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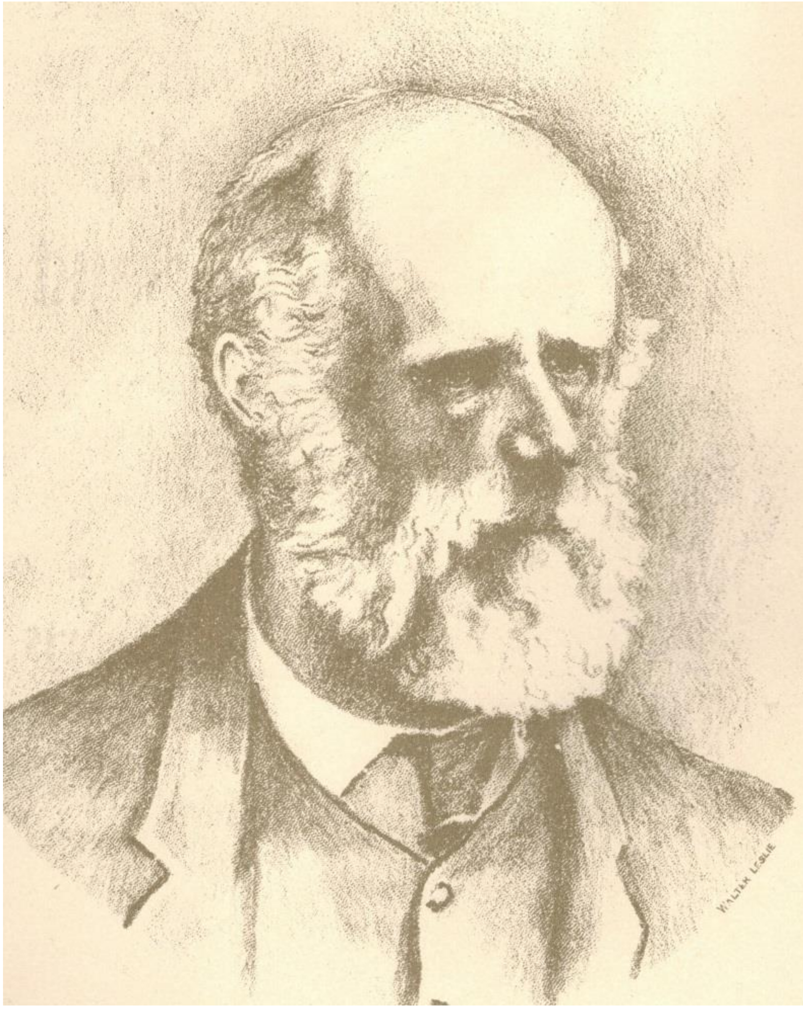

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Front cover

William Skey, Government analyst, Colonial Laboratory, by Walter Leslie (frontispiece in the *Transactions of the New Zealand Institute*, vol.34, 1901. The volume also includes the section "In Memoriam – William Skey", 554-558). Skey was the first to record chrome mica in New Zealand as discussed in an article by Rodney Grapes in this issue.

Travels of the New Zealand Geological Survey headquarters

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In 1954 as a new staff member of Geological Survey I had a visit from Jack Marwick, the retired Chief Palaeontologist whom I had met previously as a student holiday assistant while working on the fossil collections he had studied in the preparation of his masterly *Palaeontological Bulletin* 21 on the faunas of the Triassic and Jurassic (Marwick 1953) (Stevens 2018, this issue). As I had been appointed to work on the Mesozoic, Jack thought that it would be appropriate for me to have some relevant literature from his collections. The gift comprised a number of old Palaeontological Bulletins (e.g. Henderson and Grange 1926) and copies of the *Transactions of the Royal Society of New Zealand* containing Mesozoic papers (this was before xerox machines and hard copies of scientific papers were precious). In one of the Pal. Bulls. I found an old photo and as there was no identification of any type on its reverse I asked Jack if he had any information. He replied that it was a photo of the Geological Survey's first independent home at 38 The Terrace, Wellington, after it had moved from its initial accommodation in the Colonial Museum building (Nathan 2015) (Fig.1).

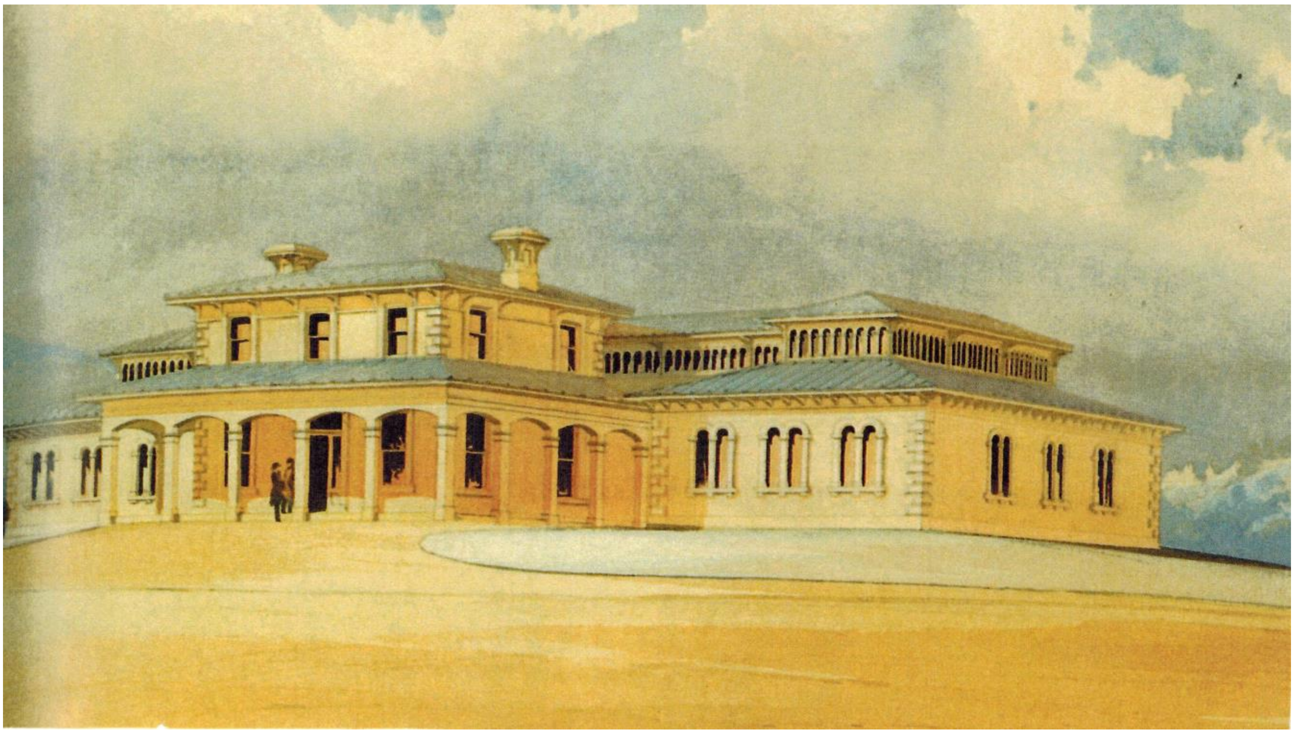

Fig.1. *A painting of the Colonial Museum by George O'Brian, reproduced in Nathan 2015, p.75 (reproduced as this figure). The infant Geological Survey after establishment in 1865 was accommodated in this building, before moving in 1920 to 38 The Terrace.*

Jack said that the photo was taken by H.T. Ferrar, a staff member of the 1920s Geological Survey (Burton 1965, pp.49, 53). Charles Fleming and Peggy Burton (Fleming 1979, p.64; Burton 1965 p.55) quote the address as 36 The Terrace. Perhaps the building was spread across two sections – 36 and 38? However, for the purposes of this article No. 38 is used, because Jack Marwick used it both verbally (to me) and in print (Marwick 1971, p.634) (see also Hornibrook 1971, p.645). Jack described the building as 'an old wooden house set back about 40ft. (12m) from the street with a sloping lawn in front. It was quite a good place to work in, with reasonable space at the time, relatively quiet for the middle of a city...'(Marwick 1971, p.634) (Fig.2).

Fig.2. 38 *The Terrace, Wellington. The Geological Survey occupied this building from 1920 to 1924, before moving to 156 The Terrace. This photo was taken by H.T. Ferrar. Jack Marwick records (Marwick 1971, p. 634) that a lawn extended out from the frontage of the building. As may be seen from the photo the lawn is not in existence and the area around the building is considerably overgrown. As Ferrar died in 1929 (Burton 1965, p.133) the date of the photo is probably somewhere between 1924 and 1929.*

The site of the Survey's building at 38 (and 36?) The Terrace, is today occupied by large office buildings immediately to the south of St Andrews Presbyterian Church. The Survey moved into the building at No. 38 in 1920 but to alleviate overcrowding moved in 1924 to 156 The Terrace (Hornibrook 1989; Stevens 2014) (Fig.3). Number 156 The Terrace was the home of the Survey's headquarters until 1958 when it moved out to Lower Hutt to a brand-new purpose-built building in Andrews Avenue (Fig.4). Subsequently the

Survey became part of DSIR Geology and Geophysics and moved to Gracefield. Later as GNS Science, a Crown Research Institute, a move was made to Avalon.

Fig.3. *156 The Terrace, Wellington. This building served as the headquarters of the Geological Survey from 1924 to 1958.*

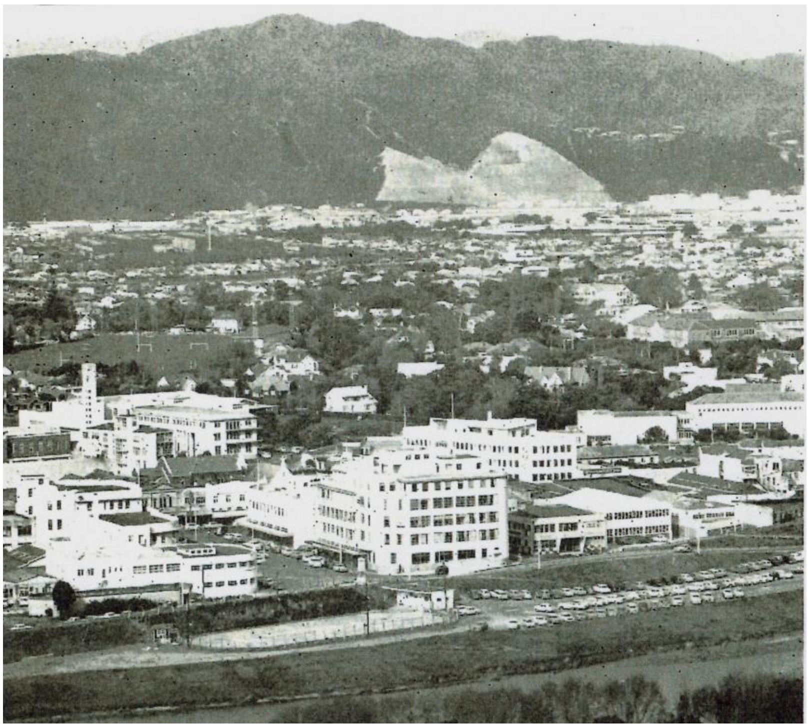

Fig.4. *In 1958 the Geological Survey moved to a new 5-storey building in Andrews Avenue, Lower Hutt. The Survey offices and laboratories occupied 4 floors. The building is the white building in the middle foreground (photo from Burton 1965, p. 125*).

References

Burton MP 1965. The New Zealand Geological Survey 1865-1965. *DSIR Information Series 52*.

Fleming CA 1979. John Marwick (1891-1978). *Proceedings of the Royal Society of New Zealand*. Part II. 107: 59-72.

Henderson J, Grange LI 1926. The geology of the Huntly-Kawhia Subdivision. *New Zealand Geological Survey Bulletin* (New Series) 28.

Hornibrook NB 1971. Finlay and Marwick. *New Zealand Journal of Geology and Geophysics* 14: 640-654.

Hornibrook NB 1989. Memories of No.156 The Terrace. *Geological Society of New Zealand Newsletter* 86: 24-27.

Marwick J 1953. Divisions and faunas of the Hokonui System (Triassic and Jurassic). *New Zealand Geological Survey Palaeontological Bulletin* 21.

Marwick J 1971. Reminiscences of the New Zealand Geological Survey. *New Zealand Journal of Geology and Geophysics* 14: 634-639.

Nathan S 2015. James Hector. Explorer, Scientist, Leader. *Geoscience Society of New Zealand Miscellaneous Publication* 140: 264p.

Stevens GR 2014. Life at 156 The Terrace, Wellington, in the early 1950s: personal memories. *Geoscience Society of New Zealand, Journal of the Historical Studies Group* 47: 29-36.

Stevens GR 2019. A few memories of Jack Marwick (1891-1978). *Geoscience Society of New Zealand, Journal of the Historical Studies Group*: this issue.

Heaphy and Hochstetter –first record of basalt in the Coromandel Volcanic Zone

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Introduction

In 1967, while doing field mapping for the Northern Coromandel 1: 63,360 (1 inch to the mile) Sheet N40, I was working along the north side of the Kuaotunu Peninsula in andesites (Mahinapua Andesite) east of Otama Beach (Fig.1). I scrambled around the rocks into Whaorei Bay and was amazed to see on the next headland (Tamaihu), a 110-m high pile of 1-3 m basalt lava flows interlayered with scoriaceous breccia (Mercury Basalts – Skinner 1976). On the east side of Tamaihu, the small peninsula of Tokarahu exposed a basalt dike swarm in a residual eruption centre of basalt scoria and broken lava bombs within a spatter-filled rift (Fig.1).

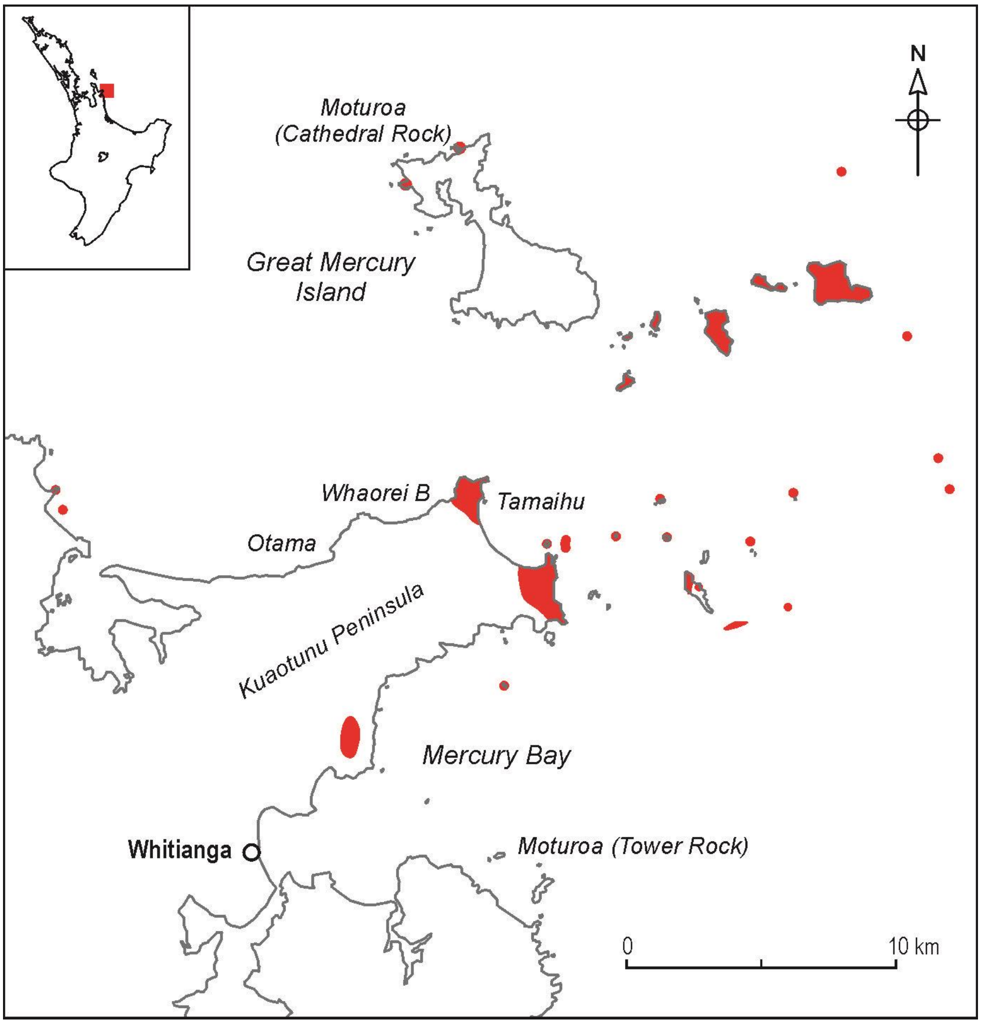

Fig.1. *Sketch map of the Kuaotunu Peninsula, Mercury Bay, and Great Mercury Island showing locality of Moturoa – Cathedral Rock on Great Mercury Island; basalt outcrops in red. (after Skinner 1976).*

I say ‘amazed’ because up to that time there had been no recognition of basalt during earlier geological surveys of the Coromandel region. Instead, the areas of basaltic rocks known today were variously mapped as andesite, greywacke, rhyolite and ignimbrite (e.g. Sollas and McKay 1905; Fraser and Adams 1907; Schofield 1967)! Although Sollas and McKay (Vol 1: p.10) noted that in Coromandel rock collections made between 1854 and 1885, prior to thin section petrographic identifications, the rock names “Dolerite basalt” “Trap basalt” and “Basalt” had been used, neither identification of the source(s) of these names, nor the localities from where the rock specimens were collected were given. No basalt was included in McKay’s collection of 406 rock samples sent to Professor Sollas for petrographic description.

Charles Heaphy in Coromandel

Charles Heaphy was employed as a draughtsman in the Auckland office of the Colonial Survey Department. In 1852, he was appointed to supervise the fledgling Coromandel gold diggings and Gazetted as Superintendent (Heaphy 1852a,b), regularly reporting on the state of the gold diggings (Heaphy 1854 - misspelt “Heaply”). By 1855, he had been appointed Commissioner of Goldfields (Heaphy 1855) although he administered them from Auckland where he produced a water-coloured, hand-drawn map of the geology of Coromandel Harbour and east from Kennedy Bay through Whangapoua and along the north side of the Kuaotunu Peninsula to Opito Bay, and north to northern Great Mercury Island (Heaphy 1857). Heaphy’s geological map of the volcanoes of Auckland has a sketch of the North Island of New Zealand that includes the general volcanic geology of Coromandel (Heaphy 1860). By this time Heaphy had met Hochstetter and had accompanied him on a visit to Coromandel Harbour and town from the 8th to the 12th of June 1859 (Johnston and Nolden 2011).

Heaphy is renowned as a more than competent artist. During his goldfields days at Coromandel, he produced a number of watercolour sketches of the region that included Maori, a marine view north of the topography from Whangarei east to Coromandel, and details of Coromandel Harbour geology and miners’ activities (Nolden and Nolden 2011; Johnston and Nolden 2011). Heaphy notes (1860, p.250-251) that he “has also supplied several original water-colour sketches, indicating the geological and volcanic features of the district” to Hochstetter. Among these was a rather faint pencil drawing of columnar islands annotated in Hochstetter’s hand “Motu roa an der Mercury Bay Nordinsel”, and preserved in Hochstetter’s estate collection of papers in Basel, Switzerland as drawing 1-4-11 (Nolden and Nolden 2011, p.38).

Hochstetter and Coromandel

In Hochstetter’s *Geologie von Neu Seeland* (Hochstetter 1864; translated by Fleming 1959), a similar illustration is included before page 89. However, it is far more detailed, and is strongly drawn with fern foliage, extra rocks and additionally, has four maori canoes, two with sails in the bay and two drawn up on the beach. The illustration is labelled as for the Basel drawing, "Motu roa, an der Mercury Bay, Nordinsel" but has (in brackets) "saülenformiger Trachyt" = columnar trachyte. In addition, there is also printed "Ch. Heaphy del. Grefe Lithogr." (lithograph by Grefe) and "Aus d. k. k. Hof. U. Staatsdrucherei" (Aus der Kaiserlich-Königlichen Hof und Staatsdrucherei = from the (Austrian) Imperial & Royal Court and Government Printing Office). In the list of Chromolithographs (p.XIV), the title is given as "Moturoa, Trachytfelsen an der Mercury Bay, Ostküste der Nordinsel".

In Hochstetter's text (p. 89; see Fleming 1959 p. 119), he states:

"Von den Mercury-Islands brachte mir Mr Smalfield Handstücke von gelbem Trachyttuff mit eingebackenen Trachyt-, Bimstein-, Obsidian- und Thonmergelbroken mit, und eine kleine Insel unter der Gruppe soll aus den regelmässigsten Säulen eines trachydoleritischen oder basaltischen Gesteines bestehen. Ich verdanke Herrn Ch. Heaphy eine schöne Skizze dieser Säulenbildungen, welche von Herrn Grefe in Farbendruck ausgeführt wurde." (Fig. 2).

"From the Mercury Islands. Mr Smallfield brought me hand specimens of yellow trachytic tuff with baked scraps of trachyte, pumice, obsidian and clay marl, and a small island of the group is said to consist of regular columns of a trachydolerite or basaltic rock. I am grateful to Mr Ch. Heaphy for a fine sketch of this columnar formation, which has been reproduced in colour by Mr Grefe." (Fig. 2).

Fig.2. *The chromlithograph by Grefe from Heaphy's drawing, in Hochstetter (1864, before p. 89).*

So here Hochstetter refers to the columnar rock as ‘trachydolerite or basalt’. Then why is the lithograph labelled ‘Trachyt” = trachyte? On pages 82-84 in the german text (Fleming *op cit*., p.113-115), Hochstetter discusses and provides a table of the various names used for volcanic rocks by European geologists at that time. He concludes that the german term ‘Trachyt’ is actually a carpetbag of six different volcanic rock types – true trachyte, amphibole andesite, pyroxene andesite, dolerite and leucite-porphyry. These last two he considers are varieties of the dolerite or basalt family. He then goes on to divide volcanic rocks into four types – rhyolite, trachyte, andesite and basalt. Hochstetter’s writing is thus the first to establish rhyolite and andesite as independent rock types. In Heaphy’s time in Coromandel, and with the probability that he learnt his geology from Ernst Dieffenbach with whom he sailed to New Zealand in 1839 (Nolden and Nolden 2011), the term ‘trachyte’ was universally used in New Zealand for almost all volcanic rocks older than Pleistocene-Quaternary. Hence, although Heaphy and initially Hochstetter labelled the sketch as trachyte, Hochstetter later amended the rock name to dolerite or basalt.

Into the 20th Century

After this there was a time gap of some 68 years when little or no interest was shown by New Zealand geologists in an obscure, in their eyes, occurrence of basalt. Marshall (1932) suggests that this was, at least partially, because of the confusion in the naming of the locality. Great Mercury Island is not actually in, but is north of Mercury Bay, it is not on what is generally known as ‘the east coast’ of the North Island, and on the outside of southern Mercury Bay proper there is a tiny island also named Moturoa, or as James Cooke named it “Tower Rock”. It was not until Marshall visited Mercury Bay and many of its islands that the locality of Motu-roa (meaning high or long island) was confirmed as the north end of what Marshall called “Mercury Island” = Great Mercury Island (Moturoa), or as it is also known today “Cathedral Rock”. He also confirmed the rock type as hypersthene basalt, and included a photograph captioned as “Fig.4. – View of basaltic rocks, north end of Great Mercury Island”. Not being critical, but in reality, a comparison of Marshall’s photo, the more recent one I have included in this article (Fig.3) and the chromolithograph in Hochstetter (1864), shows that both Heaphy and Grefe used a beautiful degree of ‘artistic licence’ in their depiction of the rock structures at Moturoa.

Another thirty-odd years were to pass before any further sampling of Moturoa-Cathedral Rock was undertaken. During a geological reconnaissance of Great Mercury Island in the early 1960s, R.N. Brothers collected *inter alia* a sample recorded as Field number 32; Auckland University Geology Department Rock Collection number 14377 (amended later to 14363 and/or 14364); Dolerite intrusion at locality NZMS1-N40/272934 Cathedral Rock. I have examined a thin section of this rock and, as Marshall, noted, it is a slightly porphyritic, hypersthene-rich, two pyroxene ± olivine basalt with a dolerite-microgabbro, subophitic texture. Olivine is relatively rare and almost entirely replaced by iddingsite/chlorite pseudomorphs with later partial alteration to siderite/calcite.

Fig.3. *Colour photo from 35 mm slide of Moturoa-Cathedral Rock; view from the north. (Photo: D. Skinner).*

Another, perhaps final, twist in the tale is reported by Murray-Oliver (1966: pp.133 and 136). In an article on New Zealand geologists who were also artists, he sets Heaphy as of "greatest value" in this respect. In particular he notes that the locality "Mercury Bay" as shown on Heaphy's 'chromolithograph' by Grefe as reproduced in Hochstetter (1864) is "faulty" as proved "by another Heaphy sepia wash drawing in private hands in Wellington. This is a closer study of Tower Rock, as Cook named it, bearing Heaphy's own title, *Moturoa. Basaltic Rock, Great Mercury Island*." Unfortunately, Murray-Oliver does not reveal the ownership of the 'private hands', and as noted above, Cook's 'Tower Rock' is the other, small Moturoa in Mercury Bay itself. So who is or was confused? I can say without any doubt, having been there, that the Heaphy Basel pencil drawing and the Hochstetter chromolithograph attributed to Heaphy really do depict, allowing for artistic licence, Moturoa-Cathedral Rock on the north end of Great Mercury Island, and the first recorded basalt locality in the Coromandel Volcanic Zone.

Acknowledgements

This account is an expansion of an oral paper presented at the recent Hamilton Conference of the Geoscience Society of New Zealand (Skinner 2012). My thanks to Simon Nathan and Tony Christie for reviews, and Philip Carthew for figure scans and draughting.

References

Fleming CA 1959. *Geology of New Zealand*. The voyage of the Austrian frigate Novara round the world, Geological part, first volume. An edited translation from the german of Hochstetter 1864 (q.v.): 320p. New Zealand Government Printer, Wellington, New Zealand.

Fraser C, Adams JH 1907. The Geology of the Coromandel Subdivision, Hauraki, Auckland. *New Zealand Geological Survey Bulletin* 4.

Heaphy C 1852a. *New Zealand Government Gazette* (Province of New Munster) No. 30: 183-184.

Heaphy C 1852b. *New Zealand Spectator and Cook's Strait Guardian* Volume VII, Issue 769: 5-6.

Heaphy C 1854. On the gold-bearing district of Coromandel Harbour, New Zealand. *Quarterly Journal of the Geological Society of London*. *Proceedings* 10/1: 322-324.

Heaphy C 1855. On the Coromandel gold-diggings in New Zealand. *Quarterly Journal of the Geological Society of London. Proceedings* 11/1: 31-35.

Heaphy C 1857. Digital copy of a hand-drawn map covering parts of the Coromandel Peninsula. *Charles Heaphy: Manuscript maps*. National Library of New Zealand MapColl—c832.15caq/1857/Acc.51904: Ex Humboldt- Universität zu Berlin 2008.

Heaphy C 1860. On the volcanic country of Auckland, New Zealand. *Quarterly Journal of the Geological Society of London*. *Proceedings* 16/1: 242-252.

Hochstetter F v 1864. *Geologie von Neu-seeland. Beitrage zur Geologie der Provinzen Auckland und Nelson. Reise der Österreichischen Fregatte Novara um die Erde*, Geologischer Theil, Erster Band. Aus der Kaiserlich-Königlichen Hof- und Staatsdruckerei, Wien: 274p, 5 Karten, 11 Tafeln. Wien.

Johnston M, Nolden S 2011. *Travels of Hochstetter and Haast in New Zealand 1858-1860*. Nikau Press, Nelson, New Zealand: 336p.

Marshall P 1932. Notes on some volcanic rocks of the North Island of New Zealand. *The New Zealand Journal of Science and Technology 13*: 198-202.

Murray-Oliver, AAStCM 1966. Some notes on New Zealand geologists and artists. *New Zealand Journal of Geology and Geophysics* 9: 133-145.

Nolden S, Nolden SB 2011. *Hochstetter Collection Basel. Part 1 – New Zealand paintings and drawings*. Mente Corde Manu Publishing, Auckland, New Zealand: 69p.

Schofield JC 1967. *Sheet 3 Auckland* (1st Ed.), Geological Map of New Zealand 1:250,000, Department of Scientific and Industrial Research, Wellington, New Zealand.

Skinner DNB 1976. *Sheet N40 and part sheets N35, N36 & N39 Northern Coromandel* (1st edition). Geological Map of New Zealand 1:63 360. Map (1 sheet) and notes (28p.). New Zealand Department of Scientific and Industrial Research, Wellington.

Skinner DNB 2012. Paleovolcanology of the Late Miocene-Early Pliocene Mercury Basalts, Coromandel Volcanic Zone (CVZ). In: Pittari A., Hansen, R.J. (eds). Abstracts, Geosciences 2012 Conference, Hamilton, New Zealand. *Geoscience Society of New Zealand Miscellaneous Publication 134A*: 83.

Sollas WJ, McKay A 1905, *The Rocks of the Cape Colville Peninsula, Auckland, New Zealand.* Vol. I: 289p. New Zealand Government Printer, Wellington.

A few memories of Jack Marwick (1891-1978)

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Charles Fleming provided an excellent and very full account of Jack Marwick's life, his science and his many accomplishments and honours (Fleming 1979). Alan Beu contributed a concise biographic entry for the New Zealand National Biography (Beu 2010). These two contributions have been used to prepare a condensed bibliography as follows: Jack Marwick was born on 3 February 1891 at Maheno, near Oamaru, Otago. After attending Oamaru North School he enrolled at Waitaki Boys' High School. Jack's interest in geology arose as a result of some classes in geology provided by the school's Rector Dr. J.R. Don. Also, George Uttley an enthusiast for bryozoan fossils, was a teacher at the school while completing his MSc. on Oamaru geology. Jack helped George with his thesis and in the process picked up a large amount of geological knowledge. From 1907 Jack was a pupil-teacher and studied Latin and English as an extramural student of the University of Otago. In 1910 he attended the university and the Dunedin Teacher's Training College. He graduated in 1912 with an MA first-class honours, presenting a thesis on the geology of the Waihao Basin South Canterbury. After a period of school teaching in Otago, Jack applied in 1915 for a position as palaeontologist with the NZ Geological Survey. However, no appointment was made because of World War 1. He then served in the NZ Army in the Middle East and was awarded the Military Medal. On his return from military service in 1919 Jack re-applied for a position and was appointed as an Assistant Geologist on 5 May 1920. From this point on, he functioned as the Geological Survey's only palaeontologist and in this role concentrated on the description of many of the Tertiary fossils and on the subdivision and correlation of the huge basins of Tertiary rocks exposed in New Zealand. In 1937 Jack teamed up with Harold Finlay and the names 'Finlay and Marwick' became synonymous with huge advances in New Zealand Tertiary palaeontology and stratigraphy (Hornibrook 1971).

Jack Marwick, formal portrait. Photo by Lloyd Homer. Frontispiece of MacKenzie (1971).

In the late 1940s and early 1950s Jack undertook a massive revision of the New Zealand Triassic and Jurassic faunas which culminated in the milestone publication *Palaeontological Bulletin* 21 (Marwick 1953). Jack retired in 1953 but continued working from home completing long-delayed research projects and reporting on fossil collections for the oil companies then carrying out reconnaissance surveys in New Zealand.

Jack was widely respected throughout the Geological Survey and the national geological community. He had a genial and calm outlook on life and brought to his science a kindly, gentle, wise but intellectually acute approach. He received many honours: the Hamilton Memorial Prize (jointly with Harold Finlay), the Hector Memorial Medal and Prize, the Hutton Memorial Medal and a Fellowship of the Royal Society of New Zealand. Jack and his wife Ivy had two sons and two daughters, all science graduates. Thora, a daughter, was the Dux of Hutt Valley High School and George, a son, after wartime service in the RNZAF, taught me science at Hutt Valley High School. Jack died on 17 August 1978.

I first met Jack Marwick in 1953 when I was employed as a student assistant in the Palaeontological Section of the New Zealand Geological Survey at 156 The Terrace, Wellington. The section was housed in a large room at the front of the house, facing out across The Terrace. Charles Fleming, the Chief Palaeontologist, sat at a big desk at the very front of the room, beside a large window. In front of Charles' desk sat Ron Brazier, palaeontological artist. In the middle of the room sat Pat Olsen, Tertiary macropalaeontologist (Stevens 2014). On the far side of the room was a large table with preparation gear – hammers, chisels, etc. I sat at a desk against the wall behind Pat Olsen. Most of the walls were lined with tall multi-drawer wooden cabinets. Cabinets also lined the corridor outside. A large epidiascope stood in the corridor. This machine was used to project images of fossils onto a makeshift screen fixed to an end wall, so that enlarged drawings could be made.

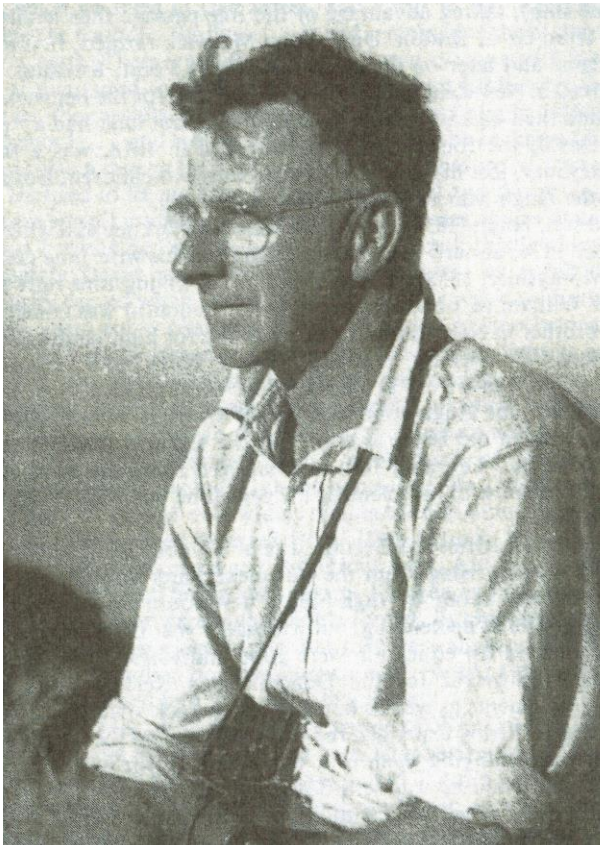

Photo from Fleming 1979, p.59.

For the entire Christmas holiday of 1953-1954 my job was to label, organize and check the collections Jack had used in the preparation of his Pal. Bull. 21. As at that stage Jack had retired he came into the office occasionally to see how things were going. We used to chat in a friendly way about my university studies and I was very impressed indeed that such an eminent scientist would even give me the time of day! As the end of the holiday approached I tidied up and compiled a list of various things that had come to light, such as typos, incorrect specimen numbers etc. Sometime later, after I returned to university I found that Charles had arranged for my list to be printed as a 4-page insert to be placed into copies of the Pal. Bull. My first scientific paper!!

Jack lived a block away from my parents home in Waterloo, Lower Hutt. As it happened, a roll-call of geologists resided in the Waterloo-Woburn area: Mont Ongley, Jack Marwick, Martin Te Punga, myself, Bruce Waterhouse, John Bradley and Prof. Cotton. Norcott Hornibrook lived in the city end of Waterloo Road. So Jack was in good company! After his retirement Jack and Ivy lived in a 'California bungalow' in Cambridge Terrace, Waterloo (Stock and Reynolds 2014). These bungalows were very popular in the subdivisions of the late 1920s and early 1930s. [My parents had one in Collingwood Street, Waterloo.] All the California bungalows in the Waterloo area had a large veranda extending half-way across the front of the house. Being of a Californian design the verandas were originally used in California for the occupants to sit outside in the hot, humid summers. However, in the New Zealand climate most verandas were not used for this purpose and were glassed-in for use as an extra room. Jack's house had a glassed-in veranda that he fitted out for use as a study and a small work bench equipped with hammers and chisels. I visited him on a number of occasions to discuss aspects of my research and he showed me his library and, very proudly, his large vegetable garden.

Jack completed a number of research projects as well as servicing for oil companies. The extra income from the latter source was most welcome because Jack had retired at a time when Government Superannuation was not inflation adjusted and his Super had been severely eroded by the rampant inflation of the time. The produce from his vegetable garden certainly saved the day and made life a lot easier.

References

Beu AG 2010. Marwick, John. *Dictionary of New Zealand Biography*. *Te Ara – The Encyclopaedia of New Zealand*.

Fleming CA 1979. John Marwick (1891-1978). *Proceedings of the Royal Society of New Zealand*. Part II. Vol. 107: 59-72.

Hornibrook NB 1971. Finlay and Marwick. *New Zealand Journal of Geology and Geophysics* 14: 640-654.

MacKenzie I (Ed.) 1971. John Marwick 80th Birthday Issue. *New Zealand Journal of Geology and Geophysics* 14 (4).

Marwick J 1953. Divisions and faunas of the Hokonui System (Triassic and Jurassic). *New Zealand Geological Survey Palaeontological Bulletin* 21.

Stevens GR 2014. Life at 156 The Terrace, Wellington in the early 1950s: personal memories. *Geological Society of New Zealand, Journal of the Historical Studies Group* 47: 29-36.

Stock N, Reynolds P 2014. *Bungalow*. Random House, Wellington. 383p.

Chromian muscovite in New Zealand – a history

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Chrome mica, chromglimmer, fuchsite[1], chrome muscovite, chromiferous muscovite, chromian muscovite, Cr(III)-muscovite, or chromium-containing muscovite, is a particularly eye-catching mineral because of its brilliant green colour (Fig.1). World-wide, all the above names have been used by different researchers at different times to describe this variety of muscovite. James Park, who uses the term *fuchsite*, described it as "…a beautiful emerald-green variety of muscovite, sometimes containing as much as 4 per cent of oxide of chrome. It has no commercial value, except as a rare mineral for cabinet collections" (Park 1888). Hutton (1940) (*New Zealand*) suggested the term *chromiferous muscovite* for those containing up to 1 wt.% Cr_2O_3 and *fuchsite* for those with more. Whitmore et al. (1946) (*Canada*) preferred the varietal term *chromian muscovite* rather than *fuchsite*. The *Mica Subcommittee* of the *Commission on New Minerals and Mineral Names (Czech Republic, Italy, Russia, USA, Germany, Portugal, France, Japan)* of the *International Mineralogical Association*, recommends that the single name *chromian muscovite* be adopted (Rieder et al. 1998), and this is the name used here.

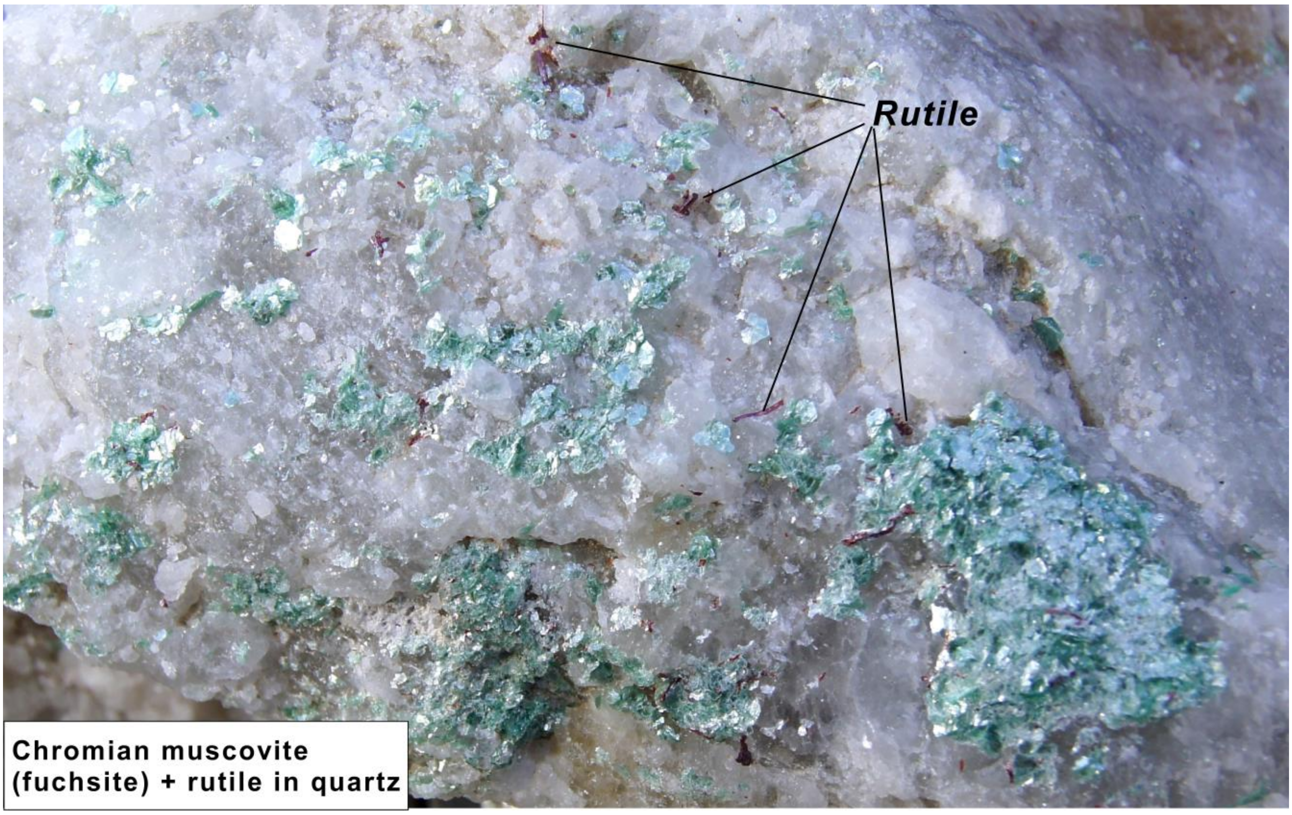


Fig.1. *Sample from Cr-muscovite-bearing quartzite (Onekaka Schist), Go-Ahead Creek, NW Nelson. Cr_2O_3 in the muscovite ranges from 5-6 wt.%. (Photo: R Grapes).*

In New Zealand, chromian muscovite has had an interesting and somewhat controversial early history beginning in 1880. The first recognition of this mineral was on May 5 of that year by William Skey, analyst of the Colonial Laboratory in Wellington: "No. 2728 (*the laboratory number assigned to the specimen*) is chrome mica, occurring in thin veins permeating the talcose schist of the Lake Wakatipu District, at Moonlight Gully. It was collected by the Survey (Mr. McKay). Being mixed rather intimately with its associated schist, I could not separate it for full analysis. The occurrence of chromium in this district as an essential constituent of a mineral had not before this been made known to us. This specimen afforded 1.0 per cent of chromic oxide, to which substance in part its deep-green colour is due. Its full analysis will appear in the next report." (15th Annual Report 1881, p.).

In this (16th Annual Report 1882), Skey quoted his analysis which to him proved the mineral to be "Penninite (chrom-chlorite), and its colour is due to the chromic oxide present" (p.32), not muscovite (Analysis 1 in Table). Nevertheless, in the same report another specimen, from Dusky Sound, was described as "a green-coloured laminated mineral No.2803 (2), irregularly traversing a micaceous quartz in this district, also has chromic sequioxide for its colouring matter. It is chrom-glimmer, a rather rare mineral, for which only one locality is given by Dana in his work on mineralogy, and this Schwarzenstein" (p.33) (Schaffhäutl 1842, p.50; 1843, p.311; Dana 1850, p.357) (Analysis 3 in Table). The "chrom-glimmer" that Skey is referring to is chromium muscovite (*chromglimmer*/*fuchsite* of Schaffhäutl; *fuchsite* of Dana) and can be considered to be the first positive find of this variety of muscovite in New Zealand.

In the same year, Samuel Herbert Cox, Assistant Geologist and Inspector of Mines, published the second part of his "Notes on the mineralogy of New Zealand" (Cox 1882) in which he reports two finds of "chrome mica". Chrome mica from Dead Horse Gully "occurs as flat tabular plates of a green colour, and belongs to the hexagonal system. It is talcose in appearance and feels soapy to the touch but Mr. Skey's analysis precludes it falling into the talc group, and it must therefore be considered as a *chrome-magnesian mica*, the percentage of water in which is somewhat high" (4.09 wt.% H_2O). Cox compared Skey's analysis with that of a "somewhat similar mineral" – green "chrome magnesia mica", also called chromglimmer, and also from Schwarzenstein (Schaffhäutl 1843; Dana 1850, p.360), but drew attention to the low silica and higher alumina in Skey's analysis (Analyses 2 in Table). Because of its low alkali content, Skey regarded the mineral as chromian chlorite (penninite variety), not mica, while Cox's comparative mica of Schaffhäutl/Dana contains 7.27 wt.% K_2O[2]. The sample analysed by Skey was submitted by Alexander McKay in 1880. Cox mentions that the Dead Horse Gully sample "occurs on the strike of the Moke Creek copper lode" which is associated with "chloritic schist" (McKay 1881; p.136), an association which lent support to Skey's identification of the "mineral". He also records that "a similar mineral has been forwarded by Mr. W. Docherty from Dusky Sound where it occurs in gneiss", but which was the chrom-glimmer or *fuchsite* variety, also reported by Skey (1882; p.33).

The analysis of the hexagonal tabular green mineral from Dead Horse Creek produced by Skey is neither the penninite variety of chlorite nor the chrome-magnesian mica mentioned by Cox, but is clearly a mixture of several minerals –mainly chlorite-chromian muscovite (in the Al_2O_3-Cr_2O_3-(Fe,Mg)O plot under footnote**6**, Skey's analysis plots on a chlorite - chromian muscovite tie line), with possible accessory tremolite and pyrite (see Table). An analysis of a fuchsite-chlorite schist quoted in Hutton (1942) from Dead Horse Creek is compared with Skey's "mineral" analysis in the Table, and while it indicates similar Si, Al, Cr, Mg and Ca content, the much higher Fe, lower K (as combined alkalis) and H_2O in Skey's analysis, suggests the presence of Fe-oxide or pyrite (higher iron), lower modal chromian muscovite (lower K_2O), and higher tremolite/epidote to account for CaO content and lower H_2O. The mineralogy of the fuchsite-chlorite schist (P.1793) analysed by Hutton is chlorite, chrome mica, with accessory titanite (dominant), partly limonitised pyrite (0.05 wt.% S), Al-epidote, calcite (only trace CO_2 present), and tremolite. With respect to Ti in titanite ($CaTi[SiO_4](O,OH,F)$), Hutton's analysis has 0.85 wt.% TiO_2. Skey does not record the presence of titania which, if present in his sample but not analysed for, may have accounted for the 2.18% CaO in his analysis, rather than, or in addition to, tremolite and epidote.

Georg Ulrich (1885, p.309), Director of the Otago School of Mines at Otago University, was the first to use the term "fuchsite" for deep to light emerald green coloured samples collected by William Docherty from the Dusky Sound area, having "first identified this mineral several years ago in specimens broken from the same layer containing … Ouvarovite" (p.309) (*uvarovite*; chromian garnet). He also described a light bluish-green variety associated with biotite from the same area and notes that the fuchsite was sometimes associated with chromite (source of chromium in the fuchsite). No chemical analysis was made but from a blowpipe test performed on fine green scales, Ulrich produced "a fine emerald-green colour, indicating the presence of a not inconsiderable percentage of chromium" (p.310). James Park subsequently verified the presence of fuchsite in one of seven mineralized beds (No.1) discovered by Docherty that he investigated in 1887 (Park 1888), and probably the same rock that Ulrich examined. Ulrich also mentions that "Mr. Docherty had been told by Mr. Cox, who first examined it (*the fuchsite*), that it was Uranium mica (*Torbernite*), but the outlines and elasticity of the scales at once proved the incorrectness of this determination."(p.309). This is an interesting statement. In the first place there is no such mineral as "Uranium mica", and the name "*Torbernite*", inserted in italics by Ulrich based on the information supplied by Docherty, is a hydrous copper uranium phosphate ($Cu(UO_3)2P_2O_5.12H_2O$), but it can be emerald-grass-green in colour and also foliated or micaceous in habit. It is possible that Docherty confused "chromium" for "uranium" if the identification from Cox was verbal (note that in the passage quoted above Ulrich states "told by Mr. Cox")**3**, because Cox (1882) refers to the same mineral as chrome mica (as noted by Ulrich; footnote‡, p.309), and "torbernite" is not in his list of New Zealand minerals.

	1	2	3	4	5	6
SiO_2	39.25	47.68	47.95	46.35	40.16	45.06
TiO_2				0.28	0.85	0.10
Al_2O_3	22.12	15.15	34.45	29.69	23.29	35.35
Cr_2O_3	1.56	5.90	3.95	4.60	1.61	0.93
V_2O_3				tr	0.04	
Fe_2O_3		5.72^1	1.80^1	0.23	0.52	0.80^1
FeO	18.69			0.85	6.68	
MnO	0.41	1.05		0.01	0.13	0.02
MgO	10.60	11.58	0.71	1.93	11.26	1.09
NiO					0.09	
CaO	2.18		0.42	tr	1.40	0.02
Na_2O	1.13*	1.17	0.37	0.78	0.25	0.59
K_2O		7.27	10.75	10.53	6.04	9.72
BaO				0.15	0.07	1.51
P_2O_5				0.01	0.04	0.01
H_2O^+	4.06	2.86		4.69	7.44	
H_2O^-				0.12	0.20	
CO_2					tr	
F			0.36	0.04	0.06	
S				0.05	0.05	
LOI^2						4.65
Total	**98.87**	**98.38**	**100.76**	**100.31**	**100.18**	**99.85**

* Combined alkalis; tr = trace; ^{1}All iron as Fe_2O_3; ^{2} Loss on Ignition.

1. Cr-bearing "penninite" variety of chlorite Dead Horse Gully (Skey 1882; p.32).
2. "Chromglimmer" (Schaffhautl 1843) or "chrome mica" (Dana 1850), and listed under "biotite" as a variety. Quoted in Cox (1882; p.405) together with "penninite" analysis of Skey.
3. "Chromglimmer" (Schaffhautl 1842, p.50); named "fuchsit" (Schaffhautl 1843); quoted as "fuchsite" by Dana (1850, p.357).
4. Fuchsite, Dead Horse Creek (Glenorchy District, Lake Wakatipu Region, Western Otago), analysed by F,T. Seelye (Hutton 1942; Table 1, p.34).
5. *Fuchsite-prochlorite-schist* (P1793), Dead Horse Creek (Hutton 1942; Table IV, p.62).
6. Pure chromian muscovite part of "goodletite" boulder, Westland (Grapes and Palmer 1996).

The Dead Horse Gully "peninnite" and "chrome-magnesian mica" identified by Skey and Cox, respectively, was described as fuchsite and figured in Sollas and McKay (1906). The sample (No.413/4774) was characterized as a "finely foliated mica schist, containing fuchsite" which McKay records as forming a bright green band about a foot thick (rather different from Skey's description which was probably another specimen), and described by Sollas as "a foliated aggregate of grains of quartz and feldspar, of fuchsite and muscovite, and granules of sulphides. Small rutile crystals here and there" (p.158). Unfortunately, McKay's microphotograph of the "fuchsite schist" is rather unsatisfactory in terms of its black and white contrast and focus which is appears somewhat blurred (Fig.2). The presence of quartz and plagioclase would suggest that the sample was similar to the oligoclase-fuchsite-quartz schist described and analysed from Dead Horse Creek by Hutton (1942).

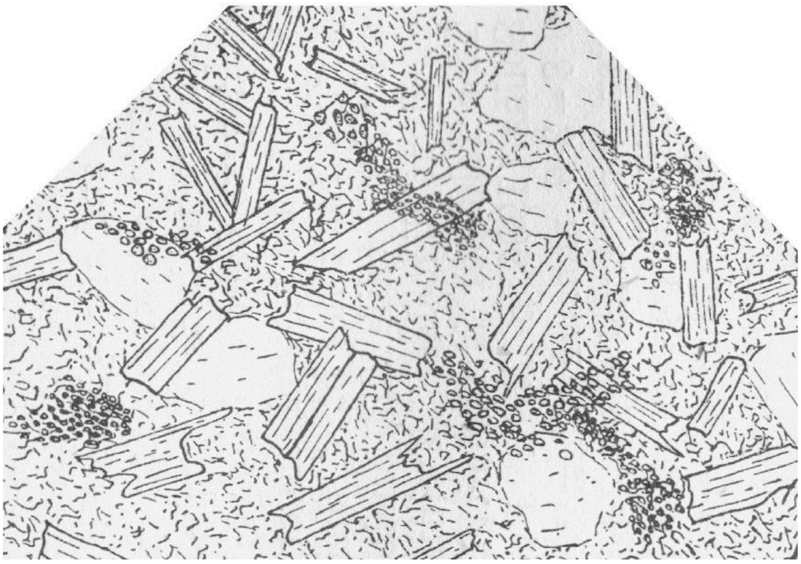


Fig.2. ***Above***. *Photomicrograph of fuchsite schist from "Dead Horse Gulley, Moonlight Creek, Lake County, Otago" by Alexander McKay (plane polarised light; no scale given).*
Below. *Microscope drawing (x26) of fuchsite-chlorite schist from Dead Horse Creek cut parallel to the "ab" fabric directions (i.e., parallel to the schistosity) showing the unorientated habit of the chromian mica laths within a chlorite matrix and clusters of rutile (cropped from Fig.2B of Hutton 1942).*

Chromian muscovite was recorded from the Pounamu Formation, Southern Alps, by Bell and Fraser (1906) in a "ruby rock" (later named *Goodletite*, Fig.3), where crystals of pink (and blue) corundum "usually occur" in a "dark green matrix chiefly composed of chrome mica and (*?*) altered olivine" (p.77; the chrome mica was not confirmed by Morgan (1908) in the same "ruby rock"[p.164], and the occurrence is not listed in Morgan 1927). Bell (1907) also identified the mineral at Parapara, NW Nelson, as a "curious mica quartzite… a beautiful nile-green rock, composed mainly of medium-grained quartzose layers, separated by thin partings of a beautiful green chrome mica, which is probably fuchsite[4], and which gives the rock its colour" (p.40). Further occurrences of fuchsite have been reported by Cooper (1976, 1995) in tremolite schist, McPherson Creek, south Westland, and nephrite tremolite-chlorite schist, Muddy Creek, NW Otago; by Grapes and Palmer (1996) in a goodletite boulder, Hokitika; by McKlintock and Cooper (2003) as an accessory mineral in kyanite-orthoamphibole hornblendite, Makawhio River, south Westland.

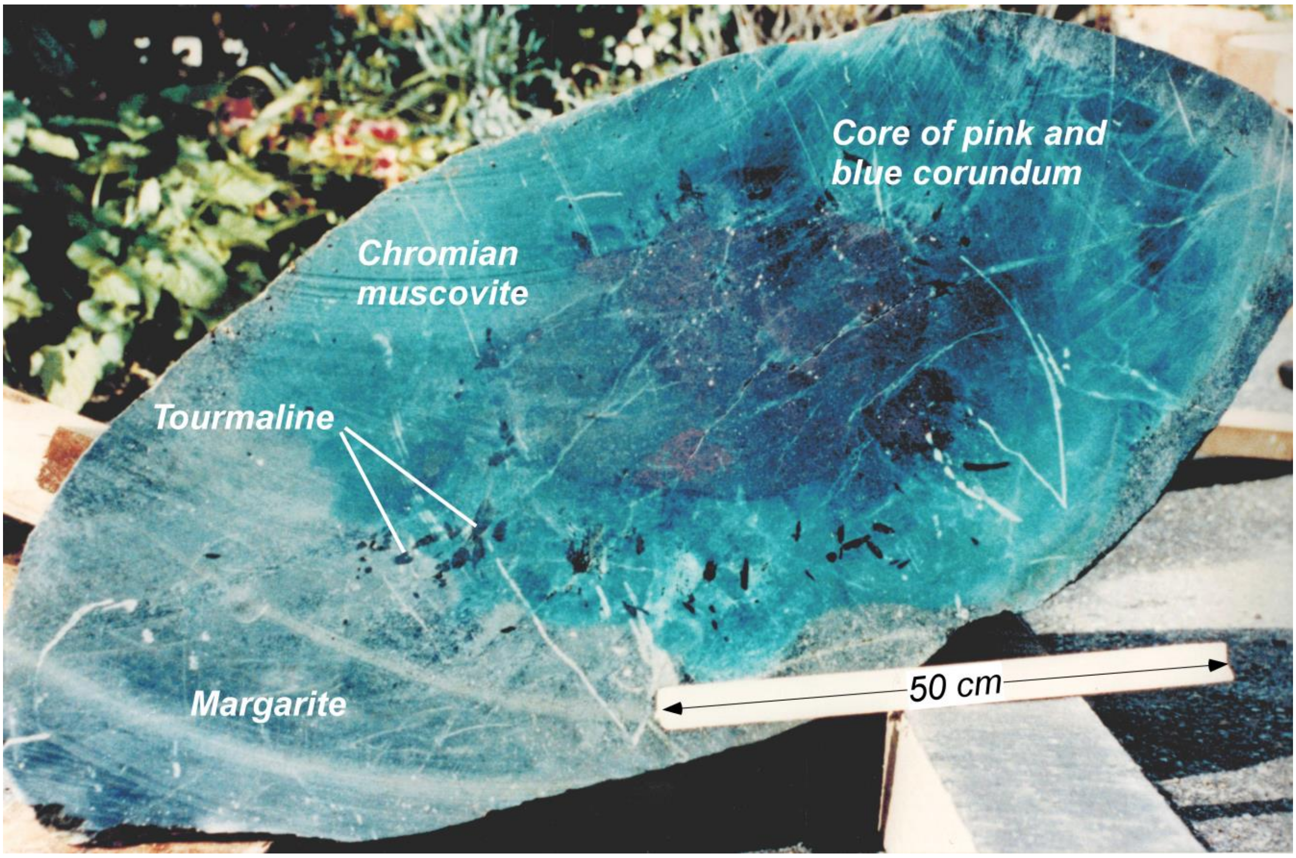


Fig.3. *Sawn boulder of "Goodletite" showing a core of pink (ruby) -blue (sapphire) corundum encased in emerald green chromian muscovite surrounded by margarite (Ca-mica), collected from Striplands Creek, near Hokitika, Westland, by Mr. Spike Jones of Kaniere. A slice of this boulder is in the Hokitika Museum The chromian muscovite part of the boulder contains 0.80 wt.%* Cr_2O_3 *(Photo: R. Grapes).*

The first analyses of a chromian mica in New Zealand, in goodletite described by Morgan (1908, p.123-124), was given by Hutton (1940) and although it only contains 0.27 wt.% Cr_2O_3[5] and exhibited colourless to very palest green pleochroism, it was deemed to be fuchsite. A pure separate of the mineral from the original chrome mica locality at Dead Horse Creek was also analysed by F.T. Seelye of the Dominion Laboratory and quoted in Hutton (1942). It contains 4.60 wt.% Cr_2O_3 (see Analysis 4 in the Table), and, at the time, arguably the highest percentage of chrome oxide in muscovite[6]. Chromian mica compositions with Cr_2O_3 contents ranging from 0.10 to 4.1 wt.% and a bulk analysis of 0.80 wt.% (Analysis 6 in Table) for the pure Cr-muscovite part of a *Goodletite* boulder (Fig.3), were also determined by Grapes and Palmer (1996). Chrome oxide percentages in muscovite ranging from 0.08 to as much as 8.5 wt.% were analysed from eight quartzite-schist localities in NW Nelson by Challis et a. (1995).

The most recent and detailed work on chromian muscovite from New Zealand (two samples from NW Nelson and one from Westland *Goodletite* supplied by the author) is by Briggati et al. (2001). Their investigation involved single crystal XANES (X-ray Absorption Near Edge Structure) spectrographic analysis to characterize Cr^{3+}-behaviour in muscovite (Cr^{3+} substitutes for Al in the octahedral sites) to allow resolution of structural distortions and local cation ordering to a scale of unit-cell length.

[1] Named in 1843 by Karl F. Emil von Schaffhäutl in honor of Johann Nepomuk von Fuchs, Professor of chemistry and mineralogy at the University of Landshut and curator of the mineralogy collection. The mineral was originally reported from Schwarzenstein, North Tyrol, Austria. Schaffhäutl originally analysed the mineral in 1842 referring to it as *chromglimmer* and named it *fuchsite* in his 1843 paper.

[2] Assuming that Schaffhäutl's analysis was of a pure mineral separate, the structural formula of this unusual green chrome-magnesian mica on the basis of 11(O) and with all the iron as FeO (Schaffhäutl quotes all iron as Fe_2O_3 in his analysis which seems unlikely), is:

$$(K.Na)_{\mathbf{0.81}}\,(Mg_{1.21}Mn_{0.06}Fe^{2+}_{0.30}Cr_{0.33}Al_{0.58})_{\mathbf{2.48}}\,(Al_{0.66}Si_{3.33})_{\mathbf{4.00}}\,O_{10}\,(OH)_2$$

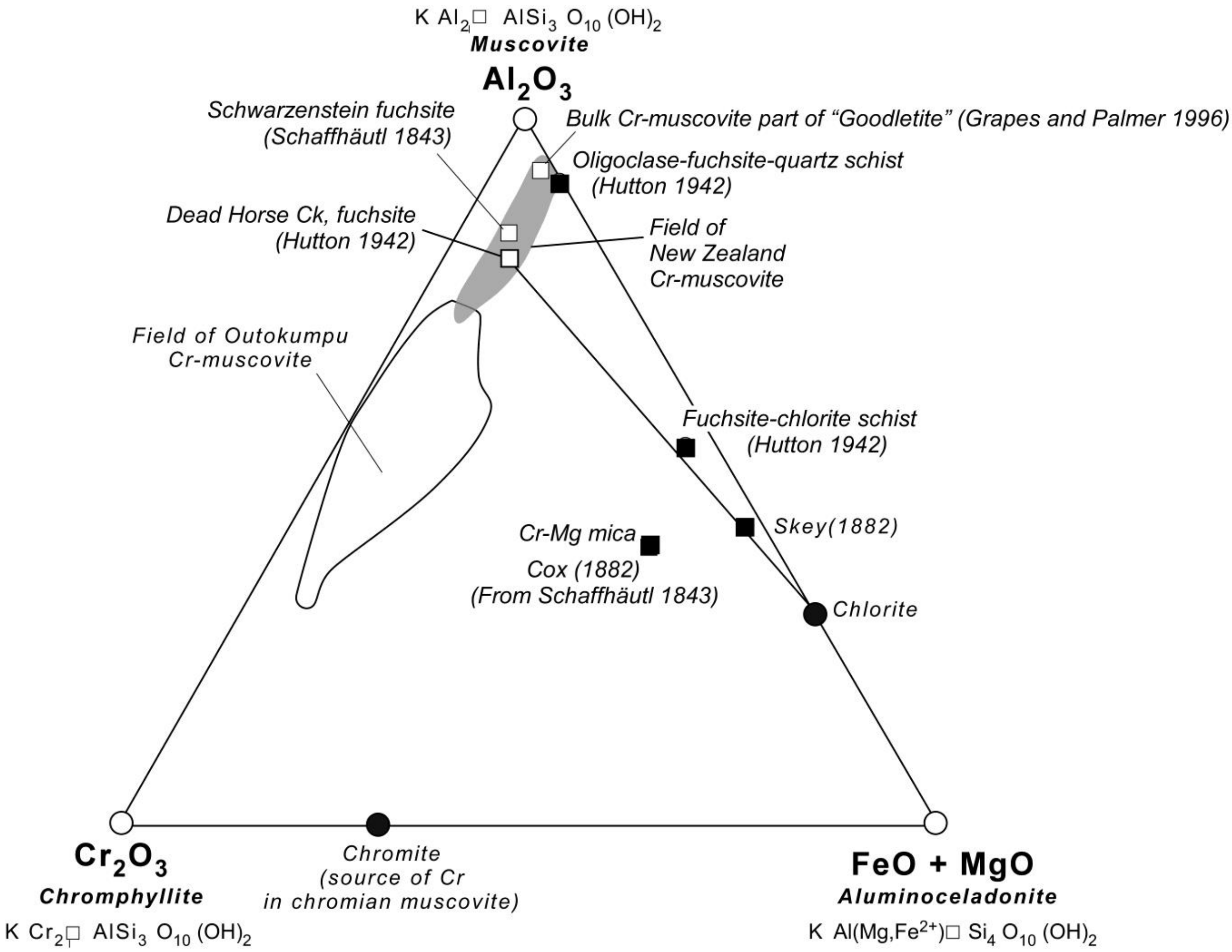
The sum of the octahedral cations per formula unit of 2.48 is very close to 2.5 for mica compositions intermediate between dioctahedral (e.g., muscovite) micas with < 2.5 octahedral cations and trioctahedral (biotite) micas with •2.5 octahedral cations. Dana (1877) includes this mineral under "biotite". Schaffhäutl's analysis which is listed in Cox could therefore represent a solid solution between two intermediate mica end-members – $KMg_{2.5}Si_4O_{10}(OH)_2$ and $K(Mg_{1.5}Al)_{2.5}(Si_3Al)_4O_{10}(OH)_2$ with Fe^{2+},Mn substituting for Mg and Cr for Al in the octahedral sites. Such end member compositions (without Cr, Fe) have been experimentally synthesized and high-P and T (e.g. Green 1982), but no natural example, except perhaps the sample analysed in 1843, has been reported. The high Cr_2O_3 of 5.90% in Schaffhäutl's analysis (see Table) makes it a unique mica composition, but clearly not one from Dead Horse Gully, although Cox was diligent in quoting the analysis listed in Dana in attempting to characterize Skey's analysis, although the low combined alkali content (analysis 1 in Table) should have alerted him to the fact that it could not be a mica!

3 Cox examined the Mt. Solitary Copper lode, Dusky Sound, with Docherty in 1877 (Cox 1878), and he may have been shown a sample containing chromian muscovite at that time, telling Docherty that it was "chromium" (or "uranium" according to Docherty) mica.

4 Parapara Inlet locality described in detail by Challis et al. (1995) as a ~60m thick layer of Cr-muscovite-bearing quartzite (Onekaka Schist) that contains a conspicuous ~0.5m-thick bright green mica-rich layer. The mica contains between 1.1 and 4.7wt% Cr_2O_3.

5 This is a wet chemical analyses of a pure muscovite separate from the rock. Electron microprobe spot analyses indicate that the mica is inhomogeneous (compositionally zoned) with Cr_2O_3 ranging between 0.10 to 4.1 wt.% (Grapes and Palmer 1996). A single crystal separated from Westland *Goodletite* used for XANES analysis by Brigatti et al. (2001) and analysed by electron microprobe gave 1.16 wt.% Cr_2O_3.

6 Since 1940, many analyses of chromian muscovite worldwide have been published (e.g. Whitmore et al. 1946). In New Zealand, muscovite with the highest Cr_2O_3 content of 8.47% has been analysed by electron microprobe as part of a compositionally inhomogneous grain associated with uvarovite garnet in a quartzite from Plumbago Creek, NW Nelson (Challis et al. 1995). Chromian muscovite with between 7.6 and 27.4 wt.% Cr_2O_3 (the maximum recorded worldwide) occurs in quartzite at Outokumpu, Finland, notable for the large number of Cr-rich silicate and oxide minerals associated with massive sulphide deposits (Treloar 1987); see Al_2O_3-Cr_2O_3-(Fe,Mg)O plot below .



Wt.% Al_2O_3-Cr_2O_3-(Fe,Mg)O plot of chromian muscovite (fuchsite) (Schaffhäutl 1843; Hutton 1942, Grapes and Palmer 1996), "chrome-magnesian mica" (Schaffhäutl 1843, Cox 1882) and "chrome penninite" (Skey 1882) compositions together with "fuchsite-bearing schists" from Dead Horse Creek, western Otago (Hutton 1942). Composition fields of New Zealand and Outokumpu chromian muscovite is shown. Dioctahedral mica end-member compositions, *muscovite*, *chromphyllite*, *aluminoceladonite*, are also indicated. Note that Skey's analysis of the Dead Horse Creek "chrome penninite" falls on a tie line between the Dead Horse Creek fuchsite of Hutton (1942) and the generalized chlorite composition, as discussed in the text.

References

Bell JM 1907. The geology of the Parapara subdivision, Karamea, Nelson. *New Zealand Geological Survey Bulletin* 3.

Bell JM, Fraser C 1906. The geology of the Hokitika sheet, north Westland quadrangle. *New Zealand Geological Survey Bulletin* 1.

Briggati MF, Galli E, Medici L, Poppi L, Cibin G. Marcelli A, Mottana A 2001. Chromium-containing muscovite: crystal chemistry and XANES spectroscopy. *European Journal of Mineralogy* 13: 377-389.

Challis A, Grapes R, Palmer K 1995. Chromian muscovite, uvarovite, and zincian chromite produced of regional metasomatism in northwest Nelson, New Zealand. *Canadian Mineralogist* 33: 1263-1284.

Colonial Museum and Laboratory, Sixteenth Annual Report 1882. Colonial Museum and Geological Survey of New Zealand. Government Printer, Wellington.

Cooper AF 1976. Concentrically zoned ultramafic pods from the Haast Schist zone, South Island, New Zealand. *New Zealand Journal of Geology and Geophysics* 19: 602-623.

Cooper AF 1995. Nephrite and metagabbro in the Haast Schist at Muddy Creek, northwest Otago, New Zealand. *New Zealand Journal of Geology and Geophysics* 38: 325-332.

Cox SH 1878. Report on the Mount Solitary Copper Lode, Dusky Sound. *New Zealand Geological Survey Reports of Geological Explorations 1877-8*, 11: 10-13.

Cox SH 1882. Notes on the mineralogy of New Zealand. *Transactions of the New Zealand Institute* 14: 418-450.

Dana JD 1850. *A System of Mineralogy, comprising the most recent discoveries*. George P. Putnam New York and London.

Grapes R, Palmer K 1996. (Ruby-sapphire) - chromian mica - tourmaline rocks from Westland, New Zealand. *Journal of Petrology*, 37: 293-315.

Green TH 1982. Synthetic high-pressure mica compositions between dioctahedral and trioctahedral mica series. *Contributions to Mineralogy and Petrology* 78: 452-458.

Hutton CO 1940. Optical properties and chemical composition of two micas from Westland, South Island, New Zealand. *The New Zealand Journal of Science and Technology* 21/No.68/May:330-331B.

Hutton CO 1942. Fuchsite-bearing schists from Dead Horse Creek, Lake Wakatipu region, western Otago. *Transactions and Proceedings of the Royal Society of New Zealand* 72:53-68.

McKay A 1881. District west and north of Lake Wakatipu. *New Zealand Geological Survey Reports of Geological Explorations 1879-1880* [13]: 108-147.

McClintock MK, Cooper AF 2003, Geochemistry, mineralogy, and metamorphic history of kyanite-orthoamphibole-bearing Alpine Fault mylonite, south Westland, New Zealand. *New Zealand Journal of Geology and Geophysics* 46: 47-62.

Morgan PG 1908. The geology of the Mikonui subdivision, north Westland. *New Zealand Geological Survey Bulletin* 6.

Morgan PG 1927. Minerals and mineral substances of New Zealand. *New Zealand Geological Survey Branch Bulletin* 32.

Park J 1888. On mineral deposits, Dusky Sound. *Reports of Geological Explorations during 1887-88*: 9-15,

Reider M, Cavazzini G, D'Yakonov Y, Frank-Kamenetskii VA, Gottardi G, Guggenheim S, Koval PV, Muller G, Neiva AMR, Radoslovich EW, Robert J-L, Sassi FP, Takeda H, Weiss Z, Wones DR 1998. Nomenclature of mica. *Canadian Mineralogist* 36: 41-48.

Schaffhäutl K 1842. Ueber ein neues chromhaltiges Alkali- und Thonerde-Silikat (Chromglimmer? nach Breithaupt). *Annalen der Chemie und Pharmacie* 44: 40-56.

Schaffhäutl K 1843. Chemish-mineralogische untersuchungen. *Annalen der Chemie und Pharmacie* 46: 325-347.

Sollas WJ, McKay A 1906. *The rocks of Cape Colville Peninsula, Auckland, New Zealand*. Vol 2, Government Printer, Wellington

Trealor PJ (1987) Chromian muscovites and epidotes from Outokumpu, Finland. *Mineralogical Magazine* 51: 593-599.

Ulrich GHF 1885. Notes on some mineral occurrences at Dusky Sound, West Coast of Middle Island, New Zealand. *New Zealand Journal of Science* 2: 306-314.

Whitmore DRE, Berry LG, Hawley JE 1946. Chrome micas. *American Mineralogist 31: 1-21*.

Lost subdivisions: an account of Geological Survey mapping projects that were never completed or only published after considerable delays.

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(GNS Science)

Introduction

In 1905 James Mackintosh Bell was appointed the second Director of the New Zealand Geological Survey which had become almost defunct in the years leading up to the retirement of James Hector in 1903 (Nathan 2015, pp 195-97). Young and enthusiastic, Bell had gained experience with the Canadian Geological Survey, and was keen to set up a systematic geological mapping programme, based on the Canadian model he was familiar with. Bell decided to progressively map large areas of similar geology, called *subdivisions*, with maps to be published at a scale of one mile to an inch (1:63,360). The maps for each subdivision were to be accompanied by a detailed descriptive text, with maps and text for each subdivision published as a *New Zealand Geological Survey Bulletin*.

Bell set an example to his staff by leading fieldwork himself and publishing several NZGS Bulletins. He started a work pattern was to persist for almost 40 years, with staff in the field over the summer and back at base in Wellington writing up work for publication and overseeing the drafting of maps during winter months. 32 bulletins were published between 1906 and 1927, with little delay between fieldwork and publication. Bell and his successor, P.G. Morgan (Director from 1911-27) believed that geological mapping was the primary task of the Geological Survey, and that nothing should impede completion and prompt publication of geological maps. Only one mapping survey was not completed during this period – the Heaphy subdivision was abandoned in 1909 due to temporary financial cutbacks.

Progress in geological mapping slowed dramatically from 1927 onwards. This coincided with the appointment of Dr John Henderson as Director of the Geological Survey following Morgan's sudden death. Henderson was also dedicated to the continuation of the geological mapping programme, but was frustrated by factors outside his control (Burton 1965, pp 67-74). Difficult economic times led to funding cuts that became worse in the early 1930s due to the worldwide depression. The Geological Survey had been incorporated into the new Department of Scientific and Industrial Research, founded in 1926 under Dr Ernest Marsden who had less commitment to systematic mapping, but was keen to introduce modern techniques, including geophysics. As the depression deepened, Marsden and Henderson were under pressure to cut costs (including deferring publication of completed mapping) and to undertake projects that showed obvious economic gain. The low point was in 1932-33, when the only official Geological Survey publication was the annual report and there was little money to undertake fieldwork. Only two NZGS bulletins were published between 1928 and 1936. The result was a backlog of unpublished bulletins and incomplete surveys. Some were never published, and others appeared decades later, after World War II. The record for the longest gap between the start of fieldwork and publication is held by the Murchison subdivision (started in 1926, published in 1968).

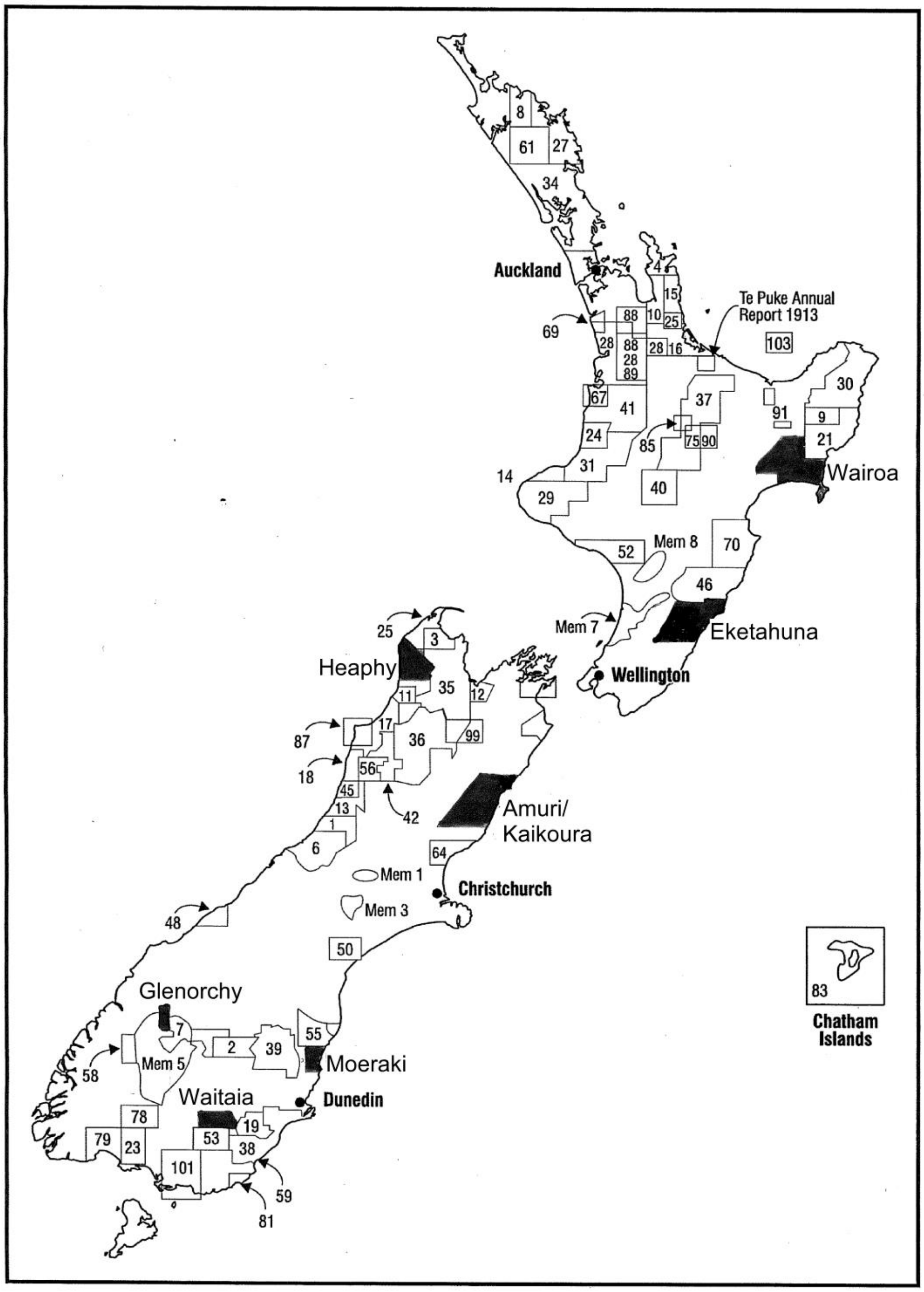

Fig. 1. *Locality map, showing coverage by NZGS bulletin mapping in the first part of the twentieth century. Numbers refer to the numbers of NZGS bulletins. The areas shown in black are the subdivisions where the maps were never published, but for which the original field sheets are held in the Mapping Section at GNS Science.*

Subdivision name	Start of fieldwork	Publication	Date
Heaphy	1907	*Never published*	
Motueka	1923	NZGS Bulletin 35	1959
Kaitangata-Green Is	1923	NZGS Bulletin 38	1939
Mangakahia	1925	NZGS Bulletin 61	1960
Wairoa	1926	*Never published*	
Murchison	1926	NZGS Bulletin 36	1968
Rotorua	1926	NZGS Bulletin 37	1937
Te Kuiti	1928	NZGS Bulletin 41	1946
Tongariro	1929	NZGS Bulletin 40	1960
Eketahuna	1930	*Never published*	
Amuri/Kaikoura	1930	*Never published*	
Waikaia	1935	*Never published*	
Dannevirke	1935	NZGS Bulletin 46	1953
Moeraki	1937	*Never published*	
Glenorchy	1937	NZGS Report 40	1969
Orepuki	1939	NZGS Bulletin 79	1969

Table 1. *Summary list of NZGS subdivisions that were either not published or only completed after long delays.*

The maps for several surveys were drafted and printed in the 1930s, but not published because the bulletin text had not been written. R.W. Willett, director of the Geological Survey from 1955-66, nominated authors to complete a brief text and see three bulletins through to publication, leading to the delayed publication of Bulletins 35 (Motueka subdivision), 36 (Murchison subdivision), and 40 (Tongariro subdivision).

A recent inventory of GNS map collections by Catharina Fisher has led to all the field sheets prepared during early 20th century mapping being sorted, catalogued and digitised. The background to those surveys that were never completed or were only published after long delays is not easily available. This background is documented in the sections that follow for the benefit of future geoscientists.

Geological mapping in the early 20th century

With a few local exceptions, no topographic maps were available in the early 20th century, so a major part of each geological survey was the preparation of an adequate topographic base map on which the geology could be plotted. The Lands and Survey department produced cadastral maps showing land ownership and major survey points such as trig stations based on *Survey Districts* – rectangular blocks of about 100 square miles, which the Geological Survey grouped together to make up a Subdivision.

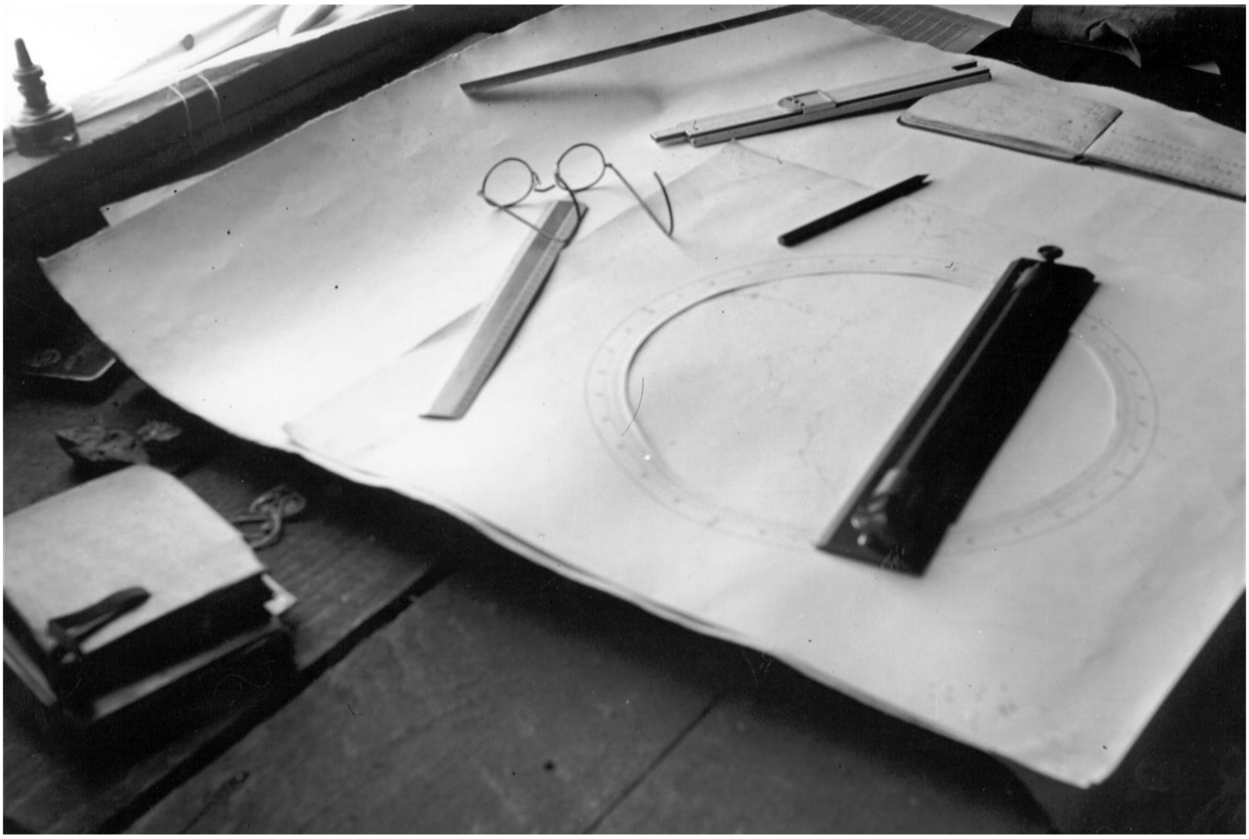

Fig 2. *Geologists working in the field were expected to plot up their observations at night or on wet days. Max Gage took this photograph of equipment he used: notebook, protractor sheet on tracing paper, parallel ruler, slide rule for calculations, scale and 4H pencil. After a traverse was plotted and adjusted on tracing paper, it was pricked through on to the Whatman's field sheet, and geological features were marked in coloured inks. Photo: M. Gage (from Gage and Nathan 1999)*

For the first decade of the mapping programme, beginning in 1905, each survey party included a surveyor and field assistants to produce the topographic map, but after World War I the geologist usually had to fill in detailed topographic information by pace and compass surveys. Before fieldwork started the Geological Survey draftsman would prepare a set of fieldsheets for each subdivision on sheets of Whatman's card at a scale of four inches to the mile (1:15,840) showing trig points, main roads and other topographic information obtained from the Lands and Survey Department. There were usually four sheets for each Survey District (labelled NE, NW, SE, & SW). The geologist would then add information from daily traverses, including structural data and lithological notes, in coloured ink. The field sheets contain much more information than the final published maps, and are regularly consulted by geologists working in specific areas.

Paleontological problems

The period of publication delays in the 1930s coincides with a time when major advances in the age dating of Cenozoic rocks using microfossils was made by H.J. Finlay. Although a general early or late Cenozoic age was easily established from macrofossils (mainly mollusca), detailed dating using foraminifera by H.J. Finlay was not possible until the publication of two major papers (Finlay and Marwick 1940, 1947). As a consequence, much of the earlier mapping, particularly thick mudstone or turbidite sequences on the east coast of the North Island, became regarded as out-of-date, and this was possibly a reason why some delayed surveys were not published.

List of unpublished or delayed subdivision maps

The list that follows includes information on mapping of subdivisions that were not completed or published, but for which GNS holds the original field sheets. The annual reports of the Geological Survey give year-by-year progress reports on surveys then underway. It also includes information on Bulletins that were greatly delayed before publication, and in several cases completed by people who had not done the original mapping. The list is chronological, based on the time at which mapping started in each subdivision.

Heaphy subdivision

J.M. Bell identified the mountains of NW Nelson as an area of considerable mineral potential, and planned to map a large block between the mouth of the Heaphy River and the Aorere valley which he named the Heaphy subdivision (Nathan 2009). Lacking any flat land, the area was inaccessible and virtually uninhabited, so Bell arranged for a hut to be built near the mouth of the Heaphy River as a base for geological investigations.

Topographic work began in the 1907/08 summer, and geologist E.J.H. Webb started making geological observations at the same time although handicapped by the lack of a topographic base map. Financial cutbacks in 1909 led to the temporary cessation of fieldwork, and subsequently the Heaphy subdivision was quietly abandoned. Some of the geological observations made by Webb were later incorporated in maps for the Collingwood subdivision (NZGS Bulletin 25; Ongley and Macpherson 1923). Nathan (2009) gives a more detailed account of the work undertaken for the Heaphy subdivision and later geological work undertaken there.

Motueka subdivision

Fieldwork started in the Motueka subdivision in the 1923-24 summer with geologists Les Grange, Eric Macpherson and John Henderson, and continued during the following two field seasons. The 1926 annual report noted that the survey had been completed and that a report was in preparation. Eleven maps were drafted and printed about 1930, but the bulletin text was never completed. 25 years later a short text was compiled from information in NZGS annual reports and other published sources by G.C. Shaw, leading to publication of NZGS Bulletin 35 (Henderson, Macpherson and Grange 1959).

The Motueka subdivision included most of the mountains of West Nelson, including a complex early Paleozoic succession George Grindley made considerable use of the information on the field sheets in his major re-interpretation of the geology of north-west Nelson (Grindley 1961).

Fig 3. *A field party (including surveyors, field hands and geologists) prepares to leave their base camp in the Baton River valley for the mountains. Geologist E.O. Macpherson is on the far right, and Les Grange (with camera) is kneeling in front of the horse. Photo: GNS Science.*

Kaitangata-Green Island subdivision

Mont Ongley undertook fieldwork over three seasons from 1923-24 to 1925-26, covering both the Kaitangata and Green Island coalfields and the intervening area. Although the 1926 annual report mentions that some further fieldwork was required to finish the survey, Ongley was sent to start work on the Wairoa subdivision the following year, and the Kaitangata-Green Island mapping languished for several years. The 1933 annual report noted that Ongley had written an interim report on the subdivision. A major coal resources survey started in 1936-37, with the aim of documenting coal reserves throughout New Zealand. It seems likely that this was the catalyst for the completion of the text and maps (which were drafted in 1937), with the eventual publication of NZGS Bulletin 38 (Ongley 1939).

Mangakahia subdivision

Fieldwork started in the Mangakahia subdivision in late 1925 by Hartley Ferrar, assisted by F.J. Turner. Work had only been underway for a few weeks when the survey was suspended, and the field party was transferred to undertake a soil survey in central

Otago. Nothing further was done until late 1945, when A.M. Quennell re-started fieldwork, assisted by Bob Hay. After Quennell's resignation, Hay carried on fieldwork intermittently from 1946-53. There were further delays in drafting and editing the text leading to the publication of NZGS Bulletin 61 (Hay 1960).

Wairoa subdivision

Ongley started work in the Wairoa subdivision in the 1926-27 summer. It was adjacent and south of the Whatatutu and Gisborne subdivision that he and Henderson had previously mapped in NZGS Bulletin 21. Ongley continued the work through the 1927-28, 1928-29 and 1929-30 summers, covering a large area of Cenozoic sediments that extended south to Mahia Peninula and the town of Wairoa, and east to Lake Waikaremoana. Mapping of the Wairoa subdivision was reported to be complete in the 1930 NZGS annual report, and Ongley gave a brief summary of the geology (pp 7-10) accompanied by a small-scale black and white map. The maps were never drafted for printing, no text was completed, and the bulletin was not published. Only the field sheets remain.

Murchison subdivision

Fieldwork was undertaken in the Murchison subdivision by Horace Fyfe over four field seasons from 1926-27 to 1929-30. Although Fyfe was accompanied for part of the first summer by Henderson, for the remaining period he was the sole geologist, working with a field assistant. The Murchison subdivision is a huge area of rugged mountainous country, covering 18 survey districts, and includes mapping of the feature now known as the Alpine Fault (although not recognised by Fyfe). The maps were drafted and printed about 1935, but the text was never completed. On his retirement in 1963, Fyfe left behind a manuscript describing the sedimentary rocks. This was used as the basis of the text prepared by R.P. Suggate, and published as NZGS Bulletin 36 (Fyfe 1968).

Rotorua and Tongariro subdivisions

In the early 20th century there was ongoing discussion about setting up a volcanological observatory in the volcanic region of the North Island to monitor volcanic and geothermal activity. The survey of the Rotorua subdivision was undertaken partly to extend the regional geological coverage, and partly to make recommendations on the siting and work of a volcanological observatory. Les Grange started field work in the summer of 1926-27. Over three summers he covered a huge region, extending from Rotorua in the north to Tokaanu in the south. As well as conventional geological mapping, Grange recorded information on hot springs, geysers and other geothermal phenomena. Within the volcanic region the land surface is mantled by thick ash layers deposited by recent volcanic eruptions. Grange paid attention to the surface ash layers, and was soon able to distinguish different ashes that formed the soil in different areas. This eventually was a major contribution to understanding the origin of 'bush sickness', a wasting disease in stock cause by trace element deficiencies in the Taupo Pumice.

In 1929 it was decided to extend the survey southwards to cover the Tongariro volcanoes (Tongariro, Ngauruhoe and Ruapehu), and this part became known as the Tongariro subdivision. Grange and his assistant Norman Taylor completed the Tongariro mapping between 1929 and 1931, but from this time onwards they were diverted to undertake soil surveys in different parts of the country, In 1936 Grange was appointed director of a new Soil Survey division, and left the Geological Survey. He had already completed the text of most of the Rotorua bulletin, but Jack Marwick and Horace Fyfe were given the job of writing the descriptive introductory chapter. The resulting Rotorua-Taupo bulletin (Grange 1937) was the largest NZGS Bulletin published to that time.

Although the maps for the Tongariro subdivision were drafted and printed, Grange never wrote the bulletin text. In the late 1950s it was completed by Don Gregg, who compiled a comprehensive account of volcanic events including the 1945 Ruapehu eruption, 1948-49 and 1954 eruptions of Ngauruhoe and the 1953 Tangiwai lahar disaster, and published as NZGS Bulletin 40 (Gregg 1960).

Te Kuiti subdivision

The Te Kuiti subdivision is between the Huntly-Kawhia subdivision (Bulletin 28) in the north and the Tongaporutu subdivision (Bulletin 31) in the south. Hartley Ferrar started fieldwork in November 1928 assisted by Norman Taylor, and they continued the following summer, although diverted for part of the time by soil investigations. During the 1930-31 and 1931-32 seasons Ferrar continued the mapping, completing work at the beginning of April 1932. He died unexpectedly a few weeks later.

Fig 4. *The team involved in geological and soil mapping of the Te Kuiti subdivision: Les Grange, Hartley Ferrar, J.A. Hurst and Norman Taylor. Grange was to become the first director of the DSIR Soil Bureau, to be succeeded by Taylor. Photo: GNS Science.*

Marwick was given the job of writing up the text, although he had no previous experience with the mapping. When Brian Mason joined the Geological Survey as a student assistant at the end of 1937, he discovered that he had a special status as the owner of a car – an Austin 7. Dr Henderson asked him to chauffeur Marwick on a trip around the Te Kuiti subdivision (Mason & Nathan 2001, pp 12-13). Marwick completed the text in 1938, but publication of the Bulletin was delayed during the war. It finally appeared as Bulletin 41 (Marwick 1946). Because of the delay, microfossil samples were examined by Finlay, and it is the first NZGS bulletin to incorporate the results of his biostratigraphic investigations of the Cenozoic sequence.

Eketahuna subdivision

Having completed the Wairoa subdivision in early 1930, Ongley spent the next four field seasons (1930-31 to 1933-34) mapping the Eketahuna subdivision in southern Hawkes Bay, assisted at different times by Fyfe and Williamson. Fieldwork was completed in early 1934. There seemed little chance of publication in the immediate future, so Ongley wrote a summary in the 1934 annual report (pp 1-6) accompanied by a small scale geological map. The maps were never drafted for publication, nor was a descriptive text prepared. Ongley was in the field again the following summer starting work on the Dannevirke subdivision to the south.

Amuri/Kaikoura subdivision

Although Horace Fyfe had spent the previous four summers mapping the Murchison subdivision and the text was not yet written, the following summer (1930-31) he was sent to start a new survey, the Amuri subdivision in north Canterbury/southern Marlborough. The following summer Fyfe was sent to assist Ongley with the Eketahuna subdivision, but in the 1932-33, 1933-34 and 1934-35 summers he was again working in the Amuri subdivision, assisted during the final season by Jim Healy. There is no mention of the Amuri subdivision for the following three years as Fyfe was occupied in other projects, but in early 1939 Healy was back in the field for three months. This is the last mention of the Amuri subdivision, and no summary of the geology was ever written. At some stage the name Kaikoura subdivision was applied to what had previously been called the Amuri subdivision, and the field sheets are filed under that name.

Whakaea/Waikaia subdivision

During the 1935-36 summer Jim Healy started work on what was originally called the Whakaea subdivision, north of Gore. It included Waikaia, the site of extensive dredging in the early 20th century, followed by small scale alluvial operations during the depression. Work continued by Healy and Willett in the 1936-37 summer (under the name of the Waikaia subdivision), with emphasis on locating further areas of mineable alluvial gold. Although the survey was regarded as complete, no report was written and the maps were never drafted for publication.

Dannevirke subdivision

By the 1930s, Ongley was regarded as the expert on the east coast of the North Island. Having completed four field seasons each mapping the Wairoa and Eketahuna subdivisions, he was then assigned the Dannevirke subdivision in summer of 1935-36, assisted by student assistant Max Gage, and later by Bert Quennell. In his memoirs, Gage gives an account of his experience of field work with Ongley (Gage and Nathan 1999, pp 6-13).

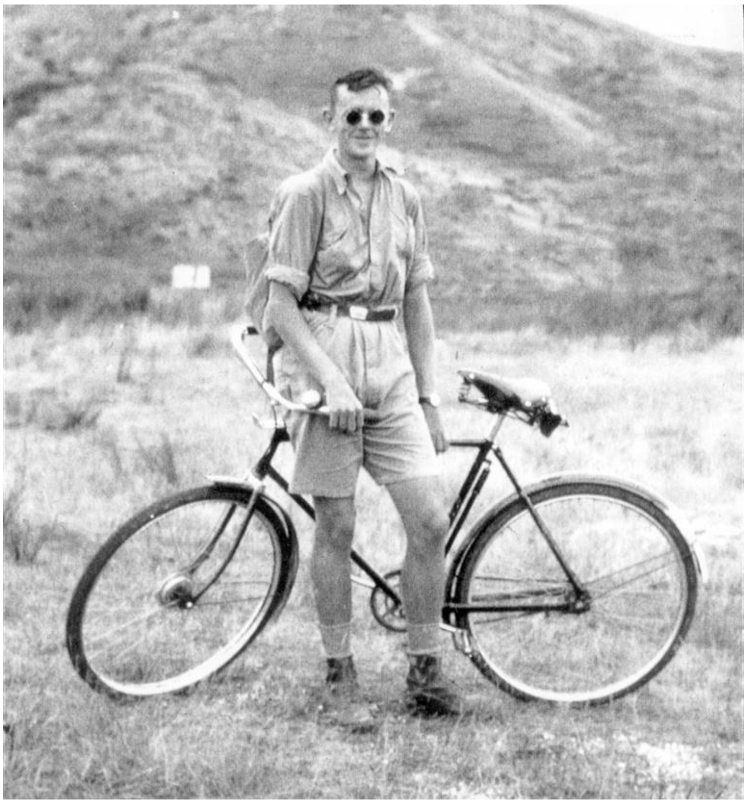

Fig 5. *When employed as a student assisting Ongley in the mapping of the Dannevirke subdivision, Max Gage was expected to provide his own bicycle, which was the main means of transport. Photo: M. Gage (from Gage and Nathan 1999).*

The following summer Ongley was diverted to other work, and the mapping was taken over by Quennell and David Brown, assisted by Brian Mason (Mason & Nathan 2001, pp 9-12). Quennell continued work the following summer, again assisted by Mason. Increased interest in oil exploration in 1938 led to a temporary exodus of NZGS staff (including Brown, Quennell, Ongley. Macpherson and Wellman), and the Dannevirke subdivision was left in limbo.

In the 1939-40 summer, work on the Dannevirke subdivision was taken over by Arnold Lillie, newly arrived from Europe. Although World War II was underway, Lillie continued work on the Dannevirke subdivision in the 1940-41 summer, assisted by Charles Fleming and Martin Te Punga, and completed the fieldwork. Because of wartime security concerns the geologists were regarded with suspicion by some of the locals, and at one stage Lillie was questioned by the police as a suspected German spy, a story that has entered geological folklore (Stevens 2005). Lillie completed a draft of the bulletin text in the winter of 1941, but because of wartime delays, it was over a decade before publication of Bulletin 46 (Lillie 1953).

Moeraki subdivision

David Brown spent five months mapping the Moeraki subdivision, south of Oamaru, in the 1937-38 summer. In contrast with other subdivisions, this was a relatively small area, expected to be completed in one summer field season. The reason why mapping was undertaken here is unclear, but it may have been to explore the coal resources of the area. Brown left the Geological Survey to work for an oil exploration company later in 1938, and subsequently enlisted in the army at the outbreak of World War 2. In the 1940 annual report it was noted that Brown had been given leave by the military authorities to complete the text of the Moeraki bulletin. The maps for the Moeraki subdivision were drafted, but for reasons that remain unclear the bulletin was never published. It is possible that the advances in micropaleontology in the 1940s made some aspects of the stratigraphy out-of-date.

Fig 6. *Photo taken high in the Richardson mountains as part of the mapping of the Glenorchy subdivision in 1938. From left: Harold Wellman, Jim Healy, unknown, Dick Willett. Photo: GNS Science.*

Glenorchy subdivision

Scheelite is a calcium-tungsten mineral that occurs in quartz reefs in the Richardson Mountains near Glenorchy, and has been intermittently mined since the 1860s. In an attempt to assist the scheelite mining industry, fieldwork was started in the Glenorchy subdivision by Jim Healy and Dick Willett, with Harold Wellman assisting them as a surveyor. The area is mountainous, with relief of over 2000 metres, and aerial photography was used to assist with construction of a topographic base map. Mapping was completed the following summer, but no bulletin text was written, and the maps were not published. The project was reactivated in the 1960s by A.R.Mutch. He described the Scheelite bearing lodes, made estimates of potential resources, and recommended future exploration. This work was published in NZ Geological Survey Report 40 (Mutch 1969).

Orepuki subdivision

In the 1939-40 summer, Harold Wellman and Dick Willett were sent to investigate the oil shale resources at Orepuki, and Willett stayed on to start work on the Orepuki subdivision. As well as oil shale, there was economic interest in the alluvial gold, and there was also an exceptionally well-exposed section through Miocene sediments in the Clifden River. Willett continued work through the 1940-41 and 1941-42 summers although often diverted by short-term economic work. The mapping remained in limbo through the later part of World War 2, but was revived by Willett and Bryce Wood in 1947, but fieldwork was only intermittent over the following decade. It was eventually published as Tuatapere subdivision (Bulletin 79, Wood 1969).

Conclusions and Acknowledgements

Spanning almost fifty years of fieldwork in the first part of the twentieth century, J.M. Bell’s vision of a systematic mapping programme was largely met, with the average publication of one bulletin every year. There were major delays due to two world wars and the depression of the 1930s. In this period six major mapping projects (subdivisions) were never completed, and ten were published many years after fieldwork was started. There were many reasons for delayed and abandoned bulletins such as personal changes, financial constraints and competing priorities. Both completed and incomplete mapping projects have left behind detail field and compilation sheets containing original field data, and these can now be consulted online through GNS Science’s archival map image repository.

I am most grateful to Catherina Fisher for her work sorting and cataloguing the archival field sheets, and to Mark Rattenbury for reviewing the manuscript.

References

Burton MP 1965. The New Zealand Geological Survey, 1865-1965. *DSIR Information Series* 52: 147p.

Fyfe HE 1968. Geology of the Murchison subdivision. *New Zealand Geological Survey bulletin* 36.

Gage M 1999. A geologist remembers: recollections of fieldwork. *Geological Society of New Zealand miscellaneous publication* 102: 53p.

Grindley GW 1961. *Sheet 13, Golden Bay*. Geological Map of New Zealand 1:250,000. Wellington: DSIR.

Grange LI 1937. Geology of the Rotorua-Taupo subdivision. *New Zealand Geological Survey bulletin* 37.

Gregg DR 1960. Geology of the Tongariro subdivision. *New Zealand Geological Survey bulletin* 40.

Hay R 1960. Geology of the Mangakahia subdivision. *New Zealand Geological Survey bulletin* 61.

Henderson J, Ongley M, Macpherson EO 1959. Geology of the Motueka subdivision. *New Zealand Geological Survey bulletin* 35.

Lillie AR 1953. Geology of the Dannevirke subdivision. *New Zealand Geological Survey bulletin* 46.

Marwick J 1946. Geology of the Te Kuiti subdivision. *New Zealand Geological Survey bulletin* 41.

Mason B 2001. From mountains to meteorites. *Geological Society of New Zealand miscellaneous publication* 109: 73p.

Mutch AR 1969. The scheelite resources of the Glenorchy District, west Otago. *New Zealand Geological Survey Report* 40: 86p + 1 map.

Nathan S 2009. What happened to the Heaphy subdivision? *Journal of the GSNZ Historical Studies Group 37*: 11-17.

Ongley M 1939. The geology of the Kaitangata-Green Island subdivision. *New Zealand Geological Survey bulletin* 38.

Ongley M, Macpherson EO 1923. The geology and mineral resources of the Collingwood subdivision. *New Zealand Geological Survey bulletin* 25.

Stevens GR 2005. A geological "spy" story. *Geological Society of New Zealand newsletter* 138: 86-89.

Wood BL 1969. Geology of the Orepuki subdivision. *New Zealand Geological Survey bulletin* 79.

A visit to Moscow during the Cold War

Graeme Stevens

In 1966 I received an invitation from the International Union of Geological Sciences to be appointed as the Australasian representative on the Stratigraphic Commission's Sub-Commission on the Jurassic System. This appointment was followed in 1967 by a request to attend an International Colloquium on the Jurassic, to be held in Luxembourg. Travel funding came from UNESCO and DSIR provided additional funds for visits to research institutions both before and after the Colloquium. At the time it was DSIR policy that if someone else was fronting up with the airfares to and from Europe, for example, a certain amount of money was provided to ensure that the staff member could use the opportunity to touch base in relevant European organizations and laboratories.

The Colloquium was quite a crucial meeting for Jurassic stratigraphy. Prior to the meeting various working groups had been busy forming agreed definitions and type sections for the international Jurassic stages (Kimmeridgian, Oxfordian, etc.). A lot of argument had been going on and one of the major stumbling blocks was the fact that many of the stages had originally been worked out in a number of European countries (England, France, Germany, etc.) and the name-bearers had been enshrined in history (e.g., Kimmeridgian derived from the Kimmeridge Clay; Oxfordian from Oxfordshire). Nationalism reared its ugly head and a lot of argument revolved around keeping the *status quo*, because of history. However, time had moved on and new sections had been discovered that provided better stratigraphy, fossil successions and clearer boundaries. At the time of the Colloquium agreement had been reached on a small number of stages and these were scheduled to be ratified by members of the Sub-Commission. However, one of the major sticking-points was the status of the Tithonian, the uppermost Jurassic stage.

Apart from problems with the stage definition, a major factor was the relationship of the Volgian to the Tithonian. Volgian was universally used throughout Russia instead of the Tithonian. The Russians pushed very strongly that the Volgian should be recognized internationally as the uppermost stage of the Jurassic, rather than the Tithonian. Towards this end the Russians fronted up in Luxembourg with a very strong delegation – most unusual for the times of the Cold War because often the Russians failed to turn up or else one or two persons from the embassy appeared in their place that were next to useless. The big drawback with the Volgian was that it had very limited application outside the Boreal region. Towards the end of the Jurassic there was the development of very marked provincialism in the fossil assemblages. A Boreal Realm could be distinguished, together with a Tethyan Realm, and an Indo-Pacific Province as an offshoot of the Tethyan Realm. A small number of Tethyan faunas overlapped into the Boreal, but because of strong endemism, very few Boreal faunas ranged into the Tethyan. Therefore stratigraphic correlations between Boreal and Tethyan were often fraught with difficulty. As the sessions of the Colloquium proceeded the Russians put a great deal of effort into showcasing the merits of the Volgian. However, in the end the voting by the Sub-Commission went against them and the Volgian was recognized as a local stage division, rather like the New Zealand local stages (Temaikan. Ohauan, Puaroan, etc.). The Tithonian was confirmed as the international stage.

At the Luxembourg meeting a bus-load of Russians turned up – but in a number of instances not the ones scheduled to appear in the relevant sessions (the absentees were obviously thought to be politically unreliable). The Russians stayed together in a small hotel and always ate together and hardly said a word to the other delegates. They were constantly chaperoned by two tough-looking women, supposedly tourist guides from Intourist, the Russian travel agency – but I bet they were KGB agents assigned to prevent any defections to the West. At the conclusion of the scientific sessions of the Colloquium the Russians were shepherded into their bus to go to the Airport. As the bus was about to depart a head count was made and – horrors of horrors – one person was missing!! The two minders flew into a panic – obviously they were facing big trouble on their return to Moscow. They ran around like headless chickens, shouting at one another. Eventually the missing person turned up (he had been taking some photos of the castle, the venue for the Colloquium) – and did he get a tongue-lashing from the two women!!

The one Russian who was very prominent in the scientific sessions of the Colloquium was Professor Vladimir Menner. As at that stage I was working up to do something with oxygen isotopes using the Kawhia belemnites, I asked him about the work with oxygen isotopes being done by people at Moscow State University. During our conversation he suggested that on my way home I travel via Moscow. He said: “I’ll look after you”. So as I had a ‘Round-the World’ air ticket, that allowed me to go to any country, providing you kept travelling in the one direction, I accepted Prof. Menner’s kind offer and made arrangements to travel via Moscow on my way home. At that time Prof. Menner was ‘Mr. Russian Geology’ and had enormous influence within the Russian geological community. So I was very lucky indeed to be taken under his wing, as it were.

Professor Menner came from an aristocratic family who had somehow survived the Revolution. He was a senior member of the USSR Academy of Sciences (and was probably a member of the Communist Party) and represented the USSR on all the various international bodies and attended all the conferences. At that time very few Russians were allowed out of the USSR to attend conferences. Often enrollments would come from Russian scientists but then virtually at the last minute they wouldn’t turn up (upsetting the conference programme) – or a person from the Russian embassy would appear in their place – worse than useless! Obviously Menner was trusted by the politicians at a very high level and allowed to operate with a great degree of freedom. This was reflected by the fact that he had a car and chauffeur, a plush office and – wait for it – a telephone!

After the Colloquium I flew to London and spent some time at the Natural History Museum, the British Geological Survey and Imperial College. I also visited a palaeontological colleague at Bristol University and travelled up to Scotland to look at collections in the Royal Scottish Museum in Edinburgh and the Hunterian Museum in Glasgow. While visiting the British Geological Survey I had a session with Raymond Casey, a palaeontologist who had just returned from a 3-month government-to-government exchange in the USSR. At this time (1967) visits to the USSR were very rare and even then they were subject to various restrictions. I had to get a special visa, supported by statements of support from my Russian colleagues. This gave me the status of an official government visitor.

Therefore it was very good to have the opportunity to have an extended talk with Raymond and to suss out the lie of the land, as it were. Amongst many other things Raymond told me to be very, very careful when moving around because you will probably be watched by plain-clothed police. In particular, don’t show too much interest in details of infrastructure such as bridges, railways, transport, power installations etc. and be ultra-careful with the use of your camera – because otherwise it might be confiscated. In particular, I should not take photos of any street scenes and stick to photos of the well-known tourist sights such as The Kremlin, St. Basil’s Cathedral, Red Square, Lenin’s tomb etc. A small thing was that Raymond asked me to not forget to buy a universal bath plug – as in all Russian hotels the plugs are missing – but they can be rented at an exorbitant daily price. This was an excellent hint.

Before leaving London Raymond asked me whether I would mind taking some gifts into the USSR for some Russian scientists who had been particularly helpful to him during his visit. Before accepting the gifts I asked to examine them before they were wrapped and addressed. The gifts consisted of four packages: two lots of antiquarian prints of English country scenes that had been purchased from Harrods and several art shops in Knightsbridge (their stickers were on the backs of the prints). The other two packages consisted of selections of mint English commemorative postage stamps. Raymond explained that the recipients had spent quite a bit of time in England on exchange visits and were absolutely dedicated Anglophiles.

I flew from London on a de Havilland Comet of British Airways. In my eyes the Comet was the most beautiful of all the jet planes (and probably still is) and it was a great shame that its short career was dogged by so many problems. As the Comet neared Moscow, the Russia customs forms were distributed. On reading the form I saw: ‘It is an offence against Russian law for foreigners to bring anything in the way of gifts for Russian citizens’.

A bit further down the form I saw: ‘It is against Russian law for foreigners to bring in foreign mint postage stamps.’ On seeing these two items I thought: ‘I am not going to carry the can for Raymond Casey – the Russian customs can have his gifts’. So I duly declared the four packages.

When I fronted up to the Customs Officer at Moscow Airport the only thing he was interested in were the four packages. He asked to see them and I arranged them along his counter, with the two containing the prints first, followed by the two with the stamps. I opened up the first package and the officer scrutinized them closely. The backs of the prints were of particular interest and he noticed the labels from Harrods and the Knightsbridge art shops. He asked me to open the second package and again he looked very closely at the contents. Then he motioned to the two remaining packages (the ones containing the stamps) and said: “The same?” I nodded, too scared to speak. He then said: “You know that you have committed an offence against Soviet law to bring these items into the country? However, as you are an official government visitor I think that we will now tear up the customs form and then you can fill in a new one, but this time don’t mention the gifts. When you have filled in the form, bring it back to me and I will stamp it. I did as I was told and the form was duly stamped. Then the officer gave me a beaming smile, shook my hand and said: “Welcome to Moscow! Have a very good visit.” I made my way to the exit full of gratitude that everything had worked out so well in a friendly manner. Needless to say, I was very annoyed with Raymond Casey. But to give him the benefit of the doubt perhaps he might have been unaware of the restrictions I had encountered. As I had better things to do with my time I didn’t take matters any further.

I walked out of the airport to a beautiful sunny day to be greeted by Prof. Menner. First he took me on a tour of many of Moscow’s tourist spots and then deposited me at the Ukrainia Hotel. The hotel is a huge palace-like marble structure on the banks of the Moskova River. It had been built during the Stalinist Era as a monument to the glories of Soviet communism and no expense had been spared in terms of marble panelling, paintings, sculptures, etc. But by the time of my visit it was starting to look rather tatty. As an official government guest I was allocated a suite – bedroom, spacious lounge and a large *en suite* bathroom. The room had huge chandeliers and I remember climbing up on a chair to check for bugs (and also behind mirrors and pictures) as the Cold War was at its height and all Westerners were regarded with a great deal of suspicion. Each floor in the hotel was patrolled by a uniformed, rather forbidding woman and she was constantly on the lookout. She was also in charge of the bath plugs that were dolled out for a hefty fee. Luckily I had purchased a universal bath plug before leaving London – thanks to Raymond Casey’s advice.

Tourists could only exchange money at the hotel office, and then at an artificially inflated rate. I was also warned that I could not take any Russian money out of the country.

Police were permanently stationed outside the hotel and you were watched very closely as you departed. On the city streets police were everywhere – usually one or two on each street corner – and as foreigners were pretty rare at that time, they followed your movements with great attention. For all that I knew, there were probably plain-clothed security agents mixing with the pedestrians.

Prof. Menner drove me to Moscow State University to meet Prof. Naidin and his colleagues. Prof. Naidin was the leader of a very active research group studying belemnites and oxygen isotopes, so I was very much looking forward to meeting him and his group. Prof. Naidin was the Russian expert on Boreal Cretaceous belemnites (e.g. Naidin 1969) and another member of his group, Mrs Teis, was an expert on the use of oxygen isotopes to determine palaeotemperatures in belemnites. Building on the initial work by Urey et al. and Lowenstam and Epstein (Urey et al. 1951; Lowenstam and Epstein, 1954), the Russian team had established an excellent reputation in the field of the application of oxygen isotopes to belemnite palaeotemperatures (Naidin et al. 1956, 1964, 1966). The discussions with my Moscow colleagues provided an excellent background to my own work on oxygen isotopes in 1964 and 1965, in conjunction with Bob Clayton from the Enrico Fermi Institute for Nuclear Studies at the University of Chicago, Harold Urey's old stamping ground (Stevens and Clayton 1971).

I had a very enjoyable and most rewarding time with Prof. Naidin and his group. I couldn't help but to compare his situation with that of Prof. Menner. Prof. Naidin, a senior professor at Moscow University, was in an antiquated and rather dilapidated building and shared a cramped room with four other people. In order to use the telephone he had to go outside into a courtyard to use a coin-in-the-slot public phone. When we went anywhere in the city we had to go by either bus or Metro – no chauffeur and no car!

My Russian colleagues took me to many of the sights of Moscow and explained their historical significance. Trips on the Metro were quite an experience, as all the stations were lined with decorative marble panels and marble statues, paintings and other art works were in abundance. No sign of any vandalis! One day Prof. Naidin took me to GUM, the large department store on Red Square, directly opposite Lenin's tomb. It was fascinating to see all the items for sale – but to my eyes so many of them seem to be very old-fashioned. Also there wasn't any choice. For example, all of the men's shoes on display were of the same type and colour and it was explained to me that one big consignment would come in – all identical except for size – and these would remain in the store until they were all sold. So if you wanted a specific colour or style, you just had to wait until the factory decided to make it! On another day Prof. Menner took me on a trip in his car out into the Moscow countryside to visit a famous monastery that was in the middle of being refurbished. On the way we called into his Dacha (country house) – a log cabin set in the birch forest and built on the edge of a lake. A very picturesque setting. Before the Russian Revolution in 1917 the

Russians were very devout people and the Russian Orthodox Church had immense power and wielded enormous influence and built beautiful churches and cathedrals throughout the land. However, in post-1917 times the communist government actively discouraged any form of religion (practicing religion was a proscribed activity) and all of the Russian churches and monasteries were closed down. The churches and monasteries were used as storehouses, offices, etc. and generally left to decay away.

At the time of my visit the Russian authorities were beginning to wake up to the tourist potential of many of their churches and monasteries. They realised that Russia was sitting on a treasure trove of magnificent buildings that tourists from the West would pay good money to see (and furthermore they would pay in hard currency). So therefore when I was in Moscow all the churches and monasteries (and there were many of them) were encased in scaffolding and substantial repairs were proceeding apace. Masses of gold leaf were being applied to the interiors and to the surfaces of the onion-shaped domes. The domes looked truly magnificent in the summer sunshine. St Basil's Cathedral absolutely sparkled.

Both Profs. Menner and Naidin made every effort to make my visit an enjoyable experience – and despite the 'Cold War' we got on famously! The discussions with Prof. Naidin's team were of great value in my later work on oxygen isotopes. All the Russian people that I met spoke very good English. Although I had taken a DSIR course in Russian I could read it far better than speak it – but even this minimal knowledge was useful in deciphering the road signs, metro station names, etc.

I left Moscow via Aeroflot (the Russian state airline) and flew southwards across the Russian Plain to the city of Tashkent. Like the prairies of North America, the plainlands of the USSR are simply enormous and we flew across them for many hours. The meals on the plane were quite unusual, consisting of a large smorgasbord platter with various savoury items that was passed around. This was followed by a large dish with savoury crackers and a big container of caviar. Very strong coffee and a glass of vodka were then offered. The meals were concluded with large bunches of grapes. As we neared the southern states – Kazakhstan and Uzbekistan – the countryside dried out and around the Aral Sea there were vast areas of desert and salt flats. After flying across the Aral Sea we passed over many fields of cotton before landing at Tashkent. The southern states of the USSR – Kazakhstan, Turkmenistan, Uzbekistan, Tadzhikistan and Kyrgyzstan – are all predominantly Muslim and in spite of Stalin's pogroms the populations have mostly steadfastly remained devout Muslims. Therefore, given this background, Tashkent has many beautiful mosques, with huge domes, tiled with exquisite turquoise mosaics. Quite a sight. After a stopover in Tashkent I flew onto Karachi, Calcutta and Bangkok, visiting the Geological Surveys of Pakistan, India and Thailand *en-route*.

References

Lowenstam HA, Epstein S 1954. Paleotemperatures of the post-Aptian Cretaceous, as determined by the oxygen isotope method. *Journal of Geology* 62: 207-248.

Naidin DP 1969. *Morphology and Palaeobiology of Upper Cretaceous Belemnites* (in Russian). Moscow University Press.

Naidin DP, Teis RV, Chupakhin MS 1956. Determination of the climatic conditions of some regions of the USSR during the Upper Cretaceous by the method of isotopic palaeothermometry (in Russian) *Geokhimiya* 8:23-34 (translation in *Geochemistry* 8: 752-764, 1956).

Naidin DP, Teis RV, Zadorozhny IK 1964. New data on the palaeotemperatures of the Maestrichtian basins of the Russian Platform and the adjacent regions obtained from measurements of the isotopic composition of oxygen in the rostra of belemnites (in Russian). *Geokhimiya* 10: 971-979. (Translation in *Geochemistry International* 1 [5]: 936-943).

Naidin DP, Teis RV, Zadorozhny IK 1966. Isotopic palaeotemperatures of the Upper Cretaceous in the Russian Platform and other parts of the USSR (in Russian). *Geokhimiya* 11:1286-1299 (translation in *Geochemistry International* 3 [6]:1038-1051).

Stevens GR, Clayton RN 1971. Oxygen isotope studies on Jurassic and Cretaceous belemnites from New Zealand and their biogeographic significance. *New Zealand Journal of Geology and Geophysics* 14: 829-879.

Urey HC, Lowenstam HA, Epstein S, McKinney CR 1951. Measurement of palaeotemperatures and temperatures of the Upper Cretaceous of England, Denmark and the southeastern United States. *Bulletin of the Geological Society of America* 62: 399-416.