb 1996, p. 90). With the passage of time the lower Hutt Valley became intensively developed with market gardens and food processing factories and eventually it became the main supplier of vegetables and fruits for the greater Wellington region. Many of the market gardens had their own private artesian wells and because the farmers lacked the means to install valves and control devices, many of the wells were simply left to run free.

As industry began to develop in the lower valley the demand for high quality water increased markedly. Industries such as the Gear Freezing Works, the Petone Woollen Mills and various food canning companies had major requirements for large quantities of pure water. The artesian water is exceptionally pure and good-tasting and as a consequence ideal for various types of food processing, for example. The purity of the artesian water is because it has had a stay of at least 40 months in the protected environment of the capped aquifer (Grant-Taylor and Taylor 1967). Also, as the water flowed southwards it was filtered by the process of passing through minute pore spaces in fine-grained sediments. As a consequence, any

biological or bacterial contamination which may have existed either in the river water or in the local groundwater has been rendered harmless.

In the late 1950s and early 1960s it became apparent that the rate of extraction of water from the artesian system was beginning to exceed the volume coming via the infiltration zone. Danger signals began to appear. At times, particularly during episodes of low flow in the Hutt River, artesian pressures would fall quite noticeably. Because the southern end of the artesian system is open-ended and discharges into Wellington Harbour in the vicinity of Falcon Shoal (near Barrett's Reef at the harbour entrance, off-shore from Seatoun), as well as at other points in the harbour, a fall in artesian pressure has the potential of enabling sea water to enter into the system. During the periods in the past when it was usual for the artesian water to be used without any restrictions sea water contamination would occasionally spread as far as the Wilford area of northern Petone (Stevens 1956b).

As a consequence, the territorial authorities, Lower Hutt City Council and Petone Borough Council, established the Hutt Valley Underground Water Authority, with the brief to study the artesian system and to regulate its use. The first task of the Authority was to reduce the wastage and to achieve this a major effort was put into locating and capping the various private wells dotted across the valley, most running to waste. Many of the Hutt industries had their own wells and these were recorded and measuring/control meters installed. As part of an on-going study, measurements were taken of river flows at various points in the Hutt River, to gain an estimate of the volumes of river water flowing into the infiltration zone. A number of monitoring wells were designated throughout the valley to obtain records of the changes in artesian pressure. A licensing system was established to regulate the overall use of the system and various users were allocated defined quotas. Four test bores were drilled down to basement – one at the Gear Freezing Works (310m), Hutt Park (181m), Wilford (128m) and Alicetown (134m) (Donaldson and Campbell 1977, Fig. 2.2).

A very strict watch was kept on any construction that was likely to need deep piling or deep excavation. For example, in 1942 two divisions of US Marines arrived in Wellington to begin training and preparations for the amphibious landings in Guadalcanal, to begin the first stage in the campaign to stem the advance of Japanese forces in the SW Pacific. To accommodate the huge quantity of stores, military equipment and vehicles extensive parts of the Seaview-Gracefield-Waiwhetu-Waterloo area were cleared, large storage sheds constructed and vehicle assembly parks established (to accommodate large numbers of trucks, amphibious tanks, amphibious armoured personnel carriers and landing craft). Because of the severe limitations on space at the wharves in Wellington it was decided to establish a docking facility at Seaview, close to the mouth of the Hutt River, to enable the discharge of cargo directly into the freshly prepared facilities in the Seaview–Waterloo area. To gain the necessary depth for shipping dredging of the sea floor would have been necessary with the likelihood of penetrating the capping layers of the artesian system. However, wiser counsels

prevailed and it was pointed out that in 1937 a similar idea was planned and dredging off the mouth of the Hutt River had resulted in a major loss of artesian water throughout the lower valley. In many instances the loss of artesian water at this time was 25-30% and recovery was very slow. The dredged areas had been rapidly filled in and any thought of a port at Seaview was abandoned.

Another incident happened in 1953 during the construction of the Estuary Bridge (Morrison 1954; Stevens 1956b). Excavation was proceeding for a large coffer dam structure to contain one of the piers for the bridge. As work continued it was noticed that the sides and floor of the coffer dam were moving upwards because of an underlying build-up of artesian pressure. Some of the sheet piles lining the coffer dam were moved upwards some 380 mm in a day. Very quickly work was stopped and various pieces of machinery and equipment sitting on the floor of the coffer dam were abandoned. Numerous truck-loads of concrete were poured into the hole in an attempt to equalize the build-up in pressure. The risk to the artesian system was such that the design of the bridge had to be drastically revised.

Because of the need to avoid similar incidents, the construction of the foundations for the new Ewen Bridge (1995-1996) necessitated special procedures and precautions and very careful monitoring. As a reflection of the care now being taken to safeguard the Artesian System, it is of interest to note that the details of properties in the artesian zone have an annotation stating the depth to the artesian system underneath the property. A property in Central Woburn, for example, has the annotation '16-18 metres down to GWRC (Greater Wellington Regional Council) aquifer'. Even in comparatively recent times the safety of the artesian system has required constant policing. For example, the operation of shingle plants, once a common feature of the Hutt River, had required constant vigilance.

The bed load of the Hutt River consists entirely of greywacke gravel. Because any soft or jointed material has been removed by prolonged abrasion during transportation by the river, the gravel is a high quality resource and as a consequence is much in demand for making concrete, etc. Additionally, sorting along the length of the river has resulted in a reasonably consistent size range, particularly in the lower reaches. As development proceeded of Wellington, the Hutt Valley and the Kapiti Coast the requirement increased for supplies of high quality gravel to be used in the making of concrete. In response to the demand numerous shingle plants were established along the length of the Hutt River in both Lower and Upper Hutt. In 1942, ten shingle plants were extracting shingle from the river bed The operation of the shingle plants was supervised by the Hutt River Board and monitoring took place of the amounts of gravel extracted, and the depth to which dredging could occur. Occasionally in the lower valley dredging was suspended because material from the capping layer, the Petone Marine Beds, appeared in the dredged material, indicating that the dredging had penetrated the upper levels of the capping layer and the potential therefore existed for rupture of the artesian system. The relevant shingle plants were closed. In addition, over time it was noticed

that despite monitoring of the removal of shingle the level of the river bed had been markedly reduced. In the 1960s it was determined that the bed of the Hutt River had been lowered by some two metres over 20 years. The lowering of the bed had the effect of reducing the total surface exposure of the gravels in the infiltration zone available for water to sink down into the artesian system. A complicating factor was that the supply of shingle to the stretch of the river below Taita Gorge had itself been diminished.

Over time the demand for aggregate far outstripped the supplies that could be obtained from the river. Also, from 1965 onwards, because of the need for constant monitoring of the shingle plants and often the activities of some irresponsible operators, they were progressively closed down. To provide an alternative source of supply, large quarries were opened up in the basement greywacke at – Karehana Bay, Ngauranga Gorge, Horokiwi and Haywards. In the lower Hutt Valley a large shingle plant at Belmont gradually phased out the extraction of river shingle and instead was converted into a processing operation for rock material transported from a quarry at Haywards.

The raw quarried material is fed into a crushing plant. Initially the crushed material is graded by means of screens and sieves. As the presence of too high a proportion of clay is undesirable, a large amount of water is used to wash the clay and silt from the crushed material. The coarse and medium fractions are used for roading and for concrete. The finer fractions are fed into a rod mill which manufactures grades of sand by crushing the hard rock with steel rods in a large rolling cylinder. Again a large amount of water is used to remove the extremely fine material (often in the form of slime) from the sand products. As sand is a commodity that is in fairly short supply in the Wellington area, the manufacture of sand eventually became a major activity.

All levels of operation of the plant, ranging from the production of aggregates through to grades of sand, sourced water from the river to wash away the fines. This water, laden with fine material, was fed back directly into the river. It was estimated that the amount of washings below 50 microns being discharged into the river was approximately 20 tons per day (Willett et al. 1973, p.12). Over time, deposits of fine material accumulated on the floor of the river. Although some amounts of such material were washed away by periodic floods, nonetheless it was observed that clogging was occurring in the river gravels, often extending to some metres in depth. As the plant was located in the infiltration zone for the Hutt Artesian System concern was expressed that because of the clogging there would be a reduction in the total amount of river water sinking down into the artesian zone, so diminishing its value to the overall community.

At times the water in the river was milky white or yellow, with a heavy load of particulate sediment. The overall appearance was very unsightly – even more so because as the river runs through the centre of the Hutt City it is visible to a substantial number of people.

As a result of representations from the Wellington Regional Water Board the Belmont shingle company and other shingle companies constructed settling ponds. In theory sediment from the settling ponds was supposed to be cleaned out periodically, dried and used as fill in subdivisions, etc. However, in practice maintenance of the settling ponds left a lot to be desired and there were many instances of overflowing and the walls collapsing – all contributing to the pollution of the river. Also people reported that the contents of the settling ponds were being regularly released into the river during the night.

Eventually the Water Board commissioned a public enquiry, chaired by Dick Willett, Assistant Director-General, DSIR and formerly Director of the New Zealand Geological Survey. The resultant report was very comprehensive (Willett et al. 1973) and among the various recommendations, the Tribunal placed an immediate ban on the practice of discharging into the river any material which may discolour the river water. During the four years before the Tribunal hearing it had been determined that the artesian head of wells in the Hutt Valley had steadily declined by over one metre and concern was expressed that the artesian system was being threatened. However, once controls were imposed on gravel extraction and discharge of washing water into the river, the rate of recharge into the artesian system improved and the artesian head recovered.

Now the Wellington Regional Council periodically 'rakes' the bed of the Hutt River in the infiltration zone to north and south of the Kennedy Good Bridge using heavy machinery to remove fine sediment and to promote the flow of river water into the artesian system. Today the Hutt Artesian System contributes some 25-30% of the water supply for the Wellington metropolitan region and a series of boreholes along the line of Knights Road in Lower Hutt feed artesian water into a large pumping station sited at Waterloo Railway Station. To satisfy demand from the public for high quality untreated water, boreholes are situated in two locations, in central Petone and central Lower Hutt. These are very well patronised, with people coming with large containers from Wellington, Upper Hutt and the Kapiti Coast.

Technical information on the Hutt Artesian System is contained in Stevens (1955, 1956b), Willett et al. (1973), Donaldson (1974), Donaldson and Campbell (1977), Brown and Zucchetto in Begg and Mazengarb (1966, pp. 90-94), and Begg and Johnston (2000, pp. 45-46). Condensations of four unpublished engineering reports on aspects of the Hutt Artesian System are included as Appendix 3 in Stevens (1955, pp. 263-273).

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"Some observations on the Geology of New Zealand" by James Coutts Crawford

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In 1855, the Quarterly Journal of the Geological Society of London published two articles on the geology of New Zealand, one by Charles Forbes (Assistant Surgeon on board the *Acheron* during the survey of New Zealand between 1848 and 1855), and the other by James Coutts Crawford (Fig.1). Crawford's article was read by the President of the Geological Society, William Hamilton, on May 16, 1855, under the title "Notes on the geology of New Zealand". It was published in abridged form as "On the geology of the Port Nicholson District, New Zealand" and is dated "Sydney, May 1848". It therefore represents one of the earliest accounts of New Zealand geology after that of the German naturalist, Ernest Dieffenbach (1843,1846). Crawford first arrived in New Zealand in November 1839; left for England in 1841 and returned to New Zealand in 1846; he again left New Zealand for England in April 1848 and must have stopped at Sydney from where he presumably forwarded his article to the Geological Society of London where it languished for seven years before being read and published in abridged form. After his return to New Zealand in 1858, Crawford was appointed geologist to the Wellington Provincial Government in 1861, a post which he held until 1864.

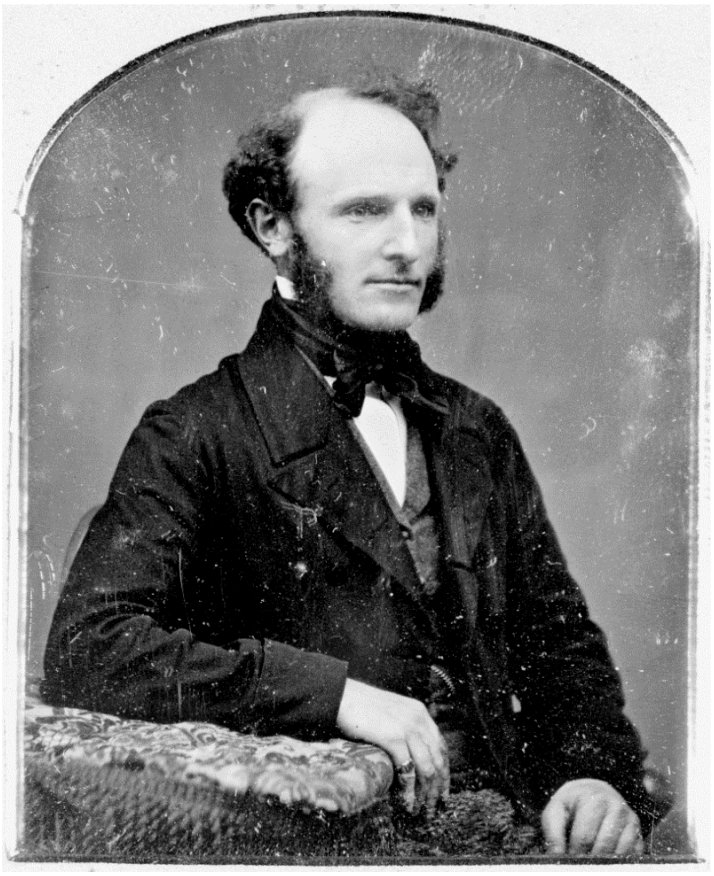

Fig.1. *James Coutts Crawford (between 1849-1856) (PA10-08-01, Crawford Family Collection, Alexander Turnbull Library, Wellington).*

An original version of Crawford's abridged 1855 article titled, "Some observations on the geology of New Zealand", is held at the Alexander Turnbull Library, Wellington (Crawford Family Papers MS-Group-0759), and is transcribed below. In the text, Crawford refers to a coloured geological map that was evidently sent with the manuscript to the Geological Society of London. So far, this map has not been located although it was probably similar, but may have extended further north, to the rough, coloured sketch map that Crawford sent to Ferdinand von Hochstetter in 1859 (also reproduced below with comments).

(**p.1**) "Some Observations on the Geology of New Zealand

Port Nicholson district including the south end of the northern island

1st. The shores of the harbour of Port Nicholson are bounded by a range of mountains having a height of from 500 feet to perhaps 2500 feet in the centre of the range. The direction of the range is from about NNE to SSW. The formation is metamorphic, and is called greywacke by my cousin Dr. Monro of Nelson, who is the most competent judge I have met with in the Colony. This range runs into abrupt mountains, forming precipitous & narrow gorges; strata broken, contorted, & at all angles, frequently perpendicular & often so altered that the stratification is doubtful. The rock is frequently of a siliceous texture, sometimes clayey & often veins into fine quartz. When struck by a hammer it breaks into angular fragments the size of road metal. It is intersected by numerous veins of igneous rock, but there is no appearance of lithic lava which may have flowed on the surface, or granite reefs, (**p.2**) and no fossil remains have as yet been detected in it. This rock crosses Cook's Straits & is found to form the central range of the Middle Island. Its northern and southern limits have not yet been ascertained.

2. Tertiary sands, clays, etc.
This is the formation of the west coast between the sea and the greywacke ranges, which latter probably underlie it. This country is very low and level, so that no extensive sections can be obtained until reaching Whanganui 110 miles from Wellington. The level of the country from there to Taranaki is higher, forming cliffs in which the stratification is very distinct & fossil trees are seen protruding from them.

5. Sand dunes
This low coast country is bounded on the shore by a strip of sand dunes thrown up by the constant NW gales varying in breadth from one mile to eight or ten. At Manawatu I observed in 1846 [*1841 in Crawford 1855*] a number of living trees, several miles inland, buried half way up their stems in blown sand.

3. Tertiary sands, clays, lignite, etc.
This is a stratified formation in the Wairarapa Valley, abutting on the eastern flank of the greywacke formation at + in (**p.3**) map. Here a gorge has been worn by a stream between the two formations and near this a stratum of lignite is found in the lower part of the cliff.

4. Supposed older Tertiary formations, composed of fossiliferous limestones & rising into mountain ranges & a very broken country. These mountains have not as yet been much investigated but I believe abound in marine shells.

The boundary between 3 and 4 has been coloured in at random, as it will require much investigation to determine.

Aqueous changes in this district
1st. The lower valley of the river Hutt or Haeretonga comprising about 8000 acres is entirely alluvial. The river floods its banks frequently every year carrying great quantities of sediment upon the land. At the mouth of the river raised banks have formed & I have seen the discoloured water from the stream after a heavy flood reach the town of Wellington at a distance of at least three miles.

2. The Ruamahanga and its tributaries water the valley of the Wairarapa district about (**p.4**) sixty miles in length. The river at its lower part expands into two lakes, the larger of which is about 15 miles in length [*Lake Wairarapa*]. Palliser Bay into which the river flows is open to the full sweep of the SE gales. The consequence is that where these gales blow hard a mass of sand & shingle is thrown across the mouth of the river which effectively dams it up. An accumulation of water then takes place in the lakes until the pressure is so great that the pent up waters sweep down and all before them & communication is again opened with the sea. These changes generally occur several times annually. The muddy water therefore of the flooded Ruamahanga must in general spread over the surface of the lakes & there deposit its sediment & the greater part of them is now so shallow that I think no distant epoch will be reached before they are left dry land.

3. The rivers on the west coast, the Waikanae, Otaki, Manawatu, Rangitikei, Wanganui, etc., all form bars at their mouths. They also flood the surrounding country to a greater or less extent & some of these, particularly the Manawatu, must bring down unusually a vast body of sediment.

(p.5) Presumed rise in the land
I think that there is every appearance to induce one to suppose a not very remote rise of the land in the country surrounding Port Nicholson. I have observed the rocks on the shores of the harbour, particularly at the Rimutaka, honeycombed by the action of the sea at a height of about 10 feet from high water mark. I was, however, quite unsuccessful in finding any shells

adhering to the rocks. The site of the greater part of the town of Wellington is a water formed terrace, evidently produced by debris brought down by small streams from the hills, spread out by the action of the waves which washed the shore. The highest part of the terrace is perhaps 80 or 100 feet above high water mark. Fluctuations in the height of the land is to be looked for in New Zealand. Earthquakes are extremely frequent coming from the direction of Tongariro, the great central volcano of the island & decreasing in energy as they recede from that point. Four years since the town of Petre [*Wanganui*], on the north side of the Wanganui [*River*] became visible from the Rev[d] R. Taylor's house on the south side of the same, after a severe shock [*July 8, 1843*]. A brig (supposed to be the *Active*) was reported last year [*in 1847*] to be found (it was said (**p.6**) by the sealers) 300 yards from high water mark on the west coast of the Middle Island. This vessel was supposed to have been wrecked about 20 years previously[1].I think it would be well worth the attention of geologists to watch the level of the land in New Zealand. A tunnel which I cut horizontally from high water mark [*in 1847*] to drain Burnham Water in the peninsula [*Watts Peninsula, and later Miramar*] near Wellington will form an admirable mark in that locality[2] (Fig.2).

Tasman's Gulf and country surrounding Nelson

I paid a short visit to Nelson in 1847 in the *H.M.S Inflexible*, but my stay there was too short to enable me to observe much of the geology. The greywacke ranges form the main range of the eastward in the direction of the Hyeri? [*Hoihere?*] or Pelorus river. Advancing westward, limestones & the coal measures are found & and in the high ranges near Massacre Bay [*Golden Bay*] primitive rocks are found. The valley of the Waimea, the principal valley of Tasman's Gulf [*Tasman Bay*], has, from the immense amount of shingle which it contains, every appearance of having once formed a sound communicating perhaps with the Wairau plain & valley. Here also there is every appearance of a (**p.7**) progressive rise in the land & it would seem that Tasman's Gulf is gradually emerging from beneath the waves. Much land is in [*the*] process of reclamation towards the eastward of Nelson at Wakapuaka.

Taranaki or near New Plymouth

I visited Taranaki for a few days in the *H.M.S. Inflexible*. The grand feature of this country is the extinct volcano of Mt. Egmont, a very perfect cone rising, according to Dieffenbach, to the height of nearly 9000 ft. above the level of the sea and presenting one of the grandest & most picturesque sights in the world (Fig.4). The prevailing rock in the mountain itself is described as lavas & trap. The only rocks which I had the opportunity of observing were the barely indurated sandstones & the soft clays & sands of the coast & true reefs of granite[3] which line the shores. A peculiar feature of Taranaki is the sand of the sea beach, which is an iron ore of great thickness. How it came there is a point worthy of attention. On the morning we left Taranaki we saw the eternal snows of the far distant Tongariro, situated in the centre of the island & an active volcano.

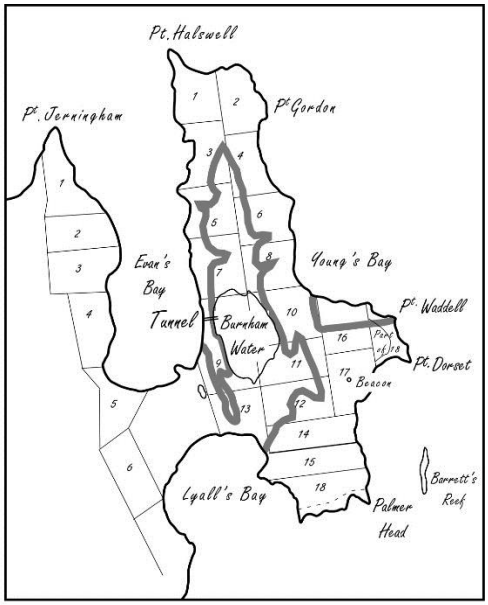

Fig.2. ***(Left)****. Pencil sketch entitled "Tunnel Haitaitai (later Miramar) Peninsula 1846, Wellington, N.Z." by James Coutts Crawford looking east and showing the exit of his tunnel to drain Burnham Water (Para Lake) in Miramar Peninsula into Evans Bay. Completed in 1847, the tunnel was the first in New Zealand. In the sketch, the entrance is cut into the cliff and is supported by beams around the opening. A small hut (possibly for the workmen) stands to the right of the tunnel and a path winds up the hill through which the tunnel has been excavated (A-229-023. Alexander Turnbull Library, Wellington). Crawford sent Hochstetter a sample of "hard greywacke-type sandstone from Ruruhaui Water Tunnel"* [4] *(Hochstetter 1864; Fleming 1959, p.35), that may refer to the same tunnel shown in Crawford's sketch. (**Right***). Map of Miramar Peninsula showing location of Crawford's tunnel and Burnham Water. The map is a copy of the one archived with Crawford's geological account transcribed here.*

(p.8) Auckland

The country surrounding Auckland is thickly dotted with, I may say dozens, of small extinct craters of a height of from 100 to 300 or 400 feet. The volcanic action has probably ceased for earthquakes are now unknown. The shores of the harbour are lined by cliffs of slightly indurated clay & sandstones, with beds of lignite towards the east. Much lava & scoria is strewed over the country."

(*Appended note, presumably to the Secretary of the Geological Society of London*)

"I regret that I am unable from my limited knowledge or rather ignorance of fossils and from the difficulty which at present exists of obtaining them, without devoting more time & trouble to their search than I could have, to find a more detailed & interesting account of the geology of New Zealand, but I hope that any information, however slight, from such remote region may be acceptable & may tend to draw the attention of geologists to a country in my opinion perhaps is of great interest for them, from the rapid changes, both aqueous and igneous now in progress. It will be perceived that I have confined my observations entirely to the districts which I have visited in person."

Fig.4. *Painting by Charles Heaphy entitled "Mt. Egmont from the Sugar Loaf Islands, Taranake 1849. (A-145-011. Alexander Turnbull Library).*

1. See discussion (pp.22-25) on the "Active" in Grapes R 2012. Haast to Lyell I. 1862. *Geoscience Society of New Zealand Newsletter* 8: 13-29.

2. After the 1855 earthquake, Crawford found that "...my tunnel is now 4^{ft} 9/10ths above the reach of high water in Evans Bay" (Crawford JC, Diary 1858, January 20. MS-Papers-1001-006. Alexander Turnbull Library, National Library of New Zealand

3. Probably a reference to the andesitic rocks of the Sugar Loaf Islands, New Plymouth.

4. The name "Ruruhaui*"* has not been traced to any particular locality on the Miramar Peninsula (footnote in Fleming 1959, p.35). It appears to be Hochstetter's misspelling of "Burnham" (as in "Burnham Water" marked on Crawford's map) when transcribing Crawford's handwriting.

Shown below is a copy of Crawford's geological sketch map of the Port Nicholson District sent to Ferdinand von Hochstetter in 1859 (Fig.4). References on the map to 'Muka muka rocks, earthquake 1855 9ft.", "Featherston", "Masterton", and "mussel found" (near

Masterton) indicate that it was drawn after the 1855 earthquake. The "mussel found' locality was described by Walter Mantell at a meeting of the Wellington Philosophical Society, November 28, 1851 (see Grapes 1995). Crawford has mislabeled the river where fossil shells were described as the "Waipoa" – this is the Waingawa River; the Waipoua River is the next major river north of Masterton. It is curious that Crawford does not show the extent of "diluvium" along the west coast that he describes in his paper under the headings of "Tertiary sand, clays, etc" and " sand dunes", although he does state that greywacke of the axial ranges probably underlies these deposits.

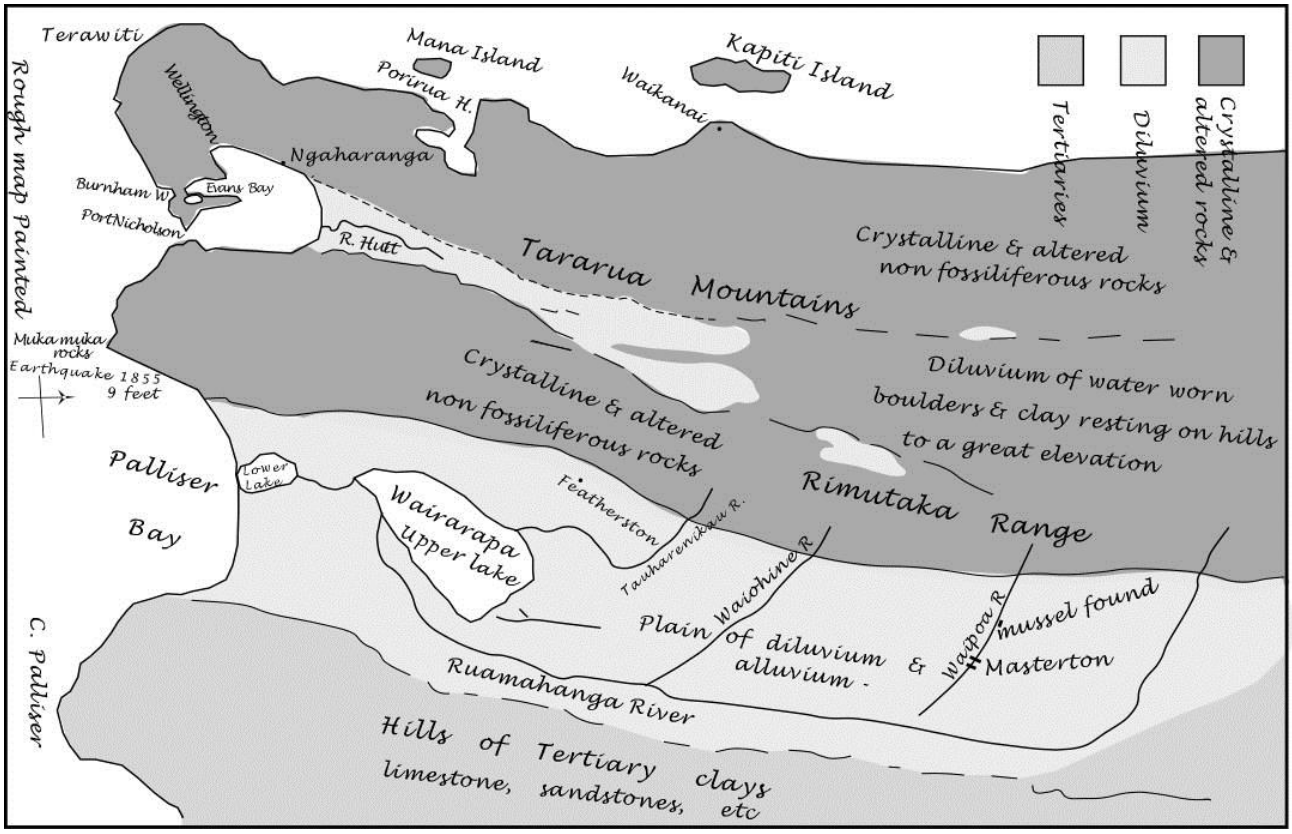

Fig.4. *Geological sketch map of the Port Nicholson District by James Coutts Crawford (redrawn from original map in the Dr. Albert Schedl Collection, Vienna, and reproduced in Johnston and Nolden 2011, p.139). The original map is coloured with; Crystalline & altered rocks = orange; Diluvium = green; Tertiaries = purple.*

The sketch map was enclosed with mineral samples as explained in an accompanying letter to Hochstetter,

"Wellington. New Zealand Feb.26. 1859
Dr. Hochstetter
Geologist re to the I & R
Austrian expedition
Sir

I bed to enclose for your consideration some specimens of a mineral lately found in the Wairarapa Valley. These specimens were found in Diluvium of the valley and I enclose two pieces of water worn quartz showing the metal on their surface. The native rock is evidently to be looked for in the main Tararua Range & probably in the gorges of the Waipoa and the Ruamahanga – but as these gorges are densely wooded and very rugged their examination will involve considerable labour. I enclose a rough geological chart to show the formations of the District."

(Original in Dr. Albert Schedl Collection Vienna)

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Moa bones and New Zealand's early museum directors

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The Moa was crucially important to the development of New Zealand science in the colonial period. Questions about Moa classification and Moa extinction gave New Zealand science an independent subject of enquiry on which colonials did not need to defer to imperial experts with access to large museum collection (Gruber 1987; Barton 2000). Moa were also important in museum building. Moa bones and bird skins were the chief local resources which New Zealand's museum directors exchanged or sold in order to expand their collections (Sheets-Pyenson 1988).

Moa astounded and fascinated everyone, from serious scientific men to Prince Albert and the general population. Ferdinand von Hochstetter, geologist on the Austrian *Novara* round-the-world exploring expedition, had admired the articulated Moa in the British Museum before leaving on the expedition (Berentson 2012, p.137). When asked by provincial governments to look for coal and gold in the Auckland and Nelson provinces in 1858 and 1859, he hoped he would be able to find Moa bones for himself. Hochstetter was given little time for bone hunting, but his assistants found some near-complete skeletons in caves and the grateful people of Nelson gave him their prize large, almost-intact *Palapteryx ingens*. In Vienna expert model builders restored the skeleton and made plaster copies which were sold worldwide (Berentson 2012, p.143).

By examining moa bone exchanges among New Zealand's early museum directors, this article emphasizes how highly valued were impressively large bones and full skeletons, and elaborates facets of museum politics and individual personalities which are little known. The three museum builders in this account are Julius Haast (1822–1887), James Hector (1834–1907) and Frederick Hutton (1836–1905), who arrived in New Zealand in 1858, 1862 and 1866 respectively (Fig.1).

Hector had the highest scientific standing of the three. Hector was Dr. Hector, educated in medicine in Edinburgh, at a time when a medical degree was the major means of formal education in the natural history sciences. He gained a reputation for geological ability and physical toughness on the Palliser expedition to western Canada in 1858 and was appointed Otago Provincial Geologist on the recommendation of Roderick Murchison. He was well-connected with scientific men at the imperial centre. In 1865 when the Colonial Government decided to set up a geological survey it offered the position of Director to Hector. In Wellington he accumulated many other national scientific roles, including Director of the Colonial Museum.

Haast arrived in New Zealand before Hector, but as a migration agent for a shipping company hoping to attract German migrants. His career was shaped by the lucky accident of his arrival the day before the *Novara*. As a German speaker (Haast was born in Bonn within the Kingdom of Prussia), with an interest in geology, he rapidly made the acquaintance of the Austrian scientific men and accepted invitations to work with Hochstetter on the surveys of the Auckland and Nelson provinces. Haast gained field experience with Hochstetter and scientific credibility within New Zealand from his association with the latter's much appreciated work. On Hochstetter's departure Haast negotiated a position as geologist with Canterbury Province.

Captain Hutton, retired army officer, arrived in Auckland looking for money-making opportunities, although, as he made clear to Hector, he would rather obtain scientific employment. He had been active in the Geological Society in London in the preceding five years. While investing in a sheep run and pursuing flax milling, he tried to revive the run-down Auckland Museum (f. 1852). Hector contracted Hutton to produce occasional reports for the Geological Survey, and in 1871 appointed him assistant geologist. Later he was curator of the Otago Museum and later again the Canterbury Museum, but this article does not go beyond the 1860s.

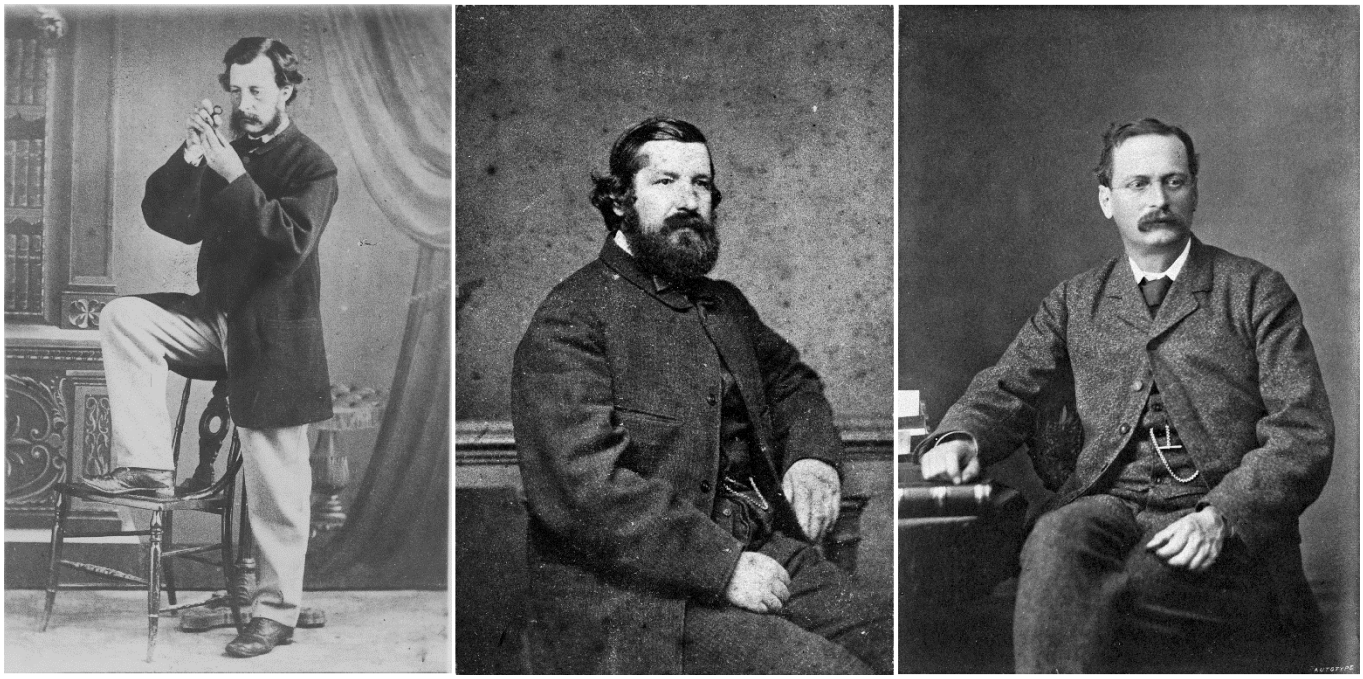

Fig.1. *Hector, Haast and Hutton, c. late 1860s – 1870s. Left to right: James Hector, after 1865, when Director of the Geological Survey of New Zealand; Johann Franz Julius von Haast, later Sir Julius von Haast (creator unknown); Frederick Wollaston Hutton (photographer unidentified).*

The early museums were seldom separate establishments. In Canterbury and Otago, Haast and Hector built up collections associated with their geological employment and

opened them to the public. When Hector left Otago his collection mouldered away. Haast's collection survived because, when his appointment as geologist came to an end, an independent Canterbury Museum (f. 1868) was established and he was appointed Director. Hutton, who operated the Auckland Museum as a volunteer, had no resources and even had to do the cleaning himself (Letter 13, 10 August 1867, in Mildenhall et al. 2013).

In early letters between Haast and Hector the enthusiasm of the romantic German contrasts with the more formal style of the Scot. Haast initially hoped that live Moa might be found in isolated parts of the middle island. He wrote to Hector, who was about to explore in the west coast of Otago: 'Lookout for the Moa. I am certain it exists there, as two years ago the Hon. Watts Russel when exploring with whaleboats the coast, killed a large Emu-like bird, and ate it! without even preserving a single feather.' (Letter 15, 5 November 1852, in Nolden et al. 2012). Although differences in personality appear clearly, the early letters between Hector and Haast were friendly. They exchanged ideas about geological formations and mountain passes, and Hector assured Haast that he would like to exchange specimens.

The importance of Moa as display items is apparent in letters exchanged between Hector and Haast in preparation for the 1865 Otago exhibition. Hector wanted to borrow Haast's cast of the Vienna Moa. But Haast said no, 'it really would not bear another journey', and he wanted to keep it in his museum as an attraction for local visitors (Letter 27, 4 January1864, in Nolden et al. 2012) Instead, he offered large European specimens from the Canterbury Museum.

Early display skeletons were usually incomplete and made up of bones drawn from different individuals, often even different species. Many large heavy large leg bones survived, but fewer ribs, pelves or feet and even fewer delicate skull bones. The early finds were seldom from a single individual. Individual skeletons and rare parts commanded high prices, as Hector glumly explained to J. D. Hooker of Kew Gardens: 'Since I wrote last enclosing Tracings of Moa Bones I have got hold of a splendid Head & nearly all the other bones of *D. giganteus*. The head is well preserved & and as it is unique I enclose tracings of 5 views of it – natural size.' However, it was only on loan and Hector could not afford to buy it: 'people give fabulous prices for them as curiosities to send home to friends who dont value them' (Letter 30, 17 July 1865, in Burns and Nathan 2012). A few months later, he confessed to Hooker that, because he no longer had the correct head, his *D. giganteus* was displayed with the head of a *Palapteryx* (Letter 35, 12 October 1865, in Burns et al. 2012).

The supply of Moa bones and skeletons was transformed in late 1866 when a swamp of densely packed bones was found at Glenmark Station near Waipara in Canterbury. The owner gave the bones to Canterbury's Provincial geologist (Fig.2). Haast had sixty separately identifiable individuals, which was greater than the total previously collected (Letter 105, 10 August 1867, in Nolden et al. 2012; Berentson 2012, p.149).

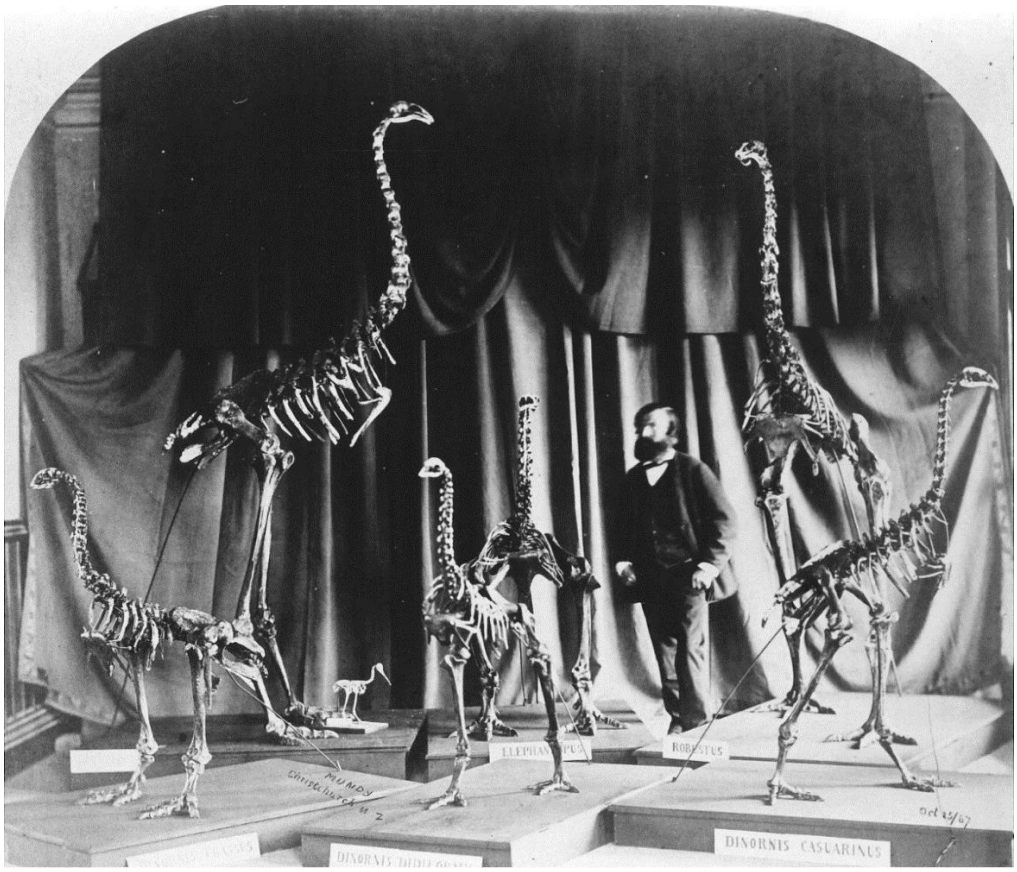

Fig.2. *Haast with the temporary exhibition of his Glenmark Moa skeletons in the Canterbury Provincial Chamber Building, 1867. (Photo: DL Mundy).*

Haast seemed secretive while excavating his bones and setting up his skeletons. Hector's employees and friends were suspicious. It is unclear to what extent the bad feelings were justified or arose from misunderstandings. John Buchanan, botanist to the Survey, changed his route when he found himself near Haast's site. In Christchurch, Haast's assistant refused to let Henry Travers from Wellington see the skeletons that were being articulated (Buchanan 1867; Travers 1867). These stories became muddled as they passed around Wellington circles. Mantell later told Haast that Buchanan had complained at not being allowed to see the Moas. Haast was puzzled – no one had seen Buchanan – but explained to Hector that his instructions had been intended to keep out the general public, not scientific colleagues (Letter 116, 27 April 1868, in Nolden et al. 2012).

In contrast to this suspicion, Haast's correspondence with Hector while excavating the swamp and articulating his skeletons was full of enthusiastic generosity. He constantly invited Hector to visit, offered duplicate bones to the Colonial Museum and asked advice. 'I repeat', Haast told Hector, that I am quite willing to let you have from my duplicates of Moa bones, what you want. All I wish to see our colonial collections … as complete and instructive as possible.' (Letter 102, 11 July 1868, in Nolden et al. 2012). Invitations continued. Could not Hector come for just one day (travelling overnight by steamer on consecutive nights), to

both admire and give his opinion on the six articulated Moa skeletons before they were photographed and before the duplicate bones were sent away in exchanges? (Letter 105, 10 August 1867, in Nolden et al. 2012). He reported on the hallux, or high back claw, which occurred on many more species than in Richard Owen's descriptions.

More than in most previous finds, near-complete skeletons were found together at Glenmark, but the swamp was packed so closely that the sets of bones were tangled together and Haast wanted to check that Hector agreed with his groupings and articulations. 'I worked the matter up very much & I would have been only too glad, to see if my deductions were correct.' (Letter 112, 25 December 1867, in Nolden et al. 2012).

Haast actions bear out his assurance to Hector that he wanted the best for colonial institutions. When his own skeletons were articulated he had spare bones to prepare two skeletons, 'as perfect, as the bones in our possession would allow me', for Hector. His formal letter carefully specified which bones were missing, which artificial, and which had been plastered together from fragments. Haast requested objects in exchange: 'a collection of NZ shells, named as far as possible & as complete as it is in your power, also the few northern Island bird skins, so as to complete our Collections', and attached a list of the desired birds. Each skeleton was divided into three sections for packing, then, because there was space to spare in the cases, Haast added some leg bones (Letters 124, 29 June 1868, and 125, 2 July 1868, in Nolden et al. 2012).

In the correspondence with Hector, Haast appears generous. But Hutton accused Haast to Hector of being mean with his Moa bones and skeletons. The Moa collection in Auckland was limited to a few leg bones, one vertebra and a skull (Letter 6, 10 June 1867, in Mildenhall et al. 2013). Hutton reported to Hector that, when asked for some skeletons, Haast had replied, 'when I shall get a box from you containing Maori skulls, frogs shells & fossils I will then send some Moa bones.' Hutton added, self-righteously, as if he did not want to denigrate Haast, 'as I do not like bargaining in science I shall say no more about it.' (Letter 7, 27 June 1867, in Mildenhall et al. 2013). My impression is that Hutton was malicious – he maligned Haast to Hector and, in later years, Hector to Haast, as if he was trying to rouse disrespect and distrust on both sides.

Gentlemen, such as the owner of Glenmark Station, might *give* bones to institutions but the convention was that museums *exchanged* specimens. Haast asked for shells and bird skins in exchange for the two skeletons he sent Hector. Moreover, countering Hutton's accusation, Haast sent eleven parcels of bones to Hutton via Hector in 1868 (Letter 126, 2 July 1868, in Nolden et al. 2012; forwarding note dated 8 July 1868, Te Papa MU000013/001/0001/0388). Hutton came to understand that skeletons were seldom given away and in 1872 offered to pay Haast for 'a good skeleton of a large species' (Letter 93, 20 July 1872, in Mildenhall et al. 2013).

From his first finds of Moa skeletons, Haast was aware of their value as exchange objects. He often proposed collaborative exchanges to Hector. Sometimes it took the resources of both to complete a skeleton or provide the range of bones that a big museum wanted. Their lists of desiderata reveal varied motives – collections of use in mining geology, systematic collections useful for classifying local specimens, and 'show' items to draw spectators to their museums. While articulating the skeletons for Hector, Haast was coordinating a collection to send to his friend, the German speaking Swiss, Louis Agassiz at Harvard. 'We ought to ask', he suggested to Hector, 'for as complete a collection of American fossils as well as a good collection of recent shells & their duplicates for Europe etc. A collection of type fishes, echinoids & Asteroids. Will you have some show things? as a large crocodile, snakes, quadrupeds. . . . All what he wants we shall find amongst your duplicates or can get it easy without any expense!' Haast expected they would also receive 'a fine share' of the collections Agassiz had made on his recent trip to the Amazon. 'Answer at once', he added, because Hector was often slow to reply (Letter 122, 26 June 1868, in Nolden et al. 2012).

Two weeks later Haast wrote excitedly to Hector about another exchange, this time with Norway. A local Norwegian, a shipping agent, would like to send bird skins and moa bones to the Christiania (Oslo) Museum and would transport them free! 'I think we can safely promise him 50 birdskins (some skins of *Apteryx* included as I have a good many)', plus Moa bones, fishes in spirits of wine, and shells, wrote Haast (Letter 131, 12 July 1868, in Nolden et al. 2012).

While Haast and Hector were engaged in these exchanges, Hutton tried to cut Haast out of a valuable exchange and ingratiate himself with Hector. Hutton, who had received a letter from the bird specialist, Alfred Newton of Cambridge University, wrote to Hector: '[Newton] says he has some sets of Dodo's bones & perhaps a solitaire leg to give away (Fig.3). He thinks of sending them to Haast but has forgotten which Museum is his; send him off at once a box of moa bones and you will get them.' 'Don't forget', he reminded Hector two months later (Letters 42, 1 January 1869, and 46, 22 February 1869, in Mildenhall et al. 2013).

Fig.3. *Dodo Skeleton*

Haast's Moa collection made him the envy of museum curators worldwide. His new museum was written up and his Moa given a half-page engraving in the *Illustrated London News* (8 February 1868). Hector heard that the engraving fell 'far short of reality' and, at last, decided to visit, but only after Walter Mantell, civil servant and Wellington gentleman, recommended Haast's new museum. Hector explained to Hooker, 'from Mantell who is a good judge I hear it is a perfect model of good arrangement. I am going to take a run down to see it.' (Letter 60, 3 June 1868, in Burns et al. 2012).

Whereas Haast treated Hector with respect this exchange suggests that Hector did not reciprocate. Haast praised Hector to Hooker for his excellent geological judgement and wished he were closer for easier consultation (Letter 71, 1 August 1868, in Nolden et al. 2013). Hector, however, responded condescendingly when Haast expressed his intention to write a paper on Moa: 'What <u>are</u> you going to write a Moa paper about? Have you any new specimens & do you feel game to go in for description? or is it a little popular notice of the bones you have found.' (Letter 106, 23 August 1867 in Nolden et al. 2012).

Hector's work was not so obviously superior to Haast's as to justify this exchange. Newton, ornithologist and Professor of Zoology and Comparative Anatomy at Cambridge, was disappointed with the bones sent from the Colonial Museum. Newton was interested in Moa distribution, but the labels recorded no locations for the bones he had received (Newton to Hector, 27 October 1870, Te Papa MU000147/003/0213). Moreover, Trevor Worthy and

Richard Holdaway identify Haast's 1869 description of *Dinornis maximus* as significant because it was named on the basis of several parts from a single skeleton (Newton to Hooker, 27 October 1870,).(Worthy and Holdaway 20012).

This article has focused on the early relationships between Hector, Haast and Hutton. Inter-personal relationships became more difficult in the early 1870s. Hector and Haast were on opposite sides in bitter disputes over Moa extinction. Haast, who had changed his mind about the contemporary survival of the Moa, argued that they had been exterminated by a pre-Maori people. Hutton and Hector also fell out.

This study supports previous analyses of the importance of Moa as museum objects, both for local display and for exchange. Moreover, because Moa were so very desirable, Moa exchange throws light on the relationships between museum directors in New Zealand. Hutton appears here as manipulative, Haast as generous and genuinely respectful of Hector. Hector's personality emerges less clearly. However, even before the moa-hunter controversy he expressed reservations about Haast's science. Hector's own practice was not perfect, as is clear from Newton's complaint about inadequate labelling. The extent to which the judgements Hector, Hutton and Haast expressed about one another were self-interested or had xenophobic elements warrants fuller consideration through close comparative study of their scientific competencies.

Acknowledgements

I am grateful to the Hocken Library, Dunedin and the Museum of New Zealand Te Papa Tongarewa, Wellington, for access to their archives. Especially, I thank Jennifer Twist, Te Papa Archivist, for her assistance. I also thank the Alexander Turnbull Library, the Hocken Collection of the University of Otago Library, and the Canterbury Museum, for permission to reproduce photographs from their collections.

Photo credits: Haast, reproduced courtesy of the Alexander Turnbull Library, Wellington (Ref: 1/4-002124-G. http://natlib.govt.nz/records/22705267). Hector, from the Hocken Collections, Uare Taoka o Hakena, University of Otago (Ref: Negative c/nE1856, scan S07-032). Hutton, reproduced courtesy of the Alexander Turnbull Library, Wellington (Ref: MNZ-0474-1/4-F. Making New
Zealand: Negatives and Prints from the Making New Zealand Centennial Collection, http://natlib.govt.nz/records/22677400). Haast and Glenmark Moas, 23 Oct. 1867, Courtesy of the Canterbury Museum (Ref: 7558).

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The lengthy biography of Haast written by his son has resulted in Haast being better known and easier to research than Hector and Hutton. Simon Nathan's work towards a biography of Hector is shifting

this imbalance. The openly available transcripts of letters on the Geoscience Society website (www.gsnz.org.nz/information/misc-series-i-49.html) have been immensely useful to me. All quotations from letters are taken from these publications. Idiosyncrasies of grammar and punctuation are in the originals.

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A letter from Collingwood, December 1866

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Amongst the extant voluminous correspondence to and from Sir James Hector (1834-1907), the first Director of the Geological Survey and without question New Zealand's leading 19th scientist, is a 16 page letter he wrote from Collingwood on 20 December 1866 to Walter Baldock Durrant Mantell (1820-1895)[1]. Mantell was the son of the noted dinosaur palaeontologist Dr Gideon Mantell and had immigrated to New Zealand in 1840. He held a number of official positions and was currently temporarily in charge of the Colonial Museum while Hector was engaged in an extensive survey of the West Coast coalfields. Commencing in Golden Bay, the survey would undoubtedly be a challenging one, which due to wet weather and the rugged terrain was to last eight months. Assisting Hector was Thomas Ridge Hacket (1827-1884), a mining geologist who had arrived in Nelson in 1857 to manage the ill-fated Dun Mountain Copper Mining Company[2]. Instead of copper, Hacket had on behalf of the company, and later on his own account, overseen the mining of chromite. When the price of chromite collapsed, Hacket and his younger brother James Henry Hacket (1827-1914), and also a mining geologist, moved to Otago where they were involved in a number of mining ventures. Thomas Hacket at times assisted Hector during the latter's tenure as Otago provincial geologist. In what, Hector again employed Hacket as a geological assistant.

Wellington to Collingwood

Hector arrived in Nelson from Wellington in early or mid-October 1866 but the coal survey did not commenced immediately as he soon after sailed for New Plymouth. On reaching New Plymouth, on 26 October, Hector in the company of Henry Robert Richmond and Thomas Kelly, the Taranaki provincial superintendent and provincial secretary respectively, inspected wells being sunk in search for oil before exploring northern Taranaki. Leaving New Plymouth on 4 November, Hector was back in Nelson the following day where he met up with Thomas Hacket who had arrived two days earlier from Wellington.

While preparing for the coal survey Hector, guided by Hacket, had time to make a quick examination of the rocks of eastern Nelson and on 6 November he rode up the Roding River to a farm Hacket owned called Aniseed Lodge. Hector also had time to visit Marybank Farm, just to the north of Nelson, where he searched for obscure fossils that Ferdinand von Hochstetter (1829-1884), with the assistance of Hacket and others, had collected in September 1859[3]. Hector's trip may not have been entirely to collect fossils for he could have taken the opportunity to visit the farm's owner, prominent politician, amateur geologist and local museum supporter William Wells (1810-1893).

On 13 November, Hector and J.W. Rayer[4], the latter a messenger in the Geological Survey as well as an assistant in the Colonial Museum, set off on horseback for Golden Bay with Hacket following later. Also to join Hector for part of his time in Golden Bay was Charles Hunter Brown, a member of Nelson's social elite. Details of Hunter Brown's itinerary are not known, other than that he joined Hector in the early part of the latter's stay in the west of Golden Bay. It also seems likely that Hunter Brown returned to Nelson about the time Hacket reached Collingwood for the latter was with Hector when the Collingwood Coal Mine at Ferntown was inspected. On 20 December, Hacket took the main overland route east before ascending the Motueka valley to the Wangapeka River where he was to rendezvous with Hector and Rayer. The plan was that Hector and his assistant would take the track from the Aorere River over the Gouland Downs to the Heaphy River and then down the coast to the mouth of the Karamea River, which they would ascend to the Wangapeka Saddle. However, on reaching the flooded Karamea River the plan was abandoned and the two men continued to Westport, which they reached about the end of the first week of January 1867. The town was rapidly expanding as gold and coal miners flocked to the Buller and on the 10 January they sailed on the steamer *Ahuriri* for Nelson, arriving there the following day. Soon after Hector and Hacket met in the Wangapeka.

On the day that Hector and Hacket parted company in Collingwood, Hector wrote to Mantell at the Colonial Museum and summarised what he had accomplished since leaving Wellington. It is the only summary we have of what was clearly a complicated and hazardous trip.

Hector's letter to Mantell

Collingwood
Dec. 20th 1866

My dear Matara[5],

I meant to have had a run to Wellington at this time to see how things are getting on & to give you all my news, but I have lost such a lot of time through bad weather that I find I must stay & keep watch for fine days to push on with my work. I should have been done here more than a fortnight since if it had not been for the incessant rain, which makes work in the Bush when there are so many sections only to be seen in creek beds, not only uncomfortable but impossible.

After my return from Taranaki where I spent a week nearly & got up to the White Cliffs[6] & back to the Ranges in spite of the bad weather, I was stuck at Nelson for some time, but during which I managed to examine the L. Secondary Strata of the Richmond Hills & got a large collection of Fossils. They are the Upper Te Anau beds of Otago without doubt being

the same strata which form the lower series of rocks between Popoturoa & Tuturau & which form the Nuggets[7].

From Nelson I went all round Takaka & Separation Point sending my pack Horse from place to place & tramping over the ranges. What will interest you is that at Motupipi a Mr Gibson who is a good botanist & I believe a careful man saw a bird which from his description I made out to be a *Notornis*. He saw it within a few yards about 3 months since in a swamp at the foot of the Takaka Ranges. Near where the Caves occur containing the Moa bones[8]. He came from India to reside here some few years since & being accustomed to observe is not likely to be deceived & as he had never seen any plate or description of the *Notornis* & knows the Pukeko quite well there could hardly have been any mistake[9]. I have impressed him with the importance of securing the bird dead or alive if possible.

From Motupipi I went off to the Tata Islands[10] with some Maoris in a canoe & then came on to this place. My only adventure was fishing a poor drowned woman out of the water, but too late[11]. There are some horrid fords in this part of the Country. There is a peculiar tint in the water that deceives one very much as to the depth & nature of the bottom[12]. Accidents are very frequent considering that after all they are only small streams.

Hunter Brown[13] joined me here as he wished to see the Pakawau & W. Whanganui Coal Fields. We were together all round Cape Farewell & Pakawau during wet weather but at West Whanganui we had a few glorious days. He returned from there, but I went down the coast to Tapiri Cliffs[14] where the Coal Formation is cut off by the Granite coming out on the Coast. The Coal Formation is extensive enough but the beds have a very drift like & false bedded look as if the material had been acted on by strong & frequently changing currents during their deposit & I doubt that the Coal seams have only a local extension in the consequence. The formation exactly resembles the Cape Paterson beds in Victoria[15] & there they have spent £0,000s in trying to follow patchy seams. I am very curious to find out the relation of the Buller strata to those here & from this will return to the West Coast by the Heaphy & down to the Karamea, then to the Mokihanui[16], Lyell & on to the Buller. Kai is the great difficulty, but on the West Coast I caught Wekas & Kouras[17] & we got shell fish in tolerable abundance & trust it will be the same further south. I will only take Rayer with me, as I find the larger the party the more to feed. I find that I take as well as ever to the swagging – only the amphibious style of life we have had in consequence of the continuous rain has been rather trying.

On the West Coast I found Haast's Cretaceous formation to be the Otara Limestone[18] with all the Characteristic fossils as at Oamaru. Some of the strata are composed of little else than the cupshaped Bryozoa that you told Haast[19] was the backbone of the Middle Island.

The Coal Formation underlies these limestones with a thin stratum of marals [marls] with septaria representing the Moeraki Clays between them. The Sandstones &c. exactly resemble those on the East slope of the Kakanui Mts. so that the Geol: sequence as well as the Fossil plants makes the Shag Point Coal of the same age as the Pakawau Coal[20]. This is very satisfactory & I see no reason why there should not be a good coal field to be struck by sinking in the Moeraki & Oamaru country so hold on to your land there.

I have been in several of the Caves here but have not found any Moa bones, not having had time or means for digging for them. I have just been over the Gold Fields which present a very dull appearance. The ground is very limited as compared with Otago Fields, but from the quantity of Quartz wash if that is any test they should have been much richer in proportion[21]. They appear to have been worked in a very stupid & imperfect manner & I daresay that there is as much gold left yet as they ever got. This is the most miserable piece of country I have seen, even close to the sea the terraces are like land on which snow rests for 9 months in the year, except that the primitive sub-Alpine vegetation is wanting. You can see absolutely sessile Manuka flowers, there not being strength in the soil to grow even half an inch of stem in places.

The character of the vegetation is very like the Gum land in the North. Rushes, heath, Manuka & the swamp fern[22].

West Whanganui is a very pretty place in fine weather, but there is no land, the hills being very steep spurs cut by gullies in all directions. It is principally remarkable for the vigour of its Oysters, sandflies & mosquitoes.

The Coal Mine[23] is as at present worked a regular humbug. Only a hole in the mud flat, which they drain with a California pump[24] at low tide & then dig out a few tons when a vessel comes in. Four men & a manager swag all their kaikai over from this place[25] & kick about there idle for the sake of a chance vessel & about over a month they send out 50 or 60 tons. It can never pay any one concerned if worked in this way. There are 5 seams – two of them very close together given about 5 ft. of good clean coal where the band is picked out. The coal is really first rate stuff to burn & sells fairly in Nelson at 50/- p. ton!! N.S.Wales coal being 45/- p. t.

The Coal near this place is 900 ft up an almost perpendicular hill part of the way being up precipices only to be passed by ladders. The seams are much the same as at Wanganui & they propose to get the coal down by inclines[26].

It is certainly the ------[27] of the usual problems & the question in this case will be not the cost per ton of raising the coal, but of getting it down. If it takes ------ H.P. to raise 100 tons of coal 900 ft. from a mine how much to raise a whole coal formation to the top of a hill

900 ft. This would be a nice question for Ramsay[28] to set to his students & it certainly does bring home to one the enormous power exercised in these dislocations[29].

I have got about 10 cases of specimens & some very good Fossils already but nothing very remarkable. Plants are not in flower yet so I have done very little in that way. Gore[30] writes me that you want ---- some (he says all your specimens, but that is surely a mistake). I suppose it is the duplication you want both for Tasmania & Sydney & the valued that you intend to retain. I wish I could be there to keep the brake on the paying out gear but as I can't, of course there can be no difficulty in your getting out any thing you want. I trust that the little boy is all right long ago[31]. Drop me a line to Nelson like a good soul & believe me with all kind wishes

Ever Your Sincere Friend
James Hector.

Footnotes

1 Hector to Mantell, 20-12-1866. MS-Papers-83-298-22, Mantell family papers, Alexander Turnbull Library.

2 For an account of Hacket brothers activities in Nelson see Johnston (1987).

3 The fossils were subsequently in Hochstetter's publications tentatively referred to as fucoids but are now known to be leaves of Jurassic age (Johnston et al. 1987).

4 J.W. Rayer worked as a field assistant for Hector in Otago and moved to Wellington with him in 1865.

5 Maori word for Mantell. In 1852, while supervising the cutting of the boundary of a block of Maori land he had purchased in Southland on behalf of the Crown, a rocky promontory was named by Maori as Matara Crags in his honour.

6 White Cliffs between Pukearuhu and Tongaporutu on the northern Taranaki coast are cut in almost flat lying sandstone and mudstone of Late Miocene (Tongaporutuan Stage) age (Edbrooke 2005).

7 The Nuggets comprise a collection of rocky islets extending seaward from Nugget Point on the Catlins coast. They formed by the erosion of a prominent rib of bedded Upper Triassic sandstones within the Murihiku terrane on the northeast limb of the Southland Syncline.

Murihiku rocks crop out in east Nelson, being offset from their southern counterparts by the Alpine Fault, and were distinguished as the Richmond Sandstone, now Richmond Group. Hector had seen these latter rocks the previous year (Burns and Nathan 2013).

8 Presumably the Pikikiruna Range on the east side of the Takaka valley where there are caves in both the Arthur Marble (Ordovician) and, at the foot of the range, in the Takaka Limestone (upper Oligocene-lower Miocene) (Grindley 1971).

9 Jabez Marriage Gibson (1822-1877), who had taken up residence at Clifton near Motupipi in 1855, was a well-travelled Englishman and was a fellow of both the Linnaean and Horticultural societies. Hector's tentative identification of the bird as "Notornis" (*Porphyrio hochstetteri*), or as it is more widely known by its Maori name of Takahe, has not been confirmed but seems unlikely. While the species is still extant in the Murchison Mountains of Fiordland, the North Island species, named after Mantell (*P. mantelli*), is extinct. A similar looking bird, but which Gibson was clearly familiar with, was the much more common swamp hen or Pukeko (*Porphyrio porphyrio*).

10 The low lying islands are of Takaka Limestone, which had been extensively quarried for lime burning.

11 On 24 November 1866 Mary Kealy was thrown from her horse while crossing the Waingaro River, which flows northeastwards into the lower Takaka River, and her body was found soon after by Hector and Rayer. She and her husband James were among the first Europeans to take up a farm in the Takaka valley and the Kealy family highlights the tough times that the settlers faced. James had been drowned in a canoe accident on the Takaka River on 27 June 1864 and she had buried a daughter who had succumbed to diphtheria a few weeks before her own death. Another two daughters were left orphans (*Colonist* newspaper *2*7 November 1866; Johnston 2007: 134).

12 Tannins leached from the beech forest clothing the surrounding mountains.

13 Charles Hunter Brown (1825-1898) arrived in New Zealand in 1849 and was a member of the wealthy landowning gentry in Canterbury and for a short time a member of the House of Representatives. Later he held the positions of magistrate in Wairoa and Civil Commissioner of Native Affairs. In early 1866 Hunter Brown, his wife Ellinor and young family moved to Nelson where he largely involved himself in the affairs of the Anglican Church and the militia. Hunter Brown was friendly with landowner and parliamentarian Dr David Monro, soon to be Hector's father in law.

14 At Kahurangi Point the unconformity between the coal measures and the underlying Middle Devonian-Lower Devonian Karamea Suite granite is intersected by the coast (Rattenbury et al. 1998).

15 The coal forms thin seams within the Rakopi Formation of the lower Pakawau Group. While the coal and its occurrence is very similar to the seams found at Cape Paterson, 100 km southeast of Melbourne, it is younger being Late, rather than Early, Cretaceous in age.

16 Mokihinui. Hector dislocated his shoulder while descending the river in 1867.

17 Maori names respectively for food, wood hen (*Gallirallus australis*) and crayfish.

18 Ototara Limestone formation of North Otago was named by the Gideon Mantell (1790-1852) from rocks and fossils sent to him in England by his son Walter (Mantell 1850). The fossils in the formation were later the basis of the Ototaran Stage, now replaced by Kaiatan, Runangan and Whaingaroan stages (late Middle Eocene to Early Oligocene) (Forsyth 2001).

19 Johann Franz Julius Haast (1822-1887) arrived in New Zealand in December 1858 and accompanied Hochstetter on his travels through New Zealand in 1858-1859. After exploring the West Coast from the Grey River to Collingwood in 1860 for the Nelson Provincial Government, he had an illustrious scientific career in Canterbury, became von Haast in 1875, and was knighted in 1886.

20 Mudstone and siltstone dominated sediments underlying the Ototara Limestone comprised Hector's "Moeraki Clays", later the Moeraki Formation of Hector, Haast and other geologists, which is now divided into a number of formations within the upper part of the Onekakara Group. The lower part of the group includes the non-marine Taratu Formation that contains the coal seams at Shag Point. As at Pakawau, the Shag Point coal is of high volatile bituminous C rank, with low sulphur content, and is of Late Cretaceous age.

21 The country extending south from Collingwood towards the Tasman Mountains comprises a northwest tilted surface or peneplain (Waipounamu Erosion Surface) cut in Paleozoic rocks and from which a sequence of Tertiary cover rocks have been all but removed by erosion. Locally remnants of the basal coal measures in the sequence contained sufficient gold to be profitably mined. However, the richest deposits were where present day streams had reworked and concentrated the gold or are in the larger rivers, cut into the surface, which carried coarser gold directly from veins in the Paleozoic rocks in the mountains. Consequently, the amount of auriferous ground, despite the widespread presence of quartz-rich sediments, was very limited.

22 Pakihi is the Maori name for an open, particularly swampy, flat lying area with vegetation dominated by low shrubs, ferns and rushes. In the Aorere valley the higher, older, terraces with soils that due, to leaching, are low in nutrients. It is probable that many of the pakihis near Collingwood have primarily arisen from Maori burning (Mew 1983; Mew and Johnston 1988).

23 On the western coast of the southern arm of Whanganui Inlet, formerly known as West Wanganui or West Haven Inlet. The very gently northwest dipping seams are within the North Cape Formation (Puponga Member) of the upper Pakawau Group. The coal is ranked as sub-bituminous A, with low sulphur (Rattenbury et al. 1998).

24 A primitive, but effective and easily constructed pump comprising a revolving continuous belt attached to which are buckets that lifted the water from the mine.

25 The route from Collingwood was north along the coast to Pakawau and then westward to the northern end of Whanganui Inlet.

26 The Collingwood Coal Mine in Gorge Creek on the precipitous lower slopes of the Burnett Range west of Collingwood. The Collingwood Coal-mining Company was formed in 1867 and constructed an incline and tramway from the mine, in the Rakopai Formation close to the base of the Pakawau Group, to a small wharf on the Aorere River near Ferntown.

27 In his haste to finish the letter, Hector's writing becomes even more difficult to read and several words are indecipherable.

28 Andrew Crombie Ramsay (1814-1891) was appointed to the British Geological Survey in 1841 and with other staff members was from 1851 a professor at the affiliated Royal School of Mines.

29 The Wakamarama Fault trends northeast along the toe of the Wakamarama and Burnett ranges and is upthrown to the northwest (Bishop 1971).

30 Richard Benjamin Gore (1840-1904) was clerk and assistant to Hector in the Otago Provincial Geological Survey and along with other Otago survey staff transferred to Wellington when the New Zealand Geological Survey was established in 1865. As well as assisting Hector, Gore was curator of the Colonial Museum.

31 This is presumably Mantell's son Walter Godfrey Mantell (1864-1927) whose mother, Mary Sarah Prince, Mantell married in 1869. The birth was not registered until 1894.

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Collections of letters written by or about 19th century New Zealand scientists

As part of an ongoing study of late 19th century New Zealand scientists, several collections of letters have been transcribed – now more than 1000 letters. These are a valuable research tool for researchers in a variety of fields, so they are being published by the Geoscience Society of New Zealand as parts of *GSNZ Miscellaneous Publication 133*, available as free downloadable PDF files from the GSNZ website, www.gsnz.org.nz – click on Publications, then Misc. Pub. Series.

- "My Dearest Georgie": transcriptions of 22 letters from James Hector to his wife Georgiana written in 1890 by Judith Nathan & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133A*, 35 pages

- "My Dear Hooker": transcriptions of letters from James Hector to Joseph Dalton Hooker between 1860 & 1898 by Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133B*, 208 pages

- "My Dear Dr Haast": transcriptions of selected letters from Robert Langley Holmes to Julius Haast between 1864-65 and 1868-70 by Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133C*, 53 pages.

- The correspondence of Julius Haast and James Hector, 1862-1887 by Sascha Nolden, Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133D*, 315 pages.

- "A Quick Run Home": Correspondence while James Hector was overseas in 1875-1876 by Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133E*, 144 pages.

- Transcriptions of selected letters from Frederick Wollaston Hutton to James Hector and Julius Haast (2nd edition) by Esme Mildenhall, Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133F*, 175 pages.

- James Hector in Northland, 1865-66 by Rowan Burns & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133G*, 57 pages.

- The correspondence of Julius Haast and Joseph Dalton Hooker, 1861-1866 by Sascha Nolden, Simon Nathan & Esme Mildenhall. *Geoscience Society of New Zealand miscellaneous publication 133H*, 219 pages.

- Letters from James Farmer to James Hector, 1876-1891 by Esme Mildenhall & Simon Nathan. *Geoscience Society of New Zealand miscellaneous publication 133I*, 133 pages.

- A man *tenax propositi*: transcriptions of letters from Charles Knight to William Jackson Hooker and Joseph Dalton Hooker between 1852 and 1883 *Geoscience Society of New Zealand miscellaneous publication 133J*. 88 pages.

- The letters of Ferdinand von Hochstetter to Julius von Haast by Sascha Nolden. Geoscience Society of New Zealand miscellaneous publication 133K, 233 pages.

Paper copies of each of the publications are also held in the library of each university.

As well as information on scientific topics and the rivalry between Julius Haast, James Hector and Frederick Hutton, the letters contain information on life in each of the four main centres, political gossip, comments on the 'native problem', and the workings of the government. There are gloriously gossipy letters from R.L.Holmes (MP 133C) and Walter Mantell (2nd part of MP13E), Hector's concerns about the 1890 industrial unrest (MP 133A), and Hutton's complaints about problems in the flax industry (MP133F).

Both Haast and Hector kept Joseph Hooker up to date with developments in New Zealand (MP133A & MP 133H), including notes on earthquakes, volcanic eruptions and other hazards. Hooker often sent extracts from their letters to the newly established scientific journal, *Nature*. One of Hector's concerns was the extent of deforestation, and the speed with which native forests were being milled or burnt. Based on his experience in Canada he advocated planting of imported conifers, and used the Colonial Botanic Garden as an experimental nursery to test out which species grew best in New Zealand.

Haast maintained correspondence with his mentor, Ferdinand von Hochstetter for over 25 years. Only the letters from Hochstetter have survived, but this have been largely overlooked because they are written in German. Sascha Nolden transcribed and translated these letters into English, and this collection is now available as MP133K

For more information, please contact Simon Nathan – s.nathan@xtra.co.nz

We would appreciate feedback from readers, information on more letters that may come to light, and advice of the inevitable corrections that will be discovered.