The History of Julius Haast's Geological Mapping of the Province of Canterbury

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In 1861 Julius Haast was appointed Provincial Geologist of Canterbury, requiring him to undertake a geological survey of the whole province, which then included Westland. To meet his obligations, Haast was expected to produce detailed reports and prepare a comprehensive map of Canterbury. The demands of the survey occupied him for the next 7 years, involving many challenging expeditions in the Southern Alps, as he gradually painted the province in the colours of a geological map. This article traces Haast's progress and the history of different iterations of Haast's geological map and sections of Canterbury, examining what they reveal about the development of his understanding of the complex geology of the province. After a more detailed consideration of his great *Geological Map of the Province of Canterbury and the County of Westland*, submitted in 1868 on completion of his contract, the focus shifts to his efforts to have that geological map published in New Zealand and overseas. The commentary then examines how he eventually came to publish an updated but smaller and simplified version of his great map in his magnum opus *The Geology of Canterbury and Westland*, published over a decade later in 1879. Finally, the historical and contemporary importance and relevance of Haast's geological surveying and cartography are considered.

Keywords: Canterbury, geological map, geological section, historical cartography, Julius Haast, Westland

Introduction

In the late 1850s, the provincial governments of New Zealand were keen to discover if their regions contained mineral resources. In December 1858, Julius Haast (1822–1887), who was acting as an agent for a British shipping company seeking to facilitate the emigration of Germans to New Zealand, arrived in Auckland. Shortly after that he accompanied pioneer geologist Ferdinand Hochstetter in surveys of Auckland and Nelson Provinces, and subsequently reported independently on remote parts of the Nelson region (Maling and Nathan 2023). The Canterbury Provincial Council then invited him to undertake a similar geological survey of Canterbury.

Haast faced a considerable challenge when appointed Provincial Geologist of Canterbury in February 1861, given that the geological map was a blank canvas and that more than half of the province had yet to be topographically surveyed. In the early 1860s, the province basically included all of the land from the Tasman Sea to the Pacific Ocean lying south of the Grey River on the west coast and the Hurunui River in the east, and north of a line from the Awarua River mouth on the west coast to the Waitaki River east of the Alps. The Provincial Council hoped that his work would locate mineral resources such as gold and coal, and lead to the development of industries in the region. Over a period of 7 years, Haast systematically explored the headwaters of all major rivers flowing eastward from the Southern Alps to the Pacific Ocean, as well as some of those flowing westward to the Tasman Sea. On different iterations (Hook and Nolden, 2024) of his topographical base map, Haast gradually painted in the canvas using geological colours and labels that reveal the development of his understanding of the complex geology of Canterbury and Westland. Haast's labours culminated in the production of his great map of the geology of the province, which he submitted in fulfilment of his obligations in August 1868, and in the completion of 24 accompanying geological cross-sections submitted several months later. The map and sections were on display when the newly built Canterbury Museum first opened its exhibitions to the public in October 1870. However, Haast's desire to have the map published for wider dissemination, and for scientific audiences overseas to appreciate, was frustrated for more than a decade until he was eventually commissioned to write a book describing all his major expeditions and summarising all his geographical and geological reports and maps. For the latter, a highly experienced Viennese lithographer was commissioned to print the finely-delineated, multi-coloured, aesthetically pleasing geological maps and sections, which are accurate renditions of the general geology of the province, given the state of scientific knowledge at the time.

While the bulk of this article documents Haast's progress and the history of his geological mapping of the province, the development of Haast's understanding of the complex geology of the region, as revealed in different versions of his geological map, is examined concurrently. Geological sections, which are an integral part of a geological map revealing relationships in the vertical dimension between different rock formations, also provide significant insights. Therefore, images of sections that accompany some of the

maps are included. Although there are many features of the geological maps that could be compared, the focus is on how Haast mapped, illustrated and interpreted two rock types – greywacke and schist – which together form the major part of the province's bedrock.

Commissioning the Geological Survey

Within a few weeks of Haast's engagement by the Nelson Provincial Government in November 1859 to explore the "Southern and Western portion" of the province in order to produce a "Topographical and Geological Map and Report of that District",[1] Richard Harman (1826–1902), an enterprising Christchurch civil engineer who had recently visited Nelson, wrote to the Superintendent of Canterbury, William Moorhouse (1825–1881), advocating the benefits of conducting a similar survey that would involve "a thorough examination" of the mineral resources of Canterbury. Harman wished "to ascertain whether the Government are disposed to regard favourably the project of such a survey … and whether they would be inclined to enter into arrangements with Mr. Haast for carrying it into effect". Harman also informed Moorhouse that he was "authorised by Mr. Haast to enter into a contract upon his behalf". On Moorhouse's behalf, the Provincial Secretary, Thomas Maude (1832–1905), asked what Haast's terms would be. Harman replied that 2 years would be the probable duration of the survey, with at least 6 months of each year spent in the field, and that Haast would expect a salary of not less than £600 per annum, and the services of a local guide, as well as those of an assistant surveyor for unsurveyed districts (Canterbury Provincial Council 1864: 3). Apparently, these conditions were deemed acceptable, but before a formal contract could be entered into Haast commenced his seven-month long topographical and geological exploration of the rugged, isolated western and southern parts of the Province of Nelson. Moorhouse visited Nelson shortly after Haast returned late in August 1860 and was preparing his report and maps. When back in Christchurch, Moorhouse wrote to Haast on 12 November, stating that "pending the ultimate closing of the Conditional Contract between yourself and the Provincial Government of Canterbury", he would be expected to "supply detailed maps and reports similar to those furnished to the Nelson Government" (Canterbury Provincial Council 1864: 4).

Clearly Moorhouse was impressed with what he had seen of the fruits of Haast's Nelson labours, such as the map[2] and report (Haast 1861), which were eventually submitted on 27 November 1860. Although Haast was neither an academically qualified geologist nor a professionally trained cartographer, his son Heinrich Haast (1864–1953) asserted that it was under the training of the German geologist Heinrich Dechen (1800–1889) that his father "acquired his skill as a cartographer which enabled him to produce his geological map of Canterbury and Westland" (von Haast HF. 1948: 2).[3] Furthermore, Haast greatly benefitted from 5 months of intensive tuition in both topographical and geological surveying and mapping while accompanying the highly experienced visiting German geologist Ferdinand Hochstetter (1829–1884) on the surveys he undertook for the Auckland and Nelson provincial governments between January and September 1859. In Hochstetter's view, by the end of that period Haast had earned his "geological spurs" (Johnston and Nolden 2024: 162) and before departing for Vienna in December 1859, Hochstetter recommended him to the Nelson Provincial Government as the appropriate person to complete the survey.

Haast's Plan and Equipment

Haast's formal engagement as the Canterbury Provincial Geologist commenced on 15 February 1861. His initial plan was to systematically survey the headwaters of all the major rivers flowing eastwards from the Southern Alps as well as the Canterbury Plains (Fig. 1).

The rudimentary equipment initially available for Haast to use on his geological survey included a "compass with clinometer" for measuring the inclination of rock

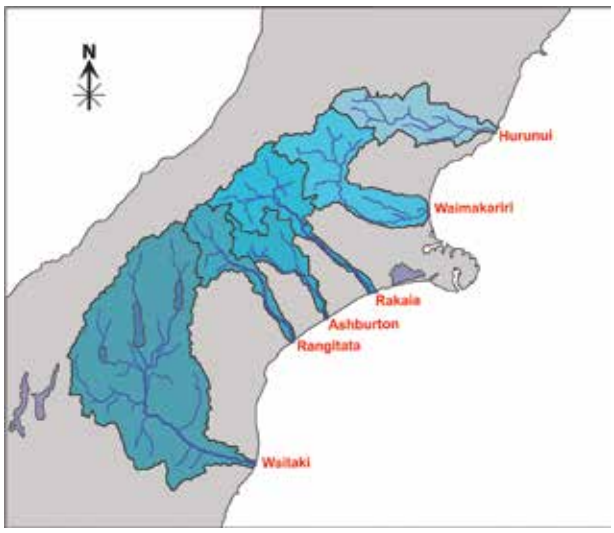

Figure 1. Major river catchments on the eastern side of the Southern Alps explored by Haast. Illustrator: Tony Mander

Age	Eon	Era	Period	Epoch	Years ago
Younger ↓	Phanerozoic	Cenozoic	Quaternary	Holocene	<– 11.8Ka
				Pleistocene	<– 2.6 Ma
			Neogene	Pliocene	
				Miocene	
			Paleogene	Oligocene	
				Eocene	
				Palaeocene	<– 66 Ma
		Mesozoic	Cretaceous	–	
			Jurassic	–	
			Triassic	–	<– 252 Ma
		Palaeozoic	Permian	–	
			Carboniferous	–	
			Devonian	–	
			Silurian	–	
			Ordovician	–	
↑ Older			Cambrian	–	<– 541 Ma
	Precambrian	–	–	–	

Figure 2. Simplified modern geological timescale. Ka, thousands of years ago; Ma, millions of years ago. The underlined names are those that Haast used and which are referred to in this article.

strata, geological hammers and chisels for obtaining rock samples, and barometers for measuring altitudes.[4] He would have also taken a hand lens to study rock samples, canvas collection bags and labels, and a small bottle of acid to test if rock contained carbonate. Written and sketched observations were recorded in field notebooks, and descriptive accounts of the progress of expeditions in journals. Neither his field notebooks nor his journals have been located and may no longer be extant, although text from the journals is sometimes quoted in his reports, articles and book. As Haast used the names of some geological eras and periods still in use today to indicate what he believed to be the relative ages of rock formations he encountered, Figure 2 has been included, although the numerical ages were unknown then.

1861: Ashburton, Rangitata and Torlesse Expeditions

After a few days of preparation, Haast set off to survey the headwaters of the Ashburton and Rangitata Rivers, which occupied him from late February to June, as topographical surveying had to be undertaken at the same time as the geological investigation. By the end of that period Haast had a better appreciation of the extent of the work required of him and realised that more than half of the province had yet to be topographically surveyed.

In July 1861 Haast was diverted by government direction to a detailed study of the Malvern Hills district, the only substantial coalfield east of the Southern Alps. While there he also explored the nearby Mount Torlesse Range, where he made detailed observations of the scientifically-challenging greywacke rock formation, the basement rock of much of the South and North islands. The latter months of that year were spent in what he called closet work, perhaps because of the cramped office space provided in the Provincial Council Building. This involved processing his geological samples and observations, as well as completing the topographical base map required before he could commence colouring in sections of a geological map based on it.

The only extant visual records of Haast's early insights into the geology of Canterbury are a tracing of a geological sketch map of the province (Fig. 3) and an undated tracing of a section from the West Coast, through Aoraki/Mount Cook, across to Banks Peninsula (Fig. 4), which is marked on the map. Both the map and the section were posted to Hochstetter in January 1862. The latter was sketched by Haast in response to a suggestion by Hochstetter that he "design a profile" similar to one sketched in red pencil on a letter dated 18 August 1861 (Nolden 2013: 56), suggesting that Haast lacked experience in preparing geological sections.

On the map Haast classified the dark grey greywacke areas as *Upper Silurian or Devonian*, and the lighter grey greywacke areas as *Silurian*, but on the section all the greywacke areas are painted purple and labelled *Palaeozoic (non-fossiliferous)*, which includes the Silurian and Devonian periods. In fact, Haast had no convincing evidence for the age of the greywacke except for a general feeling that the rocks must be as old as Palaeozoic. Although Haast painted an extensive *Crystalline Schists*

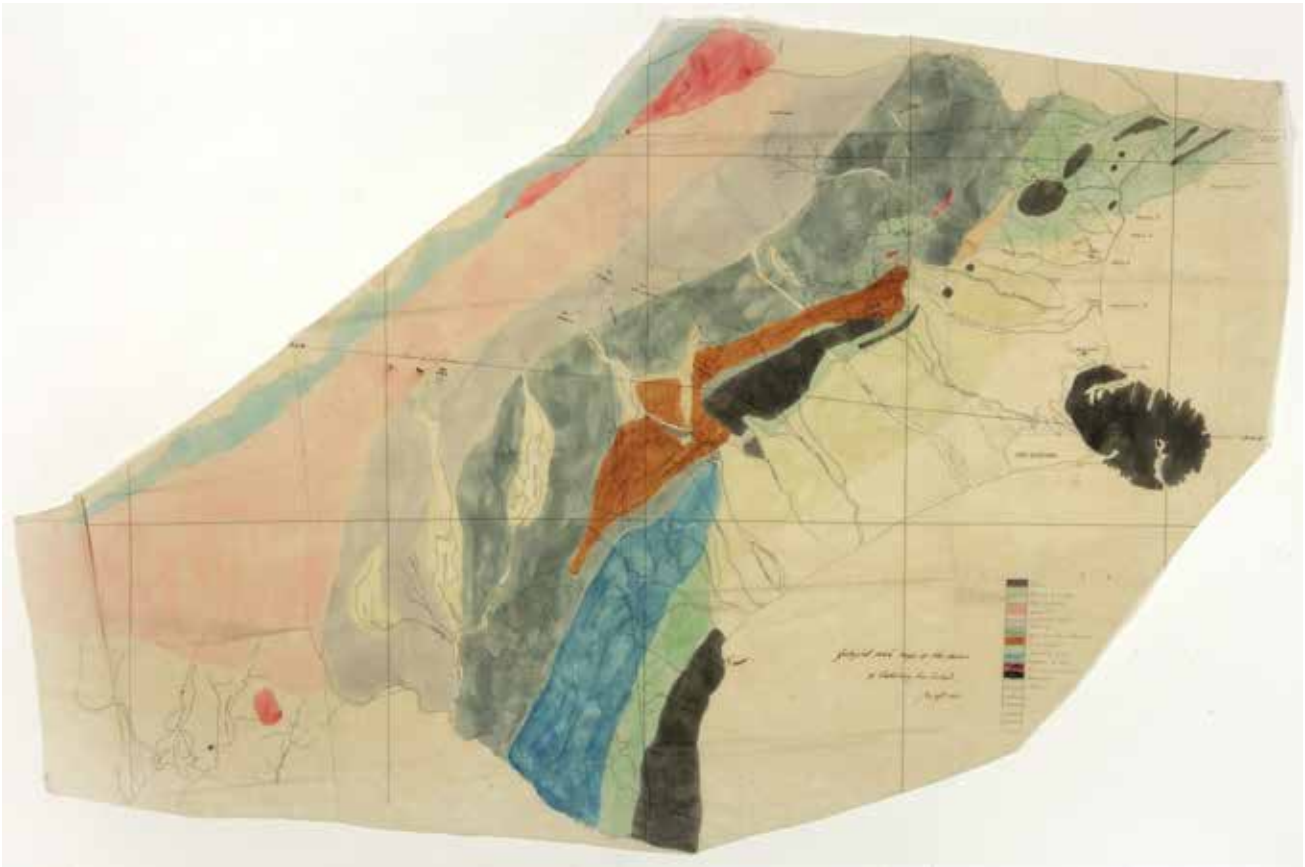

Figure 3. *Geological sketch map of the province of Canterbury New Zealand, Jan 19th 1862.* Ink and watercolour on tracing paper, 500 x 770 mm. Dr Albert Schedl Collection, Vienna

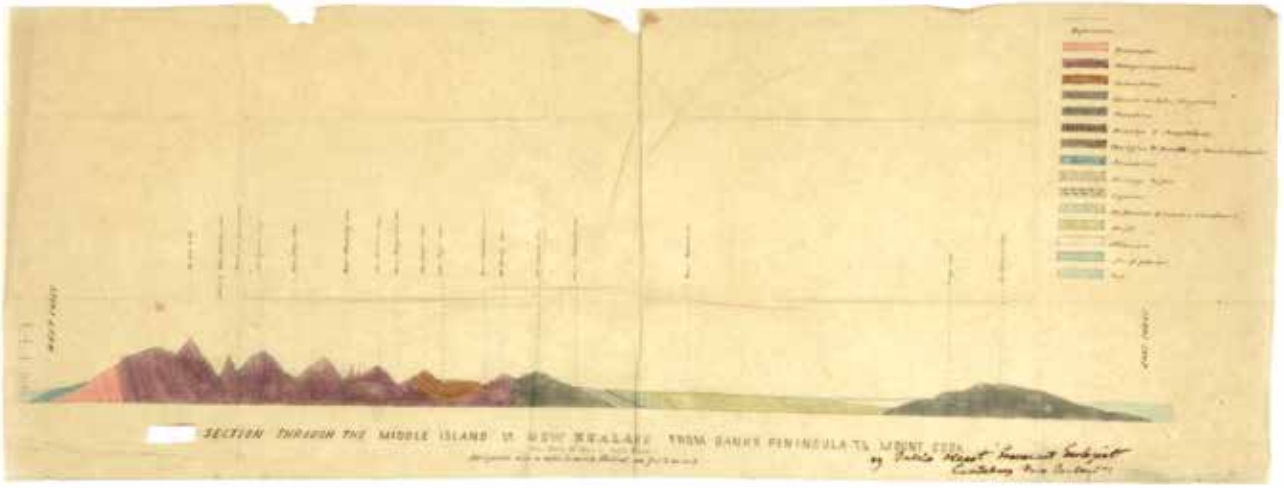

Figure 4. *Section through the Middle Island of New Zealand from Banks Peninsula to Mount Cook* [1862]. Signed Julius Haast Provincial Geologist Canterbury New Zealand. Undated. Ink and watercolour on tracing paper, 250 x 660 mm. Dr Albert Schedl Collection, Vienna

zone on the west coast of the map pink, he labelled the schist *Metamorphic* on the section. His western conjectures were, however, based on rocks collected for him by James Mackay (1831–1912), the Assistant Native Secretary (Haast 1862: 122-23) "in some of the rivers, descending from Mt Cook".[5]

1862: Waitaki Expeditions

Early in 1862 Haast spent over 4 months exploring the headwaters of the Waitaki River, an extensive area that included the glaciers that fed lakes Tekapo (Tākapo), Pukaki and Ōhau. On 12 April, Haast's party "started to ascend Mt. Cook",[6] by traversing the rocky ridge line of the Kirikirikatata/Mount Cook Range, but the rocks "became still more and more broken: hitherto they had consisted of sandstones; but now slates [mudstone / argillite] made their appearance, and about 7,500 feet above the sea we came upon a precipice of about 10 feet wide and perhaps 30 feet deep – the vertical stratum clay slates having been here decomposed: as it was impossible to round it, and we had not a ladder with us to throw across, we were obliged to retreat" (Haast 1865a: 6). Ironically, the first attempt to ascend the lower slopes of Aoraki/Mount Cook was defeated by the rock formation (Fig. 5) that eventually cemented one aspect of Haast's enduring geological legacy (see **Discussion**).

Summing up his geological insights for Provincial Secretary Maude in May of 1862, Haast wrote that the Southern Alps consist of "huge foldings … intersected by faults", with the rocks being of a "very high palaeozoic age, I discovered only faint traces of animal life, so that they can be pronounced unfossiliferous"; and on the West Coast "metamorphic rocks, as for instance Mica, Graphites and Chlorite slates [schists], without doubt, auriferous [gold-bearing]" would be found, although he had yet to visit that part of the province.[7] In additional letters written in June, Haast stated that for him to give a "full and instructive account of the geology of the province it was necessary to see the West Coast", so that he could produce "three sections through it from East to West, viz. From the mouth of the Hurunui to that of the Taramakau, 2) from Banks' Peninsula to the western base of Mt Cook, 3) from the mouth of the Waitaki to that of the Awarua".[8]

On 6 October Haast presented his first official report on the progress of the geological survey of the province to Moorhouse, which had accompanying maps and sections. These included "Geological sketch map of the islands of New Zealand, showing in broad outlines the different parallel zones" (possibly the first, albeit inevitably incomplete, geological map of the country), "Geological map of the Province of Canterbury" of unspecified scale, and "Geological sections through the middle island of New Zealand". Neither of those maps nor the sections have been located in the collections of Canterbury Museum or Archives New Zealand,[9] the two institutions that hold other Canterbury geological maps and sections by Haast. In the report Haast noted that "in the Alps, sedimentary rocks of at least two distinct periods occur, although both series agree in lithological character, joints &c. … The relations between these two palaeozoic formations of which the one

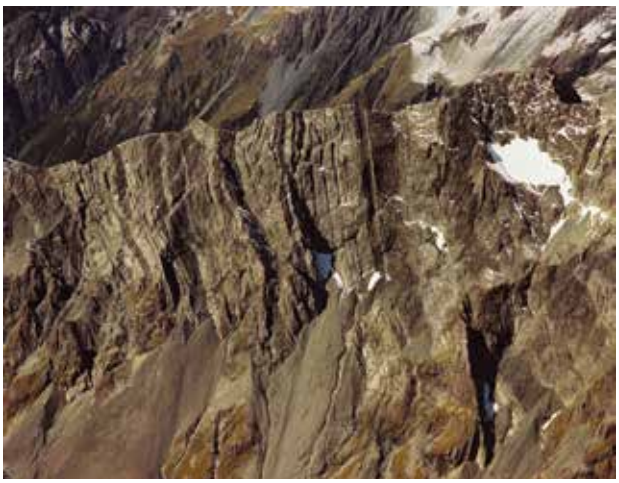

Figure 5. An exposure of *Torlesse greywacke* along the ridge of the Kirikirikatata / Mount Cook Range, which Haast's party attempted to traverse in 1862. Thick vertical beds of hard grey sandstone (greywacke) alternate with thinner beds of the softer black mudstone (argillite), which Haast called 'clay slates'. Photographer: Lloyd Homer. Geological and Nuclear Sciences, 47904/B

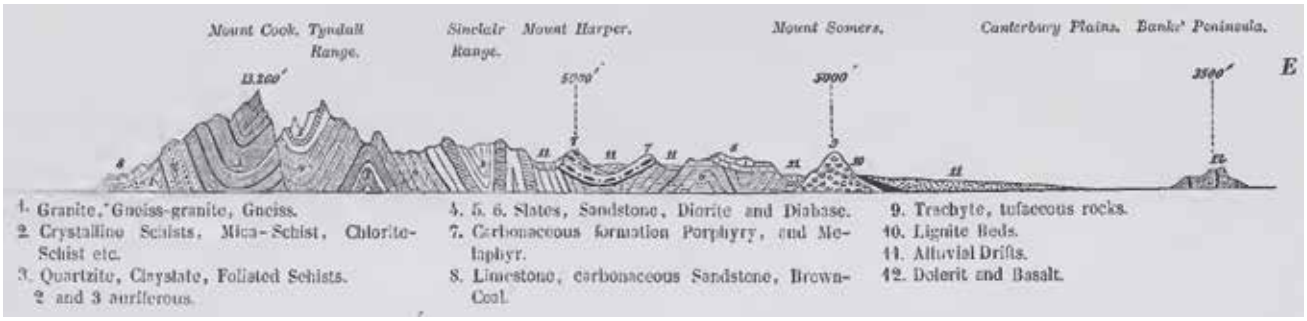

Figure 6. *Section across the Province of Canterbury, according to Dr. J. Haast* Hochstetter 1867: 487

overlies the other unconformably, are extremely difficult to decipher …" (Haast 1862: 122).

In his 1863 book *Neu-Seeland*, Hochstetter included a geological section "according to Dr. J. Haast", which he also did in the 1867 English translation *New Zealand* (Fig. 6). That illustration provides an idealised view of Haast's rock zones and the folding of strata from the West Coast, through Aoraki/Mount Cook and across to Banks Peninsula. As this section differs significantly from the tracing Haast sent earlier, he must have provided an updated version after exploring the Aoraki/Mount Cook district. It may have been a tracing of one of the sections he submitted to Moorhouse. In a letter dated 16 February 1863, Hochstetter wrote "the changes in the Mt Cook section have been made" (Nolden 2013: 90). The legend distinguishes between *Crystalline Schists* and *Foliated Schists* on the West Coast, while the greywacke areas are now referred to as *Slates, Sandstone, Diorite and Diabase*.

1863: West Coast Expedition via Haast Pass

Late in 1862, Haast set out to complete his exploration of the geography and geology of the Waitaki headwaters and then to survey the south-western corner of the province. After crossing the Lindis Pass in January 1863, Haast found that he "was not a little struck, to observe, that … the rocks hitherto nearly vertical and of the same Greywacke character, began to change into micaceous schists, dipping in a reversed direction and at a very low angle".[10] An exposure of such mica schist is illustrated in Figure 7. Haast's party then travelled along Lake Wānaka and traversed Tioripatea, the old Māori route to the West Coast which Haast, in ignorance of the Māori name, renamed Haast Pass, surveying their way down the Haast (Awarua) River to the Tasman Sea under very challenging conditions. After returning to Christchurch in May 1863, Haast informed the Provincial Secretary he had "finished about half of the Geological Survey of the Province", and that he had now begun to write "the first part of my extended Report". As it would contain "maps, sections and lithographic plates … the printing will be rather expensive", so Haast suggested that "for this purpose 200 to 300 pounds" should be set aside.[11] The suggestion was not taken up by the Provincial Government.

In August 1863, Haast presented "a map and a section" to Superintendent Samuel Bealey (1821–1909), illustrating his investigation of the western part of the province. Haast wrote that although "we can pronounce almost with certainty that no gold bearing deposits will occur on the eastern side of the main range … the circumstances that everywhere on the western slopes of our Alps, where explorers have descended gold has been found, leads us to anticipate that in the course of time payable goldfields will be opened in that important region", thus confirming that one of Haast's principal missions as Provincial Geologist was to locate such goldfields.[12] That map and section have not been located. According to Haast's son Heinrich "all of the maps relating to gold have been destroyed" (von Haast, HF 1948: 335).

1864: Ashburton and Rangitata Expeditions

Resuming field work in 1864, Haast revisited the Ashburton and Rangitata catchments from February to May before spending two months investigating the geography and geology of the Canterbury Plains. In June Haast gave the following response to a question from the Secretary for Public Works, John Hall (1824–1907), asking how long it would take to complete the geological survey of the province:

> *I shall not have finished the geological survey of the province, which I am at present engaged in, till the end of 1867. My field-work, including the West Coast, will come to a close towards the autumn of 1867, and the final reports, maps, &c., will be delivered to the Provincial Government towards the end of that year, always provided that I am not impeded by extra work or unforeseen obstacles.*[13]

Late in 1864 Haast prepared maps and sections so that the work of the geological survey of Canterbury Province would be appropriately represented at the New Zealand Exhibition held in Dunedin from January to May 1865.

Figure 7. Example of a freshly exposed South Island rock face of mica schist. Image copyright Tupungato | Alamy

These included a newly-drafted *Geological Map of the Province of Canterbury* on a scale of 10 miles to one inch (Fig. 8A) with symbols indicating strike, dip etc. (Fig. 8B), and a chart illustrating *General Sections across the Province of Canterbury N.Z.*, with the lines of the sections marked on the map. The watercolour pigments on this unvarnished map have faded due to exposure to light, making it difficult to distinguish some zones. However, Haast had a tracing made of his map (Fig. 8C) for James Hector (1834–1907), the recently appointed Director of the New Zealand Geological Survey, on which different rock formations are readily distinguishable. Hector incorporated Haast's work on the first geological map of New Zealand,[14] which was "essentially a reduction of existing provincial maps" (Nathan 2014: 98). To ensure Hector's draughtsman made no mistakes, Haast used both numerical and colour coding. However, the 1865 map was never published.

The aesthetically pleasing and carefully delineated map (Fig. 8A) drafted by Thomas Locke (1839–1873), with symbols indicating strike, dip, folds, anticlines and synclines, was Haast's first attempt at synthesising the geology of the region. As the mountains that make up much of Canterbury's high country are complexly deformed greywacke, Haast must have puzzled about how to portray this on a map, especially with the near complete absence of fossils to determine the relative age of the rocks. On the basis of what he perceived to be differences in the few fossil types located, Haast identified some small, black greywacke areas as *Upper Devonian or Lower Carboniferous*, but the age of the much more extensive, light-brown greywacke areas (Fig. 8C) is unspecified.

The original chart with two sections that accompanied the professionally drafted map has not been located, but Haast had a tracing made of it for Hector's map as well (Fig. 9). On both the map and the *Banks Peninsula to Mount Cook* section, Haast distinguished three schist formations – *Gneissic Schist*, *Mica Schist* and *Foliated and Laminated Schist* near Lake Wanaka. Although Haast had spent time at a few places on the west coast of the Province of Canterbury, becoming aware of some aspects of its geology, he was not prepared to geologically colour any part of the west coast on the map other than locations he had explored near Grey River to the north and Haast River to the south.

1865: West Coast Goldfields Expedition

From April to July 1865, Haast was back on the west coast surveying the geographical features of the country and the extent of the goldfields which were within the Canterbury provincial boundaries. On his return he promised the Secretary for Public Works, Edward Jollie (1825–1894), that in a few months he would have "the pleasure of presenting" a more extended report "with the necessary maps and sections in illustration".[15] In December, Haast forwarded to Jollie a geological sketch map of the north-western part of the Province of Canterbury at a scale of four miles to the inch, and two sections – one from the western slopes of the central chain to the west coast, and the other across the goldfield between Lake Brunner and the Hokitika River (Haast 1865b: 16). Neither the map nor the sections have been located.

1866–1867: Rakaia, Waipara, Hurunui and Waimakariri Expeditions

From March to May 1866, Haast explored and surveyed the headwaters of Canterbury's largest river, the Rakaia, and in June presented his hand-written report to Jollie. However, as publication was "unavoidably delayed by the Lithographers" until April 1867, Haast was eventually able to "append a copy of my Topographical Map of the Headwaters of the Rakaia, prepared by me in the meantime". On that lithographed map, Haast marked the lines of eight geological sections, which are reproduced on a large, folded insert of the report. Those sections illustrated deposits from "post pliocene (glacial) and recent epochs" lying on Paleozoic Rocks, consisting of "dioritic sandstone, slates, conglomerates and indurated shales" following each other in "endless succession". Haast concluded that *Palaeozoic Rocks* were indeed sedimentary and had formed on the seafloor (Haast 1866: 72, 13).[16]

On 15 October 1866, Haast presented a hand-written report on the progress of the geological survey to Jollie, in which he stated that as soon as he had completed updating his large four-miles-to-one-inch topographical map of Canterbury he intended "to begin at once with the geological map of this Province on the same scale as the topographical map".[17] The next day, in fulfilment of a directive from Jollie, Haast submitted a mounted and framed chart (Fig. 10) with "Sections and Views of the Westcoast of this Province" for the Superintendent to hang in his office. Haast noted that the "principal section across the Province from Banks Peninsula to the Westcoast across Mt Cook contains the results of my early surveys of the western slopes of the Southern Alps".[18] All of the regions of greywacke rock on that chart are appropriately painted grey and singularly labelled as *Dioritic sandstone, cherts, aphanites and clay slates* [mudstone / argillite], without any indication of the geological period involved. 'Newer' and older west coast schist zones are distinguished as well.

In March 1867, Haast replied to a letter from the Secretary of Public Works, confirming that he would indeed "complete the geological survey of the province, in the manner hitherto followed, before the end of June 1868".[19] Between January and May 1867, Haast explored the geology of the Waipara and Hurunui river districts, as well as surveying the headwaters of the last major eastern river to be examined, the Waimakariri, thus completing the major part of his geological survey of the entire province.

Given the frustration he had experienced with his geological map of Nelson languishing unpublished, and encouraged by Jollie, Haast sought an early quotation from the Christchurch lithographic firm Ward & Reeves for printing 250 copies of a ten-miles-to-the-inch "Geological Map of Canterbury" in nine colours, and of a larger, four-miles-to-the-inch Geological Survey of Canterbury map on six sheets, presumably also in nine colours. On receiving quotations of £130 and £240 respectively, he forwarded them to Jollie on 27 June, stating that the first

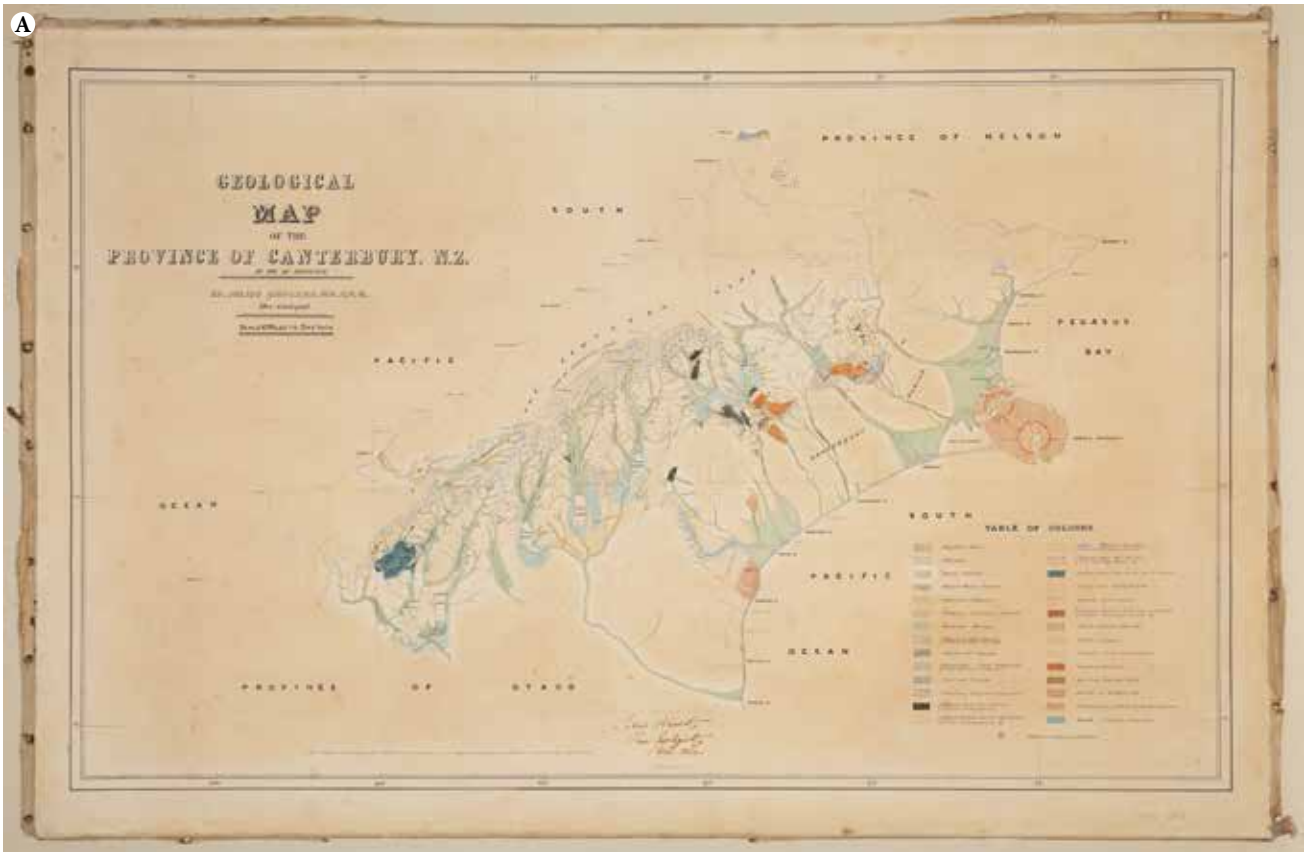

Figure 8. A, *Geological Map of the Province of Canterbury, N.Z., as far as surveyed. By Julius Haast, PhD, FGS, FLS, etc. Prov. Geologist.* Signed 'Julius Haast Prov. Geologist, Decb 1864'. Draughted by T.L. Locke, C.E. Scale 10 miles to one inch. Hand-drawn and coloured on linen-backed draughting paper, 620 x 950 mm. Unvarnished. Canterbury Museum, CMU1558. **B**, Detail from map A. **C**, Undated tracing of the above map. Archives New Zealand, Wellington, R17917394

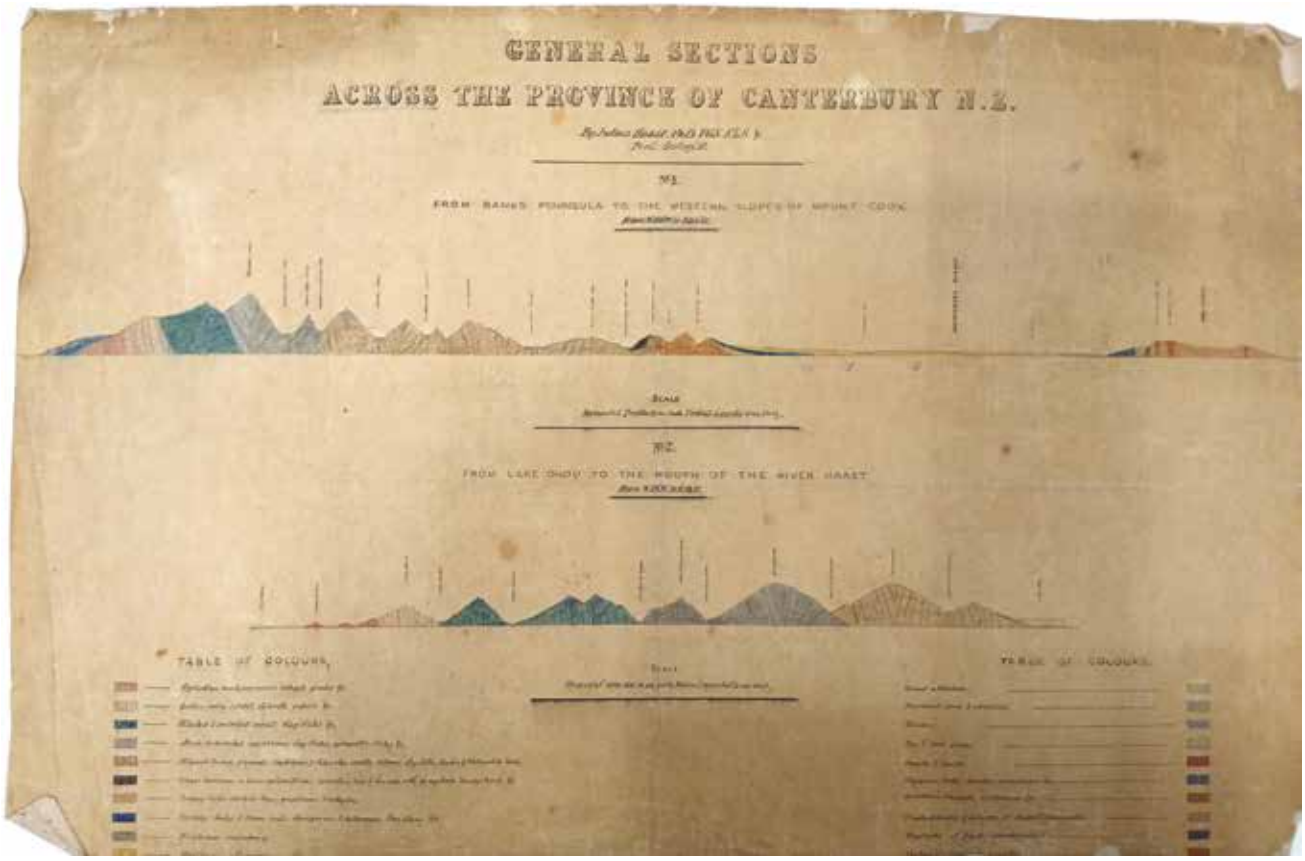

Figure 9. *General Sections across the Province of Canterbury N.Z. By Julius Haast, PhD, FGS, FLS, etc. Prov. Geologist* [1864]. Horizontal scale 15,840 to an inch, vertical scale 10,000 feet to an inch. Hand-drawn and coloured on linen-backed tracing paper, dimensions unconfirmed. Draughtsman not identified. Archives New Zealand, Wellington, R17917394

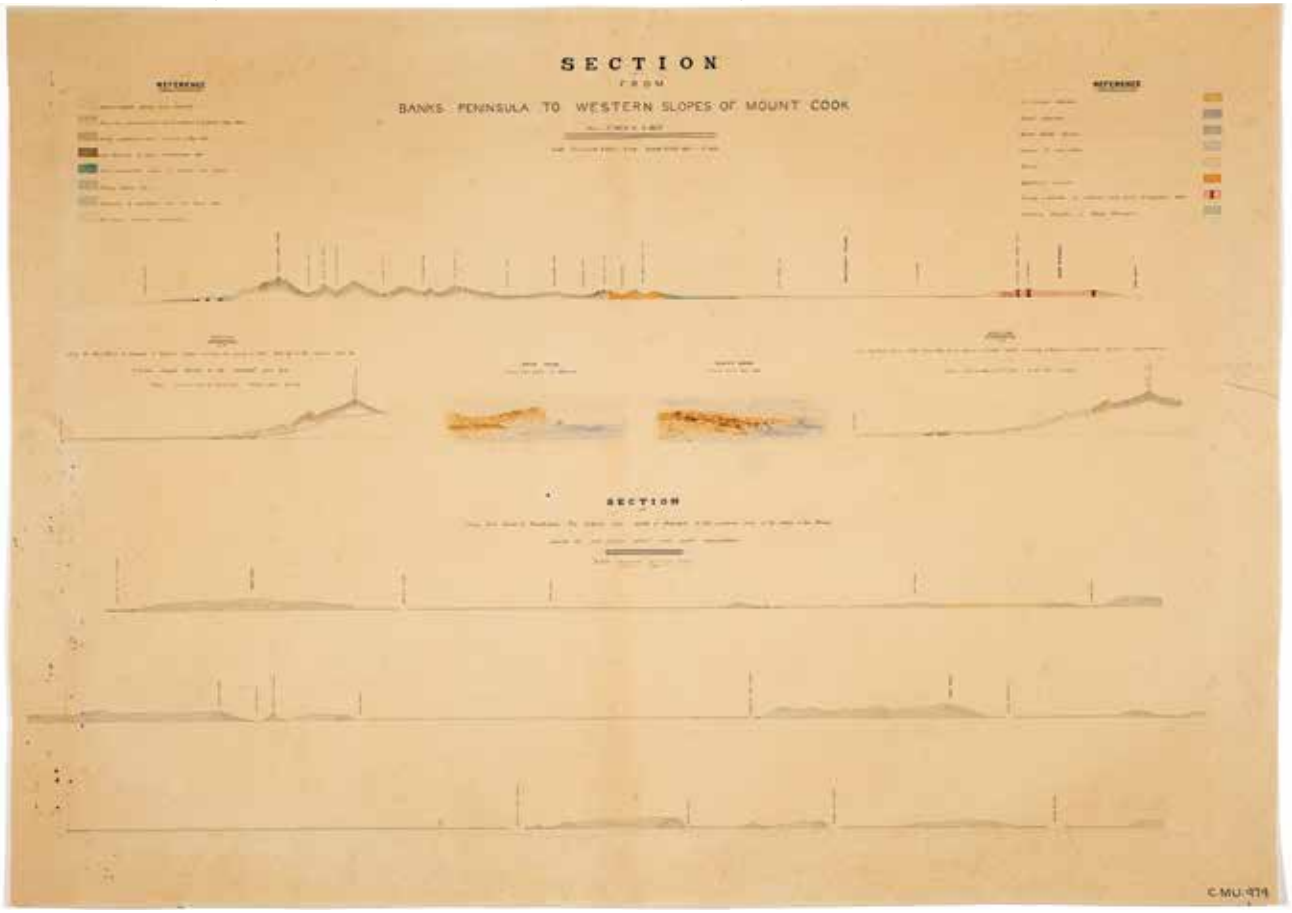

Figure 10. *Section from Banks Peninsula to Western Slopes of Mount Cook,* etc. Top section scale: horizontal 7 miles to 1 inch; vertical 20,000 feet to 1 inch. Hand-drawn and coloured on linen-backed draughting paper, 890 x 630 mm. Unvarnished. Draughtsman not identified. Canterbury Museum, CMU979

map "could not of course be published before all my fieldwork is finished", which he anticipated would occur soon "providing I have favourable summer and autumn weather". For the larger map, which would be "on the same size of those of the Geological survey of Victoria", three of the six sheets "can be placed in the printers hands, in a very short time, a fourth in December, the rest in the course of next year". In closing, Haast pleaded: "Will you be good enough to inform me if you think favourably of my proposal".[20] No written response from the Secretary has been located but in July Haast wrote to Hector saying:

> *I need scarcely tell you, how thoroughly disheartened I am there is no money to print my topographical map of the Southern Alps or the geological map of the Province. I can have both printed at once in Germany, but think that it would be wrong to send them there before all means to have them printed in New Zealand or in England are exhausted. What do you think?*

Hector made no response to Haast's question. Four months later, Haast informed Hector he had "24 sections of the Province ready, & also my map is advancing towards completion" (Nolden et al. 2012: 119, 126).

1868: Eastern Ranges, Banks Peninsula and West Coast Expeditions

In July 1867, Haast had forwarded to Jollie "a map of the province of Canterbury showing the portions of the province still unsurveyed by me, colored yellow",[21] which were then investigated when he visited the eastern base of the high country, parts of Banks Peninsula and the southern portion of the west coast from January to March 1868. As his contract with the Provincial Government was due to end in June, Haast then devoted all of his attention to completing his two great maps: the topographical map of the Southern Alps (Hook and Nolden 2024: 31) and the geological map of Canterbury. Unsure of his future, he wrote to Hector in mid-June saying that he was ready to take up "an appointment on the staff of the Geological Survey of New Zealand and under your Direction" when his current role terminated.[22] Regardless, on 30 June Haast had to inform Jollie that he would need another month to complete the maps, which he did without being paid.[23] Late in July Haast informed Hector that shortly he would be "free, consequently if there is not certainty one way or the other I must look out for some thing else, (grow cabbages etc or go home!)". But in the meantime he would "go on with my work, collecting, drawing the sections, looking out the duplicates & corresponding for exchanges & gifts", which would be of benefit to the fledgling Canterbury Museum at least (Nolden et al. 2012: 143).

On Friday 31 July, Haast finished a report for the Secretary for Public Works, titled *Completion of the Topographical and Geological Survey of the Province of Canterbury*, in which he stated:

> *I have the honour to inform you, that I have finished … the Geological Map of the Province of Canterbury & the County of Westland; and that thus my task according to the contract, into which I entered with the Government of this Province is accomplished.*

Haast asked Jollie to note that he had made only "so many Geological divisions of the formations under review as conveniently … could well be hazarded". Furthermore, he had not "attempted to subdivide our large Palaeozoic Fossiliferous beds [of greywacke], of which by far the greatest portion of the eastern side of the Central Chain is composed" (Haast 1868: 3–4).

On Monday 3 August, Haast signed the completed geological map (Fig. 11) and delivered it to Jollie. In a somewhat melancholic letter sent to Hector a few days later, Haast wrote:

> *Last Monday I handed over the maps to the Govt., I must confess I felt rather queer (we Germans are* [of] *a sensitive nature). Tuesday morning I took as far as I know the first holiday in New Zealand: I went to the Domain & Acclimatisation gardens & after lunch had a walk with Mrs Haast.*

Not one to be inactive for long, Haast continued: "Yesterday morning I set to work again beginning with the sections & I intend to stick to them & collecting & getting the fossils in order" for the museum (Nolden et al. 2012: 146).

This great map with all areas now painted with a multitude of geological colours (Fig. 12) may have been drafted by Haast, given that no other hand is acknowledged. Being a display map it was varnished for protection and enhanced visual appeal, but the varnish has yellowed with age and the original bright watercolours are now muted, making it difficult to distinguish different regions. The map summed up 7 years and 5 months of his labours as Provincial Geologist, with 44 of those 90 months spent in the field. On the map Haast appropriately coloured all of the greywacke zones grey, which he classified as *Palaeozoic*, thus reversing his earlier inclination to split the greywacke bedrock into formations from two different geological periods. In contrast, at the top of the right column of the legend Haast listed six formations with some kind of schistose rock, none of which was assigned to a particular geological era.

On 17 November, Haast wrote to Jollie saying he wished to hand over "three sheets, containing 24 Geological sections of the province, in illustration of its structure".[24] The largest sheet (Fig. 13) has four sections, with three running from the east to the west coast, as marked on the map. Haast had selected the four from his field notebooks in order "to convey a clear insight into the Geological structure of the country". Furthermore, he placed them "at such distances from each other that no important portion of the country remains unnoticed". The second sheet included "smaller sections, but elucidating the structure of important districts", and the third provided "a series of Banks Peninsula sections – so very instructive in many respects" (Haast 1868: 5).[25] While the lines of some of the eight Banks Peninsula sections are also marked on the map, whether the lines of the 12 sections on the second sheet are also present on the map will only be ascertained once that chart has been located.

Figure 11. *Geological Map of the Province of Canterbury and the County of Westland by Julius Haast, P.H.D. F.R.S. F.G.S &c Provincial Geologist*. Four miles to one inch. Signed 'Christchurch Aug 3 1868 | Julius Haast | Provincial Geologist'. Hand-drawn and coloured on draughting paper mounted on canvas, 1130 x 1720 mm. Varnished and mounted on rods. Draughtsman not identified. Canterbury Museum, CMU 2443

Presciently, at the end of his 1868 report Haast suggested that, if the Provincial Government did not intend to have his geological map and sections published, copies could be made and hung in Canterbury Museum "so that at least the public, or those interested in becoming acquainted with the geological structure of the province, can consult them" (Haast 1868: 5). If Jollie made a written response, it has yet to be located. However, a newspaper report of the following year,[26] suggests that instead of copies, the originals were returned to Haast's safekeeping as curator of the fledgling Canterbury Museum.

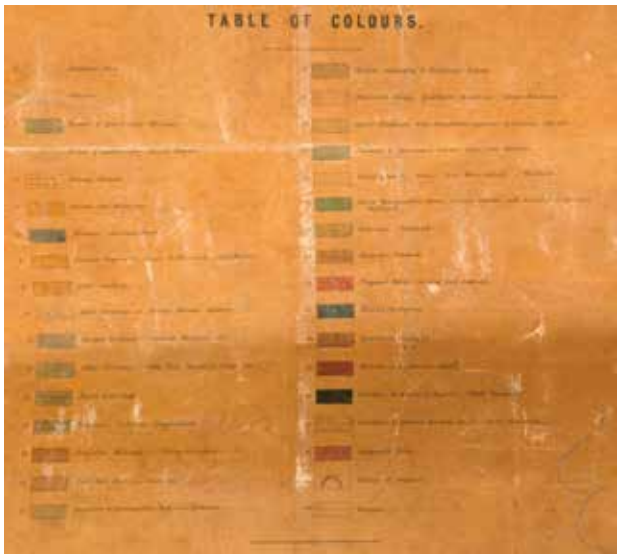

Figure 12. Legend of Haast's 1868 geological map of the Province of Canterbury. Canterbury Museum, CMU 2443

1869–1874: Minor Expeditions and Museum Opening

Early in 1869, Haast was appointed as the Curator and Director of the Canterbury Museum, then housed in cramped quarters in the stone tower of the Provincial Council Buildings. He also commenced undertaking detailed geological surveys for Hector at specific locations, 12 of which were completed during the period 1869–1874.

Haast still had hopes his map would be published, as in June 1869 he wrote to the English geologist Roderick Murchison (1792–1871) saying: "My geological map has also hitherto not yet been published, but I trust that this will be done in due time in connection with the NZ Geological Survey" (Nolden et al. 2013: 143). On 27 October, Hector sent a telegram to the Superintendent of Canterbury, William Rolleston (1831–1903), requesting "permission to publish Dr Haast's geological map as part of General Sheet map of Colony on Scale of 12 miles to inch and that you will arrange with Dr Haast for transmission of required information".[27] Rolleston replied that the Province would "gladly give the use of the map". When Haast was told of the request he informed Hector he was "truly glad" about the proposal. As there was "no copy of my map existing", Haast asked Hector to return it when he was done with

Figure 13. *Geological Survey of Canterbury. N.Z. General Sections.* One mile to one inch vertically and horizontally. Signed 'Christchurch Novb. 19 1868 | Julius Haast'. Hand-drawn and coloured on draughting paper mounted on canvas, 1860 x 1260 mm. Varnished and mounted on rods. Draughtsman not identified. Canterbury Museum, CMU16/1)

it (Nolden et al. 2012: 184–185, 187). Nothing came of Hector's plan to publish such a large map, but he did incorporate many aspects of Haast's 1868 geological map of Canterbury in the first published geological map of New Zealand,[28] which "generalise[d] the main features of New Zealand's geology" (Nathan 2012: 98). Haast's contribution wasn't acknowledged.[29]

By early 1870, the initial stage of the purpose-built Museum next to the Botanical Gardens had been completed, consisting of a large room with an upstairs gallery (Fig. 14), now known as the Mountfort Gallery after the Museum's architect Benjamin Mountfort (1825–1898). The opening of the Museum was scheduled to occur in September, so on 9 August Haast asked Hector to return "the geol. map of this Province which I forwarded you some time ago … as I wish to place it on the wall of the new Museum Building previous to its opening". Ten days later he wrote again saying that he would "like to hang [it] with all the other sections". On 5 September, Haast informed Hector that he was "most anxious that it should be on its place when I open the Museum" (Nolden et al. 2012: 226, 227, 228). That map, which eventually arrived in time for the opening on 30 September, can be seen hanging in a photograph (Fig. 14) taken by Alfred Barker a week later, between the tall *General Sections* chart on its left and the first of the two smaller section charts to its right.

1874–1876: Provincial Geologist again

In November 1874, Haast was reappointed Provincial Geologist for Canterbury, a role he fulfilled alongside his work as director of the Museum. The shorter, less arduous, geological surveys he intermittently conducted during the following year and a half focused on the detailed examination of specific areas that could be exploited for their mineral resources. Although this work filled in more of the geological detail of the province, it didn't necessarily add to Haast's overall understanding of the geology of Canterbury. By the end of March 1876, "all specimens, maps and sections were deposited in the Canterbury Museum, and thus the actual work of the Geological Survey of the Province had come to a close" (Haast 1879: 170–171).

1879: Publication of Haast's Geological Map

As the economy of New Zealand expanded during the 1870s, particularly due to immigration policies and road, rail and communications projects initiated by Colonial Treasurer Julius Vogel (1835–1899), the power of the provinces diminished greatly. The Abolition of the Provinces Act passed in 1875 meant the "sands of the Provincial Councils were running out". The numerous reports produced during Haast's geological survey of Canterbury were "either out of print or not easily accessible to the public". Early in 1876, undoubtedly much to Haast's satisfaction, the Canterbury Provincial Council therefore commissioned him to write "a final report, illustrated by geological maps, sections, and other drawings, and containing, not only the substance of all previous reports, but also a great deal of new matter", which would be published at the expense of the Provincial Council. Anticipating this project would not be completed before the dissolution of the provinces, due to occur on 1 November 1876, a sum of £250 was sequestered for printing 500 copies (100 of which were Haast's to distribute), and £150 allocated to Haast to pay for the printing of maps and sections, as well as other expenses (von Haast, HF. 1948: 826).

On 22 July 1876, the Provincial Secretary, Henry Webb (1829–1901), informed Haast he could "take steps to have the coloured maps prepared and printed in Europe at a

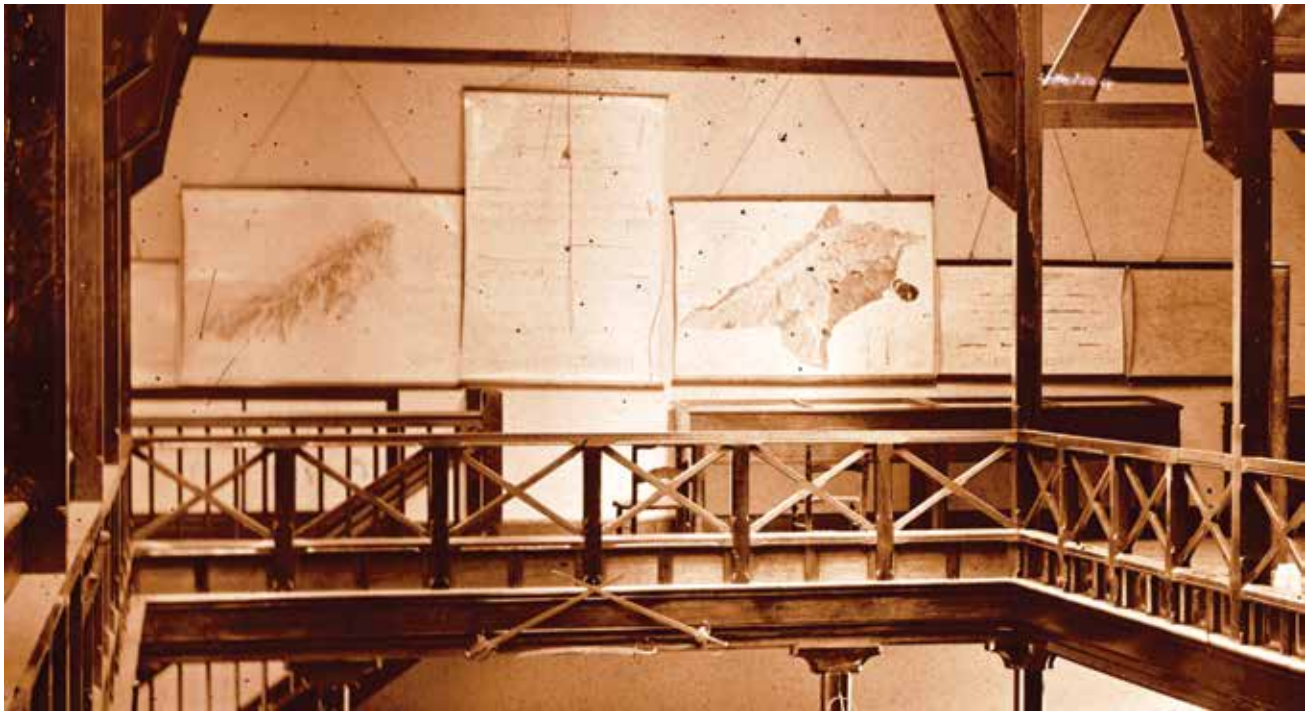

Figure 14. Photograph developed from a full-plate glass negative, showing Canterbury Museum interior on 7 October 1870 (cropped). Photographer: Alfred Barker. Dr A.C. Barker Collection. Canterbury Museum 1944.78.68

cost of £50 in terms of your letter of July 4".[30] Haast had lost no time in getting that aspect of the project underway, sparing "no effort in ensuring the maps were both accurate and attractive, serving the book well" (Nolden 2020: 48). Given the limited funding for illustrating the publication, Haast wrote to Hochstetter in Vienna asking him to obtain a quotation for printing illustrations, sections and maps, the most complex of which would be a reduced-size, multicoloured, updated but simplified version of the 1868 geological map of Canterbury. Hochstetter approached the highly experienced printer of complex geological maps Friedrich Köke (1823–1882)[31] and in August he forwarded a quote from the lithographer "for the geological map, 130 gulden Austrian currency, which is not quite £13" (Nolden 2013: 176).

It must have taken some time to have the reduced size maps and sections "prepared in Canterbury by draughtsmen working under Haast's direct supervision" (Nolden 2020: 48), as in December Hochstetter wrote: "I am expecting the geological map from you and will then have it executed for you immediately". It is not known when the maps and sections were ready, but Hochstetter had received them by 24 January 1877 (Nolden 2013: 180–181). Seven months later on 28 July, Hochstetter informed Haast that: "Finally I can let you know that a large heavy case has been sent off to London for you to the New Zealand Shipping Company". Soldered in that tin case were Haast's "geological maps and profiles, 4 packets, each containing 510 copies for your book".[32] Hochstetter added that the "maps came out quite well … and I hope you will be satisfied" (Nolden 2013: 185–186), suggesting that an issue may have occurred with the printing of a map that required up to 12 different limestone plates, one for each colour. One of the additional 10 copies of the meticulously lithographed map, stored unfolded in Canterbury Museum, is reproduced as Figure 15. In the foreword of his book Haast acknowledged the labours of Hochstetter in "superintending the printing of the chromo-lithographed maps and sections" (Haast 1879: iv).

All of the areas where Haast had encountered greywacke are coloured beige on the printed maps Hochstetter sent to Haast, indicating they are the *Mt Torlesse formation*. Haast had introduced this new name for the rock formation based on the original site where he first examined the alternating sandstone (greywacke) and mudstone (argillite) beds that make up most of the Canterbury mountains (Haast 1879: 266–280). Despite

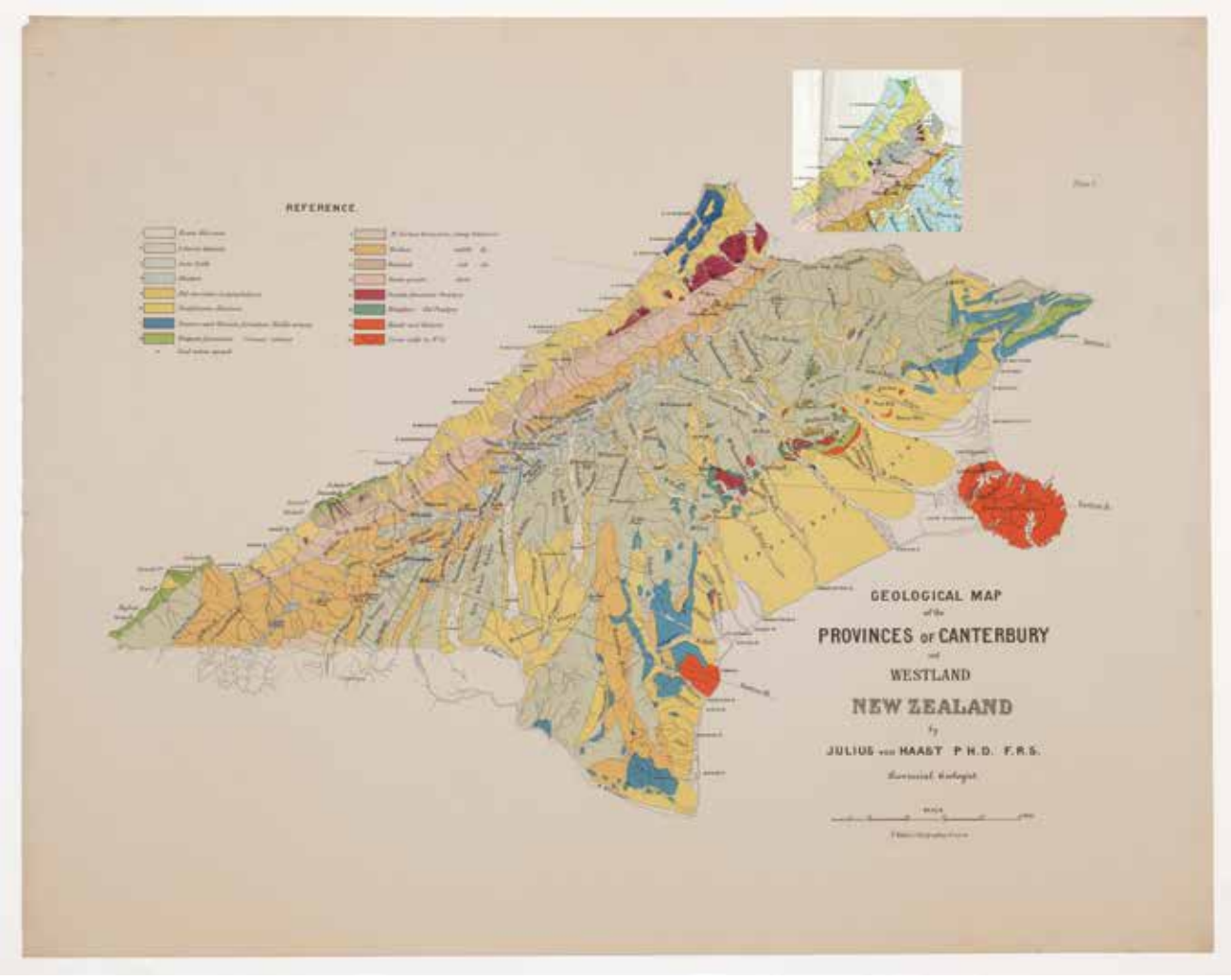

Figure 15. *Geological Map of the Provinces of Canterbury and Westland New Zealand by Julius von Haast PH.D. F.R.S. Provincial Geologist*. Scale 16 miles to the inch. Chromolithograph by F. Köke, Vienna, with additional hand-colouring. 380 x 490 mm. Canterbury Museum, CMU937.7. Inset – detail of proof copy of the same map without additional hand-colouring. Hochstetter Collection Basel, HCB 3.9.3

debate with Hector and others, Haast had decided that it was not possible to subdivide the greywacke rocks into different units or zones.

On the map Haast identified three formations with schistose rock: the orange areas labelled *Waihao formation* (semi-schist) of the middle Palaeozoic; the pink areas labelled *Gneiss granite formation* (layered schist and gneiss), which was undated due to the absence of fossils; and the grey areas labelled *Westland formation* (ancient greywacke intruded by granite) of the early Palaeozoic. Although the interpretation of these units has changed over the years, the map boundaries are still much as shown by Haast.

Among the New Zealand maps held in the Hochstetter Collection Basel (Nolden and Nolden 2013), there is a proof copy of Haast's map (see detail in Fig. 15 inset) that has significantly different colouration to the Canterbury Museum map. The two maps have been photographed under very different artificial lighting conditions. This accounts for the sage-coloured areas of the Canterbury Museum map appearing a turquoise colour on the Basel map. Regardless, there is a significant issue in that on all of the maps sent for insertion in Haast's book, some areas in northern Westland have been over-painted different colours (Nolden 2020: 49). Near the coast, areas originally printed turquoise have been painted dark blue, changing the rock type from *Mt Torlesse* to *Pareora formation*, while other areas originally printed grey have been recoloured dark red, changing the rock type from *Westland formation* to *Granite*. Clearly something went wrong with the chromolithographic process. The draft map that Haast supplied would have been both numerically and colour-coded, but the draughtsman may have used incorrect "colour-and-number" combinations. Köke's lithographers were very experienced, but one of them may have mistaken which of the available watercolour paints selected for the printing process should have been applied in those two zones on the west coast. Regardless, Hochstetter would have noticed those errors when he compared the print with Haast's original. The 510 maps would then have been painstakingly touched up by Köke's employees using fine brushes.

To accompany the map, three general sections corresponding to the paths marked Sections I, II and III on the map were lithographed on one sheet (Fig. 16, top), using the colour code of the map (Fig. 16, bottom). All three sections illustrate Haast's view that the pink and orange schist beds "are underlying, unconformably, the indurated sandstones and shales [mudstone / argillite]" of the *Mt Torlesse formation*, even though he was "not able to find a clearly defined contact line" (Haast 1871: 22–23). Haast's use of the term "unconformably" implied there must be a major gap in the geological record. In common with nearly all nineteenth-century geologists, he believed that metamorphic rocks, such as schist, were formed much deeper in the crust than sedimentary rocks, such as greywacke, therefore there had to be a gap in the record, which he described as "great unconformity". Despite "no break being visible" between the two formations, and no "difference in the strike and dip of the strata" (Haast 1879: 280), Haast did not contemplate the fact that the uplifted schist formations of the Southern Alps are variably metamorphosed greywacke sandstone and mudstone (argillite) of the *Mt Torlesse formation*.

Locating Haast's Great Geological Map

Although an 1880s photograph shows that Haast's 1868 map was still on display in the Museum,[33] no twentieth-century photograph has been located that shows the map exhibited in Canterbury Museum, and it is not known when the map and section charts were put into storage. In 1988, Brian Lovell-Smith (1912–1989) published *Maps: A Catalogue of Historical Maps in the Canterbury Museum*, and although there are entries for all three of the wall charts illustrating geological sections, which Haast produced to accompany the map, the geological map itself is not listed. This may have occurred because details of the map had not been entered in the digital database that the Museum adopted earlier. Nearly a decade later, the bibliographer Claren M Kidd published her comprehensive listing of all the historical geological maps that she had personally viewed in New Zealand institutions. Haast's 1868 geological map of Canterbury was listed as being map CMU2243 in the holdings of Canterbury Museum (Kidd 1996: 156). Initially Museum staff were unable to locate the map as there was no entry for that reference number in the Vernon database the Museum uses. Eventually a matching description was found in one of the old card index files, but its reference number was actually CMU2443. Museum staff then located the map in a tube confusingly labelled 'Canterbury & Westland Julius Haast, 1968'.

Discussion

History of the mapping

A recent survey of the earliest New Zealand geological maps found that very few were produced prior to 1860, and none from this earliest period was printed or published (Hayward et al. 2024). Scholarship conducted over a long period of time has established that Haast owed his career as a geologist largely to the fortuitous meeting with Hochstetter, under whose tutelage he acquired the practical skills required to independently execute a geological field survey. What has become more obvious through recent research focusing on Haast as a cartographer (Nolden 2022) is the fact that Haast also acquired his topographical and geological mapping skills through the time spent with Hochstetter and other surveyors in the field, including Charles Heaphy (1820–1881), Thomas Brunner (1821–1874) and James Burnett (1826–1872).

It has been suggested that Haast made up for any lack of formal training and qualifications by being well read and a fast learner with a practical can-do attitude, who never shied away from a challenge. In fact it was this confidence in his own abilities that must have helped persuade various provincial government authorities to employ him and entrust the major pioneering tasks to his execution. And pioneering exploratory geological surveys they were. What Haast experienced with Hochstetter was the first major geological survey undertaken in New Zealand when they spent 79 days in the central North Island. In the South Island, Haast subsequently undertook geological surveys and reconnaissance trips with Hochstetter, and then independently in what was to become Marlborough, and

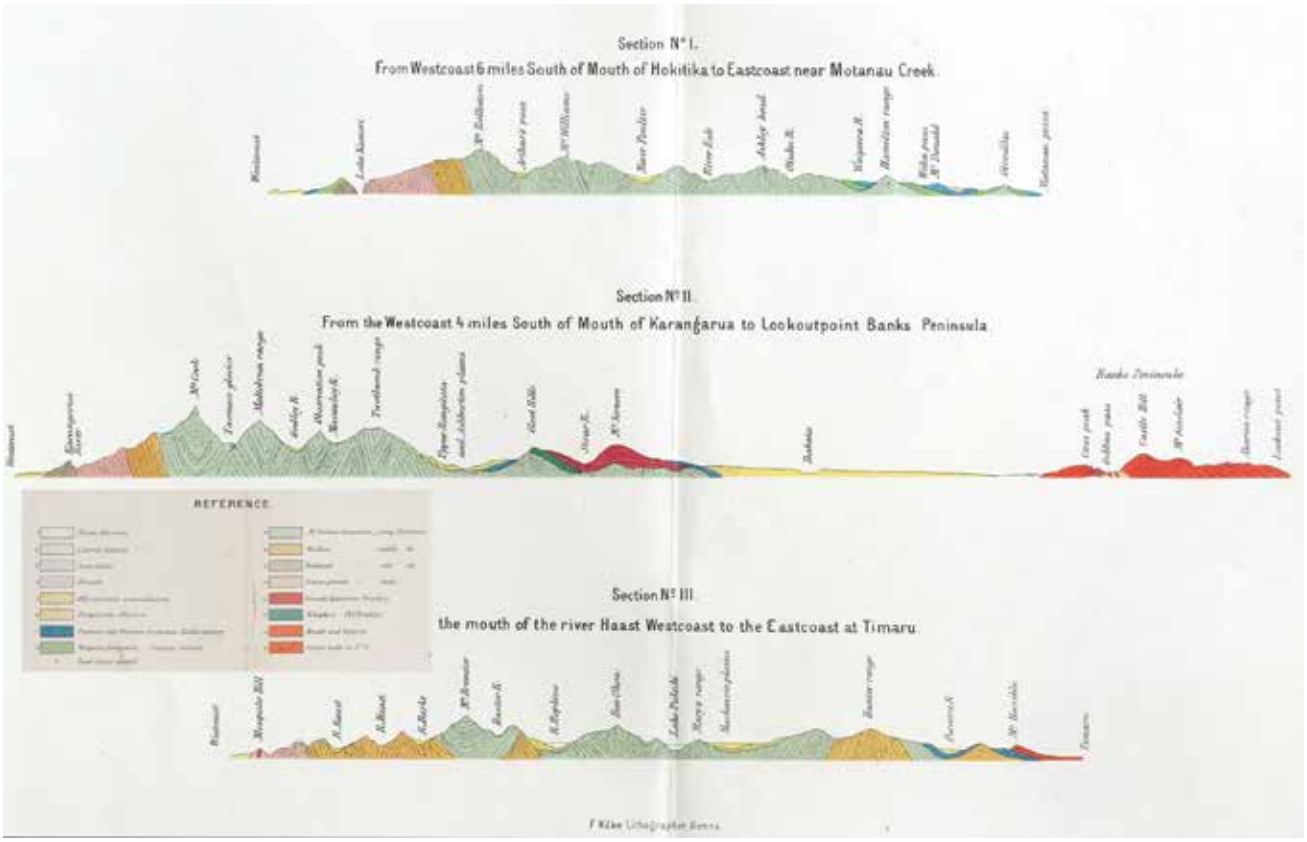

Figure 16. [General Sections], (Haast 1879, Plate IV). Chromolithograph by F. Köke, Vienna. 210 x 360 mm. Same horizontal scale as map, vertical scale unspecified. Inset: Reference Table from Figure 16. Hochstetter Collection Basel, HCB 3.9.6

in the south-western part of Nelson Province. All the while Haast was looking to discriminate geological formations and structures.

Haast's topographical mapping of the Southern Alps has been thoroughly documented (Hook and Nolden 2024) and in the present paper this has been complemented by a detailed review of his geological mapping of Canterbury. Haast was the first person to be appointed to a full-time position of Provincial Geologist in New Zealand. The task he took on was monumental and without precedent from the outset, but it grew enormously when he realised that much of the high country had not been surveyed at all, thus requiring of him the dual task of topographical and geological surveying, similar to what Hochstetter had undertaken in the North Island.

Haast quickly learnt on the job and was soon able to lead expeditions in completely uncharted territory across some of the most difficult alpine terrain found anywhere in New Zealand. Although he was ably assisted by local guides and a support party, including experienced assistant surveyors, he was solely responsible for reading the geology of the land. The task grew as he went along, and he encountered numerous delays, not so much due to inclement weather, which was to be expected, but more from other demands on his time, including special surveys when he was called on to assess potential resources such as artesian water supplies, building stone, coal deposits and goldfields.

In the end, Haast managed to complete a monumental surveying task. He also finally completed the geological map that had been a work in constant progress over the years. Again, putting this achievement in context, it is clear that no other province was geologically surveyed and mapped as systematically and to the same level of detail as Canterbury at this time. Despite the usual political upheavals and questions raised around the value of having a provincial geologist at all, Haast proved he was the best person for the job. In return Canterbury saw the task accomplished with the same person in charge from the start to the finish, and the resulting consistency in the geological mapping is of great importance.

Comprehensiveness of the mapping

Haast's geological mapping of Canterbury was thorough, and during his fieldwork in the 1860s he visited almost every corner of the province. He discovered and recorded almost all the major features, and a modern geological map looks little different from the version he published in 1879. A significant difference, though, is in the subsequent recognition of the Alpine Fault, a major fault that cuts obliquely across the South Island and forms the western edge of the Southern Alps. To modern eyes, aided by satellite imagery and aerial photographs, it seems strange that such a major feature was overlooked (and, indeed, not recognised until the 1940s), but nineteenth-century geologists did not recognise faults as major geological features. Although Haast did not recognise the boundary as a fault, on the 1879 map (Fig. 15) the boundary between schist (coloured pink) and rocks to the west – ancient greywackes intruded by granite of the *Westland formation* (light brown) – coincides closely with the Alpine Fault..

Utilisation of the mapping

During the 1860s, there was pressure to complete and

publish a geological map of the whole of New Zealand. As Director of the national Geological Survey, James Hector took a leading role (Nathan 2014), but he was dependent on Haast for information on Canterbury and the West Coast. The first map published in 1869 faithfully reproduces a simplified version derived from Haast's 1868 map. The map of New Zealand,[34] produced for the 1873 Vienna World's Fair is similar, but with a modified colour scheme. By the time a revised map[35] was published in 1884, Hector and Haast had fallen out – Hector thought that he could subdivide the greywacke rocks into units of different age, but Haast did not agree. Much of Hector's evidence has subsequently been discredited, so the 1884 version is regarded as less accurate than earlier versions.

Haast's geological mapping of the Province of Canterbury was also utilised internationally. During the late 1860s, the French geologist Jules Marcou (1824–1898) commenced working on a second edition of his 1861 geological map of the world, on which New Zealand had largely been a blank. In March 1868 Marcou wrote to Haast asking if he would be "kind enough to send me a rough sketch or outline of the principal formations of New Zealand." Later in August of that year Marcou sent Haast "a little map, on a scale similar to that of my map" asking him to "colour [it] in geologically",[36] which Haast did with Hector's cooperation (Nolden et al. 2012: 156, 158). When Marcou's *Geological Map of the World* was eventually published in 1885, New Zealand was appropriately coloured in, and the contributions of Haast, Hochstetter and Hector were acknowledged.

Legacy of the mapping

Despite the initial hopes of the Canterbury Provincial Council, Haast's mapping did not reveal significant mineral resources in Canterbury. It became regarded primarily as an agricultural region, with little in the way of mineable resources apart from aggregate and limestone. During the first half of the twentieth century the New Zealand Geological Survey concentrated on detailed surveys of areas thought to have high mineral potential. Canterbury was largely ignored and as a consequence Haast's geological mapping remained the definitive study of the region for almost a century.

In the 1950s, the Geological Survey undertook the preparation of a new 1:250,000 scale geological map of the whole country. Haast's mapping was used as the basis for much of the work in Canterbury. However, it was necessary to simplify the nomenclature of some widespread rock types, so Suggate (1961) adopted the name *Torlesse*, originally used by Haast, for the greywacke-type rocks that form the backbone of both the North and South Islands. The term *Torlesse Group* or *Supergroup* was used widely in the late twentieth century, but with changing tectonic concepts has now been modified to *Torlesse Composite Terrane*.

To the west of the main ranges of the Southern Alps and to the south, the *Torlesse* greywackes have been metamorphosed (heated and recrystallised) into new rock types known as schist and gneiss, containing minerals such as mica and garnet. Although Haast failed to appreciate that the schist he encountered in the Alps was metamorphosed *Torlesse* greywacke, he recognised and mapped two belts of metamorphic rock, which he named *Waihao formation* and *Gneiss Granite formation*; these are very similar to units mapped today as Semi-Schist and Schist (Edbrooke 2017). Suggate named these metamorphic rocks *Haast Schist*, and this name is still in use. It is an appropriate way to remember Haast's geological mapping, although it is named after the Haast River location rather than Haast personally (Suggate 1961).

Conclusion

Haast was an outstanding example of a naturalist scientist and explorer in the second half of the nineteenth century in New Zealand. He approached everything with a confidence and vigour that belied his relative lack of formal qualifications or prior experience and training. At times he demonstrated incredible resourcefulness, resilience and energy. His drive and ambition benefitted Canterbury no end, for even though he divided his attention among many fields of research and scholarly engagement, he never appears to have lost track of his obligations. Even by the standards of the period, the breadth of Haast's scientific contributions is remarkable, and on top of writing zoological, ornithological, archaeological, ethnological, geographical, geological and palaeontological articles, he was steadily contributing to the cartographic documentation of Canterbury and Westland. If he had done nothing else, he would undoubtedly be more widely celebrated now as a pioneering New Zealand topographical and geological cartographer. But as it stands, it is studies like this one that provide new insights into this aspect of his legacy.

Haast's surveying and cartography falls into various categories and stages, of which the Nelson mapping has been briefly examined (Johnston and Nolden 2024). The history of Haast's topographical mapping of the Southern Alps, previously documented in full detail (Hook and Nolden 2024), is now complemented by the present study of his geological mapping of Canterbury Province. Future research may look more closely at Haast's geological survey and mapping in Nelson Province, and his glaciological survey and mapping in the Southern Alps

Acknowledgements

The authors wish to thank the following individuals for assistance provided: Dr Keith Giles, Auckland Libraries; Dr Albert Schedl, Vienna; Johnathon Ridden, Nicolas Boigelot, Julia Nicholls and Mark Fraser, Canterbury Museum, Christchurch; Tony Mander, Christchurch; Stuart Nicholson, Wellington; Stephen Carey, Ballarat, Australia; John Jamieson, Pukerua Bay, Kapiti Coast and Caroline Etherington, Archives New Zealand, Christchurch. We would also like to thank the anonymous reviewers for their positive responses and constructive suggestions.

Endnotes

1. Letter from Alfred Greenfield, Chief Clerk, Nelson Provincial Government, to Haast, 26 November 1859. Alexander Turnbull Library MS-Papers-0037-015-04.
2. Julius Haast, *Topographical Map of the Central and Western Part of the Province of Nelson*, 1860. Ink and watercolour on canvas-backed paper, 975 x 725 mm. Nelson Provincial Museum, Bett Loan Collection, M1670.
3. Heinrich's claim may be compared to a passage in a letter his father wrote to Dechen on 6 August 1863: "Ich erlaubte mir einen unserer schneeigen Alpenriesen mit Ihrem Namen zu schmücken, als schwacher Tribut von den Antipoden, nicht allein weil die Wissenschaft Ihnen so viel zu verdanken hat, sondern auch weil Ihre vortrefflichen geol. Karten von Rheinland - Westphalen meinen ersten Leitfaden bildeten" (I took the liberty of adorning one of our snowy Alpine giants with your name, as a humble tribute from the Antipodes, not only because science owes you so much, but also because your excellent geological Maps of Rhineland - Westphalia served as the first guidelines for me). Alexander Turnbull Library MS-Papers-0037-178-22. However, the text implies that Haast used Dechen's maps as model exemplars which helped him to develop his own geological mapping, rather than Haast was trained by Dechen.
4. *List of Plant, in use of the Geological Survey*, 8 October 1861. Archives New Zealand, Christchurch, R22199235.
5. Letter from Haast to Moorhouse, 12 January 1863. Archives New Zealand Christchurch, R22199235.
6. 'Explorations in the Neighbourhood of Mount Cook', *Lyttelton Times*, 7 June 1862: 4.
7. Letter from Haast to Maude, 7 May 1862. Archives New Zealand Christchurch, R22199235.
8. Letters from Haast to Maude, June 1862. Archives New Zealand Christchurch, R22199235.
9. Historical maps and sections that were originally the property of the Geological Survey of New Zealand, which was established in 1865, were eventually transferred to Archives New Zealand Wellington this century.
10. Letter from Haast to Moorhouse, 12 January 1863. Archives New Zealand, Christchurch, R22199235.
11. Letter from Haast to Maude, 24 July 1863. Archives New Zealand, Christchurch, R22199235.
12. See also letter from Haast to Moorhouse, 14 July 1863. Archives New Zealand, Christchurch, R22199235.
13. Letter from Haast to Hall, 6 June 1864. Archives New Zealand, Christchurch, R8420845.
14. *Sketch Map of the Geology of New Zealand 1865*. Archives New Zealand, Wellington, R17916934, (https://ndhadeliver.natlib.govt.nz/delivery/DeliveryManagerServlet?dps_pid=IE89113026).Letter from Haast to Jollie, 25 July 1865 (Haast 1865: 10).
15. At the time, geologists had no idea what had produced that "endless succession", but it is now known to be caused by turbidity currents.
16. Letter from Haast to Jollie, 15 October 1866, Archives New Zealand. Christchurch, R22200644.
17. Letter from Haast to Jollie, 16 October 1866, Archives New Zealand. Christchurch, R22200644.
18. Letter from Haast to Jollie, 5 March 1867, Archives New Zealand. Christchurch, R22200644.
19. Letter from Haast to Jollie, 27 June 1867, Archives New Zealand. Christchurch, R8420845.
20. Ibid. This map has not been located.
21. Letter from Haast to Hector, 17 June 1868. Alexander Turnbull Library, MS-Papers-0037-016-22 to -24.
22. Letter from Haast to Jollie, 30 June 1868. Archives New Zealand, Christchurch, R8420845.
23. Ten years later Haast wrote that when he submitted the two maps of the province in August 1868, they were "accompanied by 138 sections on 24 sheets" (Haast 1879: 165–66). This appears to be an uncorrected error as Haast submitted only 24 sections on three sheets.
24. Canterbury Museum, CMU16/2 & 3.
25. 'Prospecting for Gold', *Timaru Herald*, 14 July 1869: 2.
26. Telegram from Hector to Rolleston, 17 October 1869, Archives New Zealand, Christchurch, R17560114.
27. *Sketch Map of the Geology of New Zealand 1869*. Alexander Turnbull Library, MapColl-830caq/1869/Acc.1382 (https://ndhadeliver.natlib.govt.nz/delivery/DeliveryManagerServlet?dps_pid=IE384829).
28. On 6 August Haast told Hector he was "at liberty to give my name as authority or to leave it altogether away" (Nolden et al. 2012: 177).
29. Alexander Turnbull Library, MS-Papers-0037-018-4. Haast's letter of 4 July has not been located.
30. Köke had lithographed the maps of the Geological Survey of the Austrian Empire.
31. The four lithographic prints were the geological map of Canterbury, the general sections chart, the glaciological map of Canterbury and geological sections of the railway tunnel.
32. *The Museum, Christchurch*, [1880s]. Hocken Collections, University of Otago, P1955-002/2-071. (https://hocken.recollect.co.nz/nodes/view/51326).
33. *Geological Sketch Map of New Zealand, 1873*, Archives New Zealand, Wellington, R17916894.
34. *Sketch Map of the Geology of New Zealand, 1883*, published in the Reports of Geological Exploration for 1883–1884.
35. Letters from Marcou to Haast, 8 March and 25 August 1868 (Alexander Turnbull Library MS-Papers-0037-158-1 and 2). Transcribed and translated by John Jamieson.

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