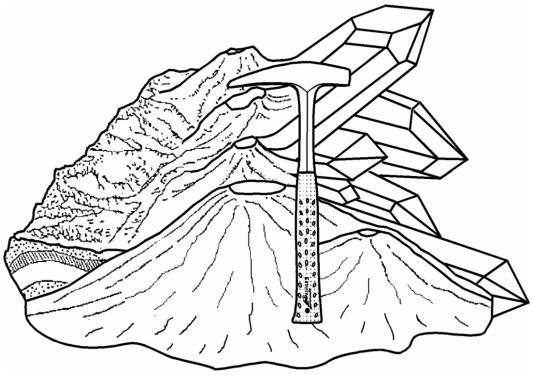


Geocene

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Geocene is a periodic publication of Auckland Geology Club, a section of the Geoscience Society of New Zealand's Auckland Branch.

Contributions about the geology of New Zealand (particularly northern New Zealand) from members are welcome. Articles are lightly edited but not refereed.

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CRATEROPORA N. SP. – A CONSPICUOUS ENCRUSTING BRYOZOAN FROM THE EARLY MIOCENE WAITIITI FORMATION OF TAITA STREAM, SOUTH HOKIANGA, NEW ZEALAND

Seabourne Rust

Overview of local geology & paleoecology

In the banks of the present-day Taita Stream near Waimamaku, South Hokianga, Northland (Fig. 1), the Waitiiti Formation of the Early Miocene Otaua Group outcrops as a shallowing-upwards, north-dipping section, largely obscured and deformed by recent slumping and mass movement, adjacent to the Waima Range (Wakefield, 1977; Evans, 1994; Hayward, 1993). We have been studying the Taita section, in an effort to record macrofossil distribution and diversity, (Rust & Yanakopulos, 2011, 2012), with results recorded in the New Zealand Fossil Record File (FR# O06/f0121).

The **Waitiiti Formation** in Taita Stream consists of poorly-bedded grey mudstone with scattered macrofossils (mainly small mollusca), passing upwards into layered mudstone and fine sandstone, with some coarser lenses or channel-fill deposits of larger lithic fragments, rhodoliths and occasional worn macrofossils. The studied assemblage comes from the uppermost 50 m of the Waitiiti Formation section, where lithic fragments often show signs of bio-erosion and are commonly encrusted by a well-preserved attached epifauna.

The majority of these rocks are reworked Northland Allochthon sandstones and mudstones of probable Paleocene – Cretaceous age. At Taita Stream, these rocks might represent part of the original 'bedrock' of an Early Miocene shallow shoal or perhaps euphotic-mesophotic zone 'reef', which once existed on the western fringes of proto-Northland, covering an area being progressively uplifted, to eventually form the Waima Range. Locally, the rocky seafloor formed a significant hardground upon which a diverse, bryozoan-rich epifauna developed.

But these reef edge rocks and associated shallow (euphotic zone) fauna were later eroded and incorporated/mixed into slightly deeper shelf settings. Thus, the assemblage can be interpreted as a 'displaced thanatocoenesis' *, a number of which are found in other comparable Miocene basin-filling strata of northern New Zealand (*cf*. Hayward, 1976; Hayward *et al*. 1989; Hayward & Triggs, 2016). Microfossil analysis by Hayward (1993) indicates deposition of the Waitiiti Formation at mid-shelf depths and confirmed an Early Miocene age (New Zealand Otaian Stage).

A notable bryozoan

Some of the most conspicuous, and relatively common, fossil-encrusting bryozoan colonies found at the locality are those of the aspidostomatid cheilostome *Crateropora* (Fig. 2). These are often recognisable without magnification,

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* *An assemblage of fossils that occurs together in a particular area from a particular moment of geological time.*

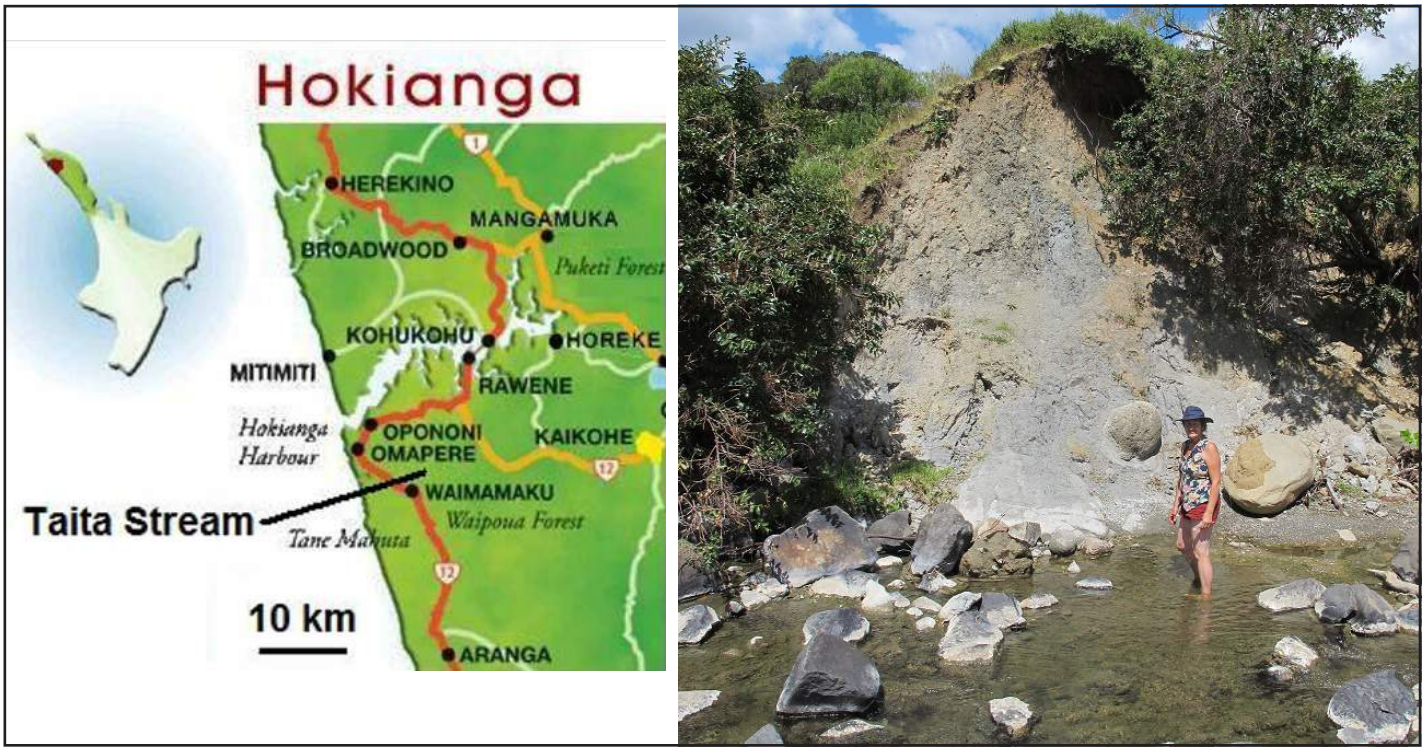


Fig. 1. Location and Waitiiti Formation outcrop on the banks of Taita Stream, South Hokianga.

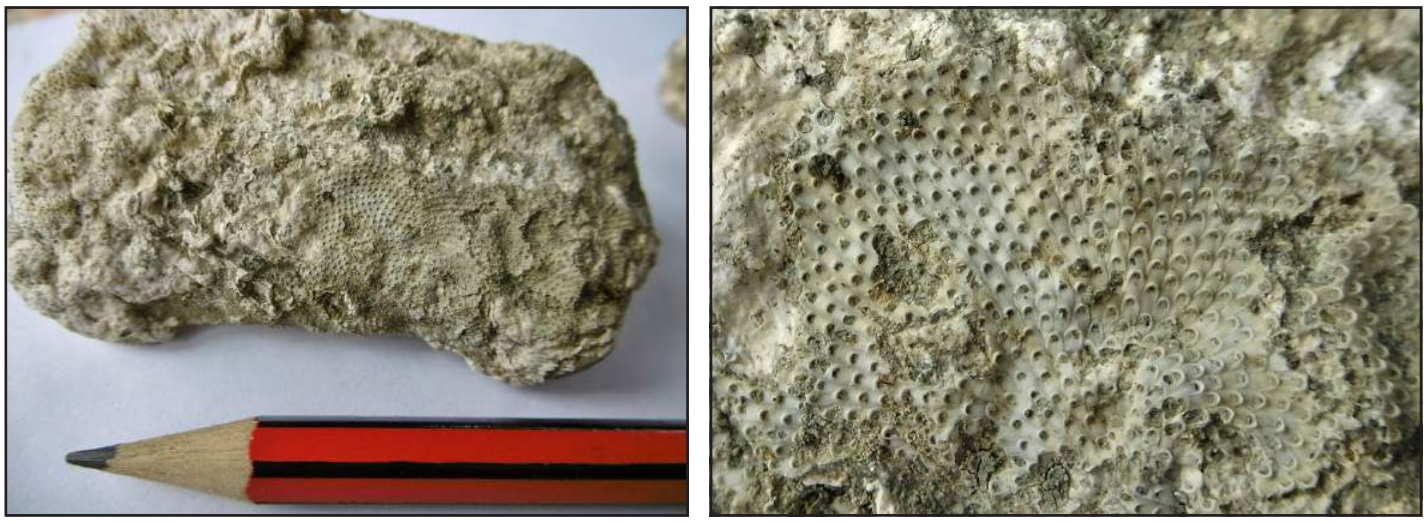


Fig. 2. A colony of a rhodolith- encrusting bryozoan *Crateropora* n. sp. (Aspidostomitidae) from the Taita Stream locality (Early Miocene).

due to the large-size of the individual zooids and sheet-like colonies as a whole. This is the first tentative record of this genus in the Cenozoic of New Zealand since a questionable report by Brown (1952, see below). It will be interesting to see whether this bryozoan taxon will also be found encrusting hard substrates in other Miocene shallow marine assemblages from Northland and Auckland.

CLASS GYMNOLAEMATA
ORDER CHEILOSTOMATA
Superfamily Microporoidea
Family Aspidostomatidae (Jullien, 1888)
Genus *Crateropora* (Levinsen, 1909)
Crateropora n. sp.

MATERIAL: Relatively common at the locality as sheet and patch-like colonies encrusting hard surfaces of lithic material and rhodoliths.

DESCRIPTION: Colony encrusting, multiserial, unilaminar. Individuals (zooids) are arranged in longitudinal rows, fairly large, oblong, longer than wide, typically 0.70–0.75 mm by 0.4–0.5 mm.

Extensive granular cryptocyst covers the frontal surface and ridges either side of the orifice/opesia. The frontal wall is relatively flat to slightly concave with an imperforate central area proximal to the orifice, and scattered small pores concentrated mainly toward distal margins of the zooid.

Orifice semicircular, 0.25 wide by 0.21 mm long, a slightly raised/thickened distal rim, sometimes rugose/bumpy, that extends laterally to become low cryptocystal ridges that taper along zooid margins. Proximally in the orifice is a prominent curved everted frontal lip.

Ovicells (brood chambers) are present in some zooids, small and immersed, with oval opening 0.11 x 0.09 mm, prominent (when present) in a hoodlike central position in the distal rim of the orifice. Also sporadic interzooidal avicularia are present in the colonies, these are elongate, almost as long as autozooids 0.55 x 0.1 mm.

REMARKS: Recent *Crateropora* are known mainly from Indonesia. The Waitiiti species is similar in morphology to the modern *Crateropora falcata* Levinsen, known from the Philippines and Kermadec region (Gordon, 1985), but with avicularia. Hence this probably represents a new species (Gordon, *pers.comm.*). Brown (1952) described a species from the Otaian Takaka Limestone, *C. muralis*, but this is possibly a Steginoporellid (Gordon *et al*. 2009) and is described as having a coarsely perforated frontal wall and more prominent extended cryptocystal ridges than the Waitiiti form, as do similar specimens from the Miocene of South Australia. There are obvious similarities with the related *Aspidostoma* spp., which occur as erect colonies from the New Zealand Cenozoic (Brown, 1952; Gordon & Taylor, 1999), and with the large zooids of encrusting *Steginoporella* spp., which can also appear similar in hand specimen without magnification. Scanning Electron Microscopy (SEM) allows us to distinguish these taxa more readily, especially characteristic features such as the shape of ovicells and avicularia (Fig. 3).

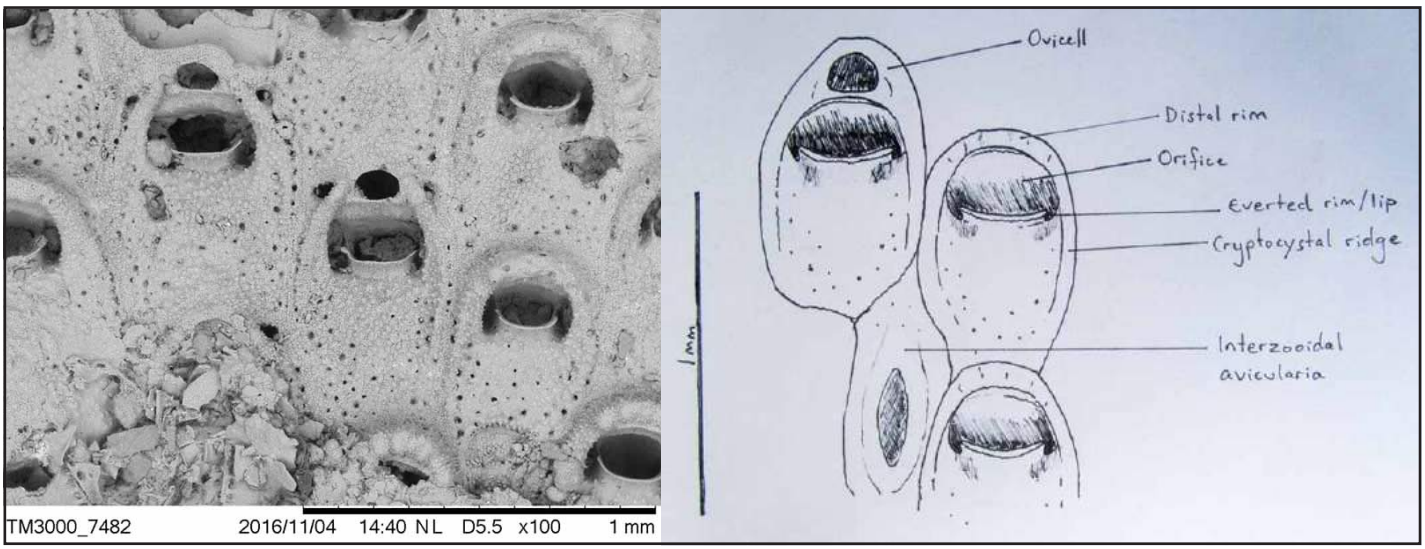


Fig. 3. SEM image and sketch of a colony of a rhodolith-encrusting bryozoan *Crateropora* n. sp. Scale bars = 1.0 mm.

Acknowledgements

Thanks to Dennis Gordon for SEM image and taxonomic advice, plus Diane Yanakopulos for assistance in the field.

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WHANGATEAU HARBOUR (OMAHA) DURING THE LAST INTERGLACIAL (125,000 YEARS AGO)

Bruce W. Hayward

Many previously unknown smaller landform features have become known as a result of the appearance of LiDAR contours for the Auckland region at a resolution of 0.5 m elevation spacing. Previously unrecognized volcanoes and Last Interglacial terraces are just two examples of features previously unknown. In this example, I was looking at the flat land (Omaha Flats–Point Wells) at the head of Whangateau Harbour, near Matakana, when I noticed landform features and contours that suggested that the harbour was once nearly double its previous size.

The Omaha Flats are a coastal terrace that was probably once intertidal harbour flats. It is mostly 4–6 m above mean sea level, which is slightly too high to have been formed during the middle Holocene high stand (6000–2000 years ago) when sea level was 1–2 m higher than present. Thus, it is most likely these were tidal flats during the Last Interglacial high stand (130,000–120,000 years ago) when sea level was up to 6 m higher than present (Hayward, 2017).

On examining the LiDAR contours over the flats, it is clear that the north-south section of Omaha Flats Rd was built along the crest of slightly raised linear ridge that is 1–1.5 m higher than the main flat area on either side (Fig. 1). This ridge extends north beyond the Point Wells road intersection, right up to the bank of the Omaha River estuary (Fig. 1). It also extends south, beyond the right-angle bend in Omaha Flats Rd, into an area of irregular, low, sandy hills that rise to 10 m above sea level (Fig. 2). The ridge is clearly a former sand spit that extended out across most of the harbour, like the much larger Omaha Spit does today (Fig. 2). It is anchored to the hills in the south through an area of former low sand dunes.

To test this interpretation of the LiDAR contours, I visited the eroding southern banks of the Omaha River estuary. The bank exposures show that most of the Omaha Flats are underlain by a thick deposit of sand (3 m + thick) and the terrace was clearly intertidal sand flats. The sand is compacted and partly cemented by oxidation of iron minerals that give the sand a rusty orange colour. This level of compaction and oxidation is not usually found in Holocene sand deposits but is prevalent in Last Interglacial and older deposits that have had tens of thousands of years beneath forest cover. At the northern tip of the ridge, the sand extends all the way up to the crest, confirming that it is an old sand spit and not a shell bank or other feature (Fig. 3). At this locality, the deeper parts of the sand deposit are less oxidized and can be seen to be composed of laminated quartz sand with stringers of black titanomagnetite sand (Fig. 4), similar to that

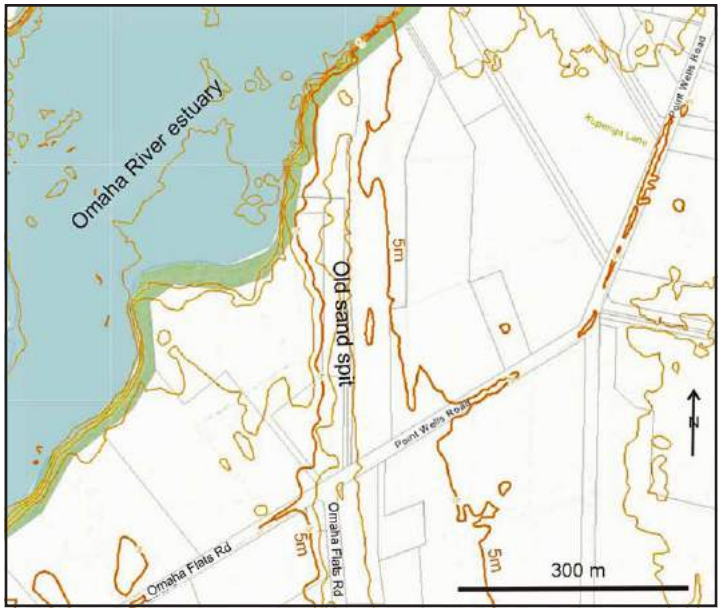


Fig. 1. 1 m interval contour map of part of Omaha Flats showing the northern end of an inferred sandspit, rising 1–1.5 m above the background level of the flats (4–5 m above mean sea level).

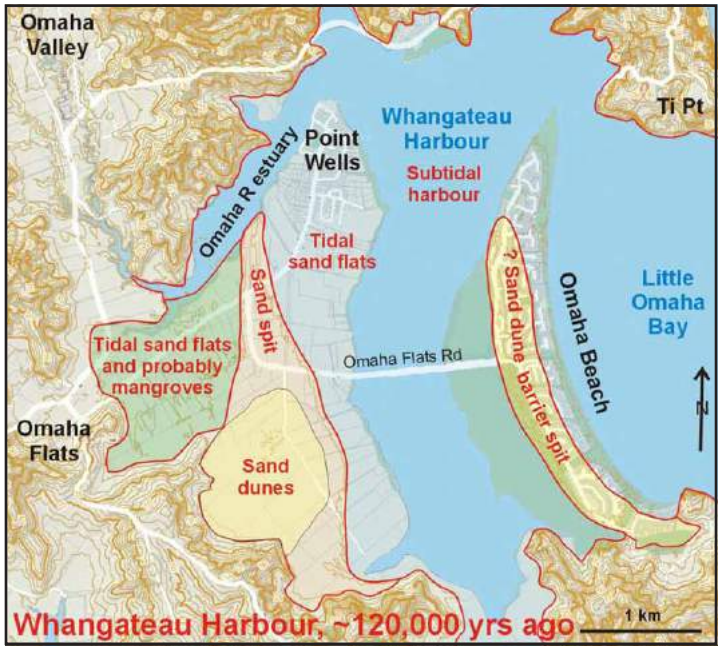


Fig. 2. Map showing inferred paleogeography of a much larger Whangateau Harbour during the Last Interglacial sea-level high stand about 125,000 years ago.

seen in the well-dated Last Interglacial beach and shallow subtidal sand at One Tree Point, Whangarei Harbour (e.g. Hayward, 2016). The Omaha River bank laminated sand also has a few trace fossils similar to those seen at One Tree Point (Fig. 4).

Thus, all evidence seems to confirm that the Whangateau Harbour was twice its present size during the Last Interglacial high stand, about 125,000 years ago (Fig. 2). The Omaha Flats area was an extensive intertidal sand flat and a low sand spit was built across it from the southern shore. Whether at that time there was an early version of the Omaha Spit similar in size and location to the present one is unknown, but boreholes could test this.

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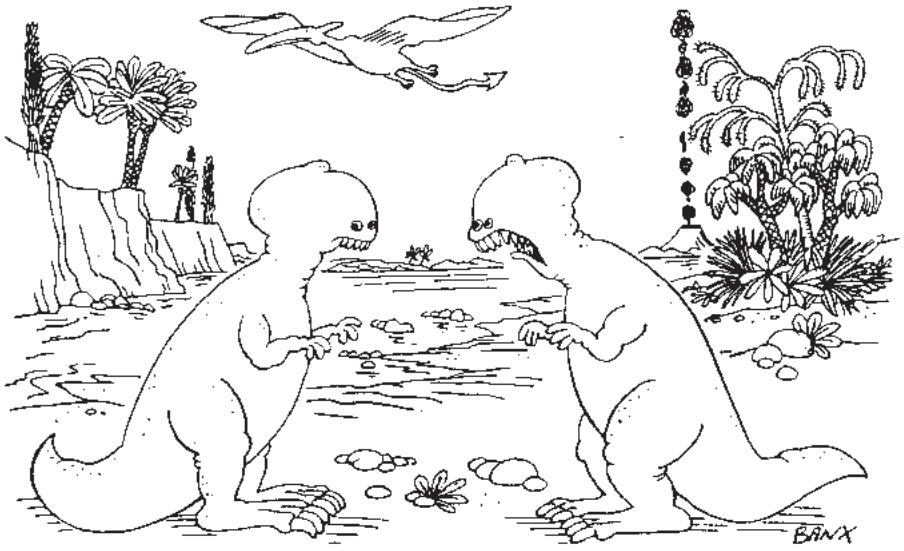


Fig. 3. 4 m-high eroding bank (6 m above mean sea level) of consolidated and weathered sand at the tip of the inferred Last Interglacial sand spit on the south shore of Omaha River estuary.



Fig. 4. 60 cm-wide photo of laminated beach sands with erosion, lensing and burrows exposed in the lower part of the eroding bank of Omaha River estuary beneath the highest point of the inferred old sand spit.

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Fossilisation I don't mind – it's carbon dating I dread."

THE ANISEED VALLEY COPPER SMELTERS AND SOME OPHIOLITE GEOLOGY

Malcolm and Ian Simpson

The Roding River and what remains of the Aniseed Valley Copper Smelters provide a fascinating day trip to view a combination of ophiolite geology and industrial history.

The Permian ophiolite belt of mafic and ultramafic rocks responsible for the magnetic anomaly runs from North Cape to Fiordland and outcrops prominently south east of Nelson at Dun Mountain. Dun Mountain is mostly made up of olivine peridotite. Dunite, named by Ferdinand von Hochstetter in 1859, contains 90% olivine with a low percentage of other minerals such as pyroxene, chromite and magnetite. Copper is dispersed in the structure of pyroxene, but is physically excluded with other minerals when dunite weathers to serpentinite, which accounts for the finding of copper ore deposits in the mineral belt in the 1850s.

Nelson, in the mid nineteenth century, was not wealthy and the lure of wealth from minerals was very strong. The outcrops of copper and chromite ore led to the formation of the Dun Mountain Company. When Hochstetter visited Nelson at the behest of the Provincial Council he stated that there were no significant lodes of copper, but that chromite might be a profitable alternative. A 20 km horse drawn railway was constructed from the port to a saddle on Dun Mountain and chromite was exported at a time when prices were high, between 1862 and the 1880s. Chrome was used for dyes and later in tanning and in steel making.

Three mines in the tributaries of the Roding River, the Champion, United and Monster mines, had promising surface lodes of copper ores including some native copper, which led to capital investment for mining, tramways and copper smelting between the 1880s and 1910.

The first smelter was built in the 1880s by the Champion Copper Mining Company and with difficulty the company produced a small amount of copper before the venture became non-viable because of low copper prices. Many local shareholders lost a lot of money on partially paid up shares and it was a financial disaster for Nelson. The first smelter used roasting stalls made from local limestone to calcine the ore to reduce impurities. The process was very slow and took two weeks. Calcine is a mixture of solids, including copper oxides, sulphides and sulphates. The calcine was then heated to 1200 degrees C with silica and limestone in an imported water-cooled furnace to produce impure matte copper. Rata wood and coal were used for heating and a Pelton wheel-driven fan for the blower. Forest fires burnt the site twice after closure and much of the smelter materials were sold off.

A Christchurch syndicate purchased the assets of the Champion Copper Mining Company. The two principle investors were Messrs Schwartz and Smythe. Schwartz

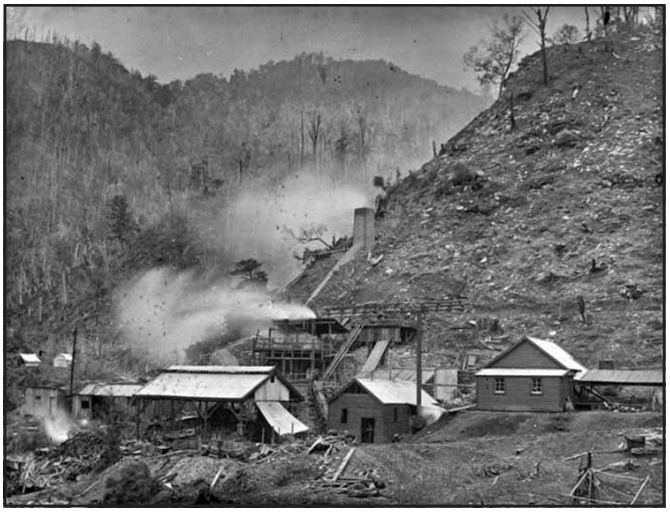


Fig. 1. Maoriland Copper Mining Company smelter circa 1907. Fumes are coming from the roasting pots. The reverberatory furnace is in the open shed and is vented to the chimney.

was a land agent but Smythe had had mining experience. In 1907. the now named Maoriland Copper Company built another smelter on the same site (Fig. 1). They used iron pots to produce the calcine and this process now only took a few hours because of an improved process using a cold air blast. The Company made use of new knowledge about the pyritic smelting process in a reverberatory furnace to produce the matte copper. In this process, pyritic ores are smelted with little or no fuel by utilizing the heat resulting from the combustion of the pyrite's sulphur content. A 45 hp producer gas engine using coke and charcoal was used to drive the smelting blowers (Anonymous, 1908; Rickard, 1905; Johnston, 1987).

Some ore was smelted in 1908 and then the mines and smelter were abandoned by the syndicate. By then Schwartz and Smythe had sold all of their 90,000 one-pound shares. Smythe had been in charge at the mines and the smelter and must have been aware from assay results (which he kept secret) that there was insufficient quality ore for the business to be sustainable. It was an inside trader swindle, but not unlawful at the time.

The copper mining ventures were a failure because there was insufficient quality ore (Fig. 2). The surface outcrops had a high percentage of copper, but the seams were variable and scattered and had low percentage ores. Much money was spent before the limited extent of the quality ore was determined.

In 1946, Malcolm Simpson reported in a diary that he accompanied John Tait, a Nelson College master, exploring the Roding River site of the copper mining relics. Access

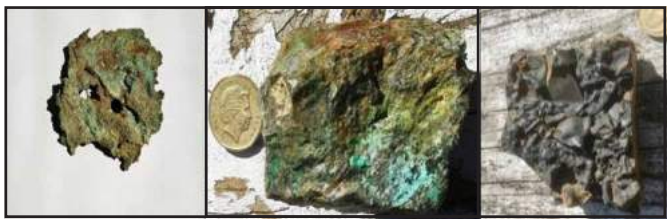


Fig. 2. Smelter site specimens (from left to right)
(1) matte copper fragment from furnace,
(2) serpentinite ore with malachite and cuprite staining,
(3) Slag from furnace.



Fig. 3. Sketch of smelter site with chimney and roasting pots and hoods 1946-7 as compared with 2018 with the chimney just seen in shadow behind trees on top just left of centre. Since 1947 the water-cooled furnace from the first smelter has been erected on the site (lower right).

by road from Nelson City was the quickest way, but denied to them. Petrol rationing and lack of vehicles due to WW2 severely curtailed travel, resulting in walking or cycling. A tunnel, running 2.7kms south from Poorman Valley (near Stoke) to the Roding River, had been driven in 1941 to carry piped water captured from a weir to link up with Nelson City Waterworks. Permission was sought and granted to enter the tunnel, which debouched a few kilometres downstream from the copper smelter.

Although a feasible means of gaining the Roding River smelter within a day, when the keys were returned the Tunnel Supervisor withdrew any future entrance. Obviously, he was concerned about safety and liability.

A year later, Malcolm was a member of a party of some 15 students, led by John Tait, who repeated a trip to the Roding River. Cycling to the Brook St road end, the group ascended Jenkins Hill 775 m to cross the Barnicoat Range. They then entered the beech forest and following a disked trail down a southerly-trending spur, reaching the Roding close to the tunnel portal. This trip was longer than the previous year and included two climbs of 750 m, but visually more attractive than 5.4 km of tunnel. On one of these trips, Malcolm did a quick sketch of the smelter site and chimney (Fig 3).

In 2019, 72 years later, there is a network of tracks and access by road opens up more time to explore this interesting area.

The easiest access to the Roding and the site of the two smelters is from the Aniseed Valley road from Highway 6 between Richmond and Brightwater. From the road end car park the smelter site is reached by a walk of about one and a half hours up the Roding River which entails three easy river crossings if there has not been recent heavy rain (Fig 4).

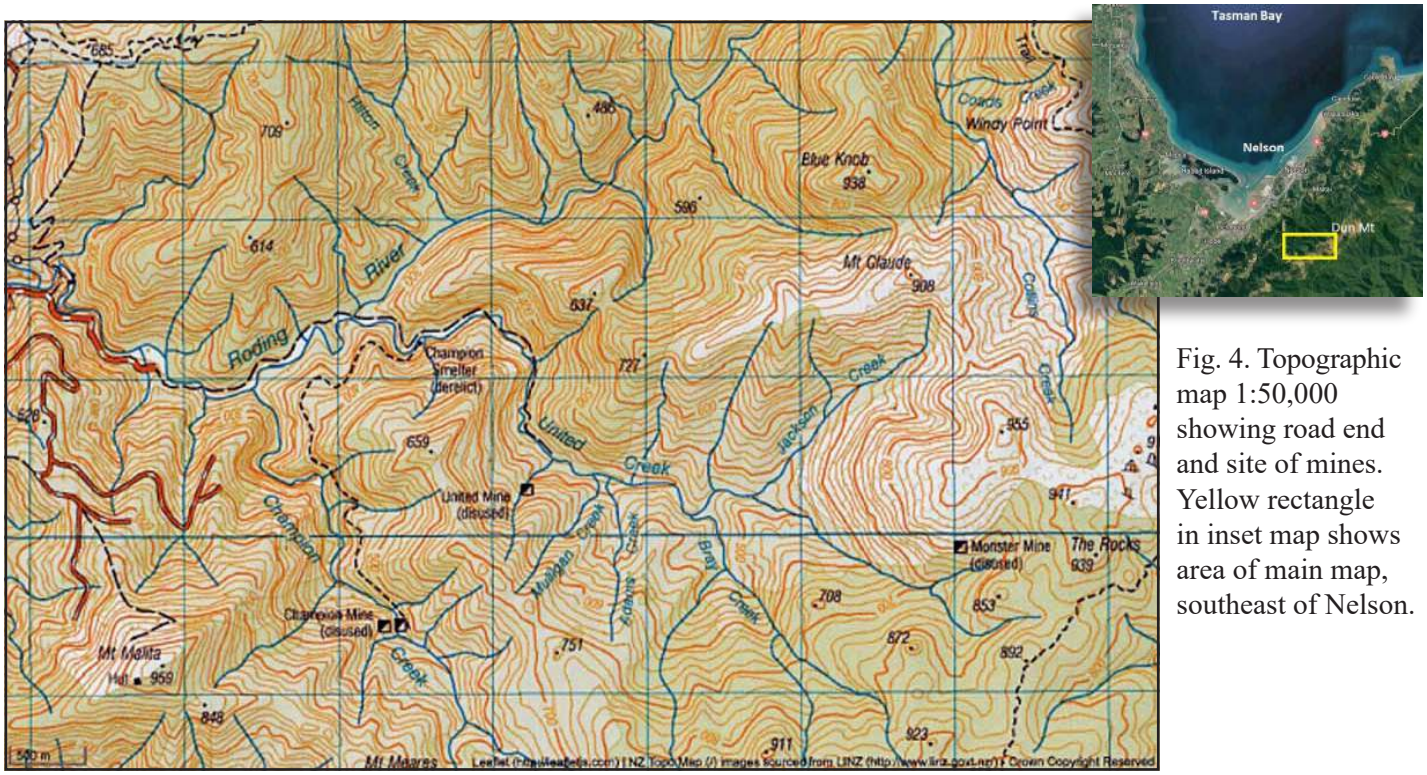


Fig. 4. Topographic map 1:50,000 showing road end and site of mines. Yellow rectangle in inset map shows area of main map, southeast of Nelson.

The road and track from the car park passes the Roding weir and provides plenty of opportunities for collection of specimens from the ophiolite of the Nelson Mineral Belt. One expects to find rodingite in the Roding River. Rodingite was named by Bell and Marshall in 1911. It is metasomatised mafic and sedimentary rock produced under the action of alkaline, calcific fluids associated with the ultramafics, and is sometimes found as dikes enclosed by serpentinite. It is made up of hydrogrossular garnet, calcic-clinopyroxene and other minerals, but is variable and always has a high calcium and low silica content. The samples in Fig. 5 are very hard (Mohs 6-7) and would have been coarse grained gabbro before serpentinisation.

Today the smelter site has the remains of the smelting furnace chimney, the roasting pots and hoods, the limestone supporting walls, a large waste pile and patches of slag. There is also the water-cooled furnace from the first smelter which was never removed (Fig. 6).



Fig. 5. left hydrogrossular garnet; right more typical appearance of rodingite.

The energy and innovative engineering of the men of the Roding copper mines and smelters has mostly been forgotten, but is a rich part of our history and deserves our recognition. Like all history, it may inform us on the decisions we make today.

Acknowledgements
We would like to thank Ross Ramsay and Mike Johnston for assistance with the identification of the rodingite.

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Fig. 6. Roasting pots and remains of Chimney.

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AN ENIGMATIC SEAL FOSSIL FROM KAI IWI BEACH

Hugh R. Grenfell and Malcolm S. Simpson

In September 2008, Malcolm visited Kai Iwi Beach on the Whanganui coast to take another look at coastal exposures of the Castlecliffian (Pleistocene), Lower Kai Iwi Siltstone (Fig.1). He found some interesting and rare fossils (FRF No. R22/f0290).



Fig. 1. Location of Kai Iwi Beach.

Seal fossils are very rare in the New Zealand fossil record. While seal bones are often found in geologically "young" dune deposits, their stratigraphic and/or archaeological status is usually not well defined. In other words, are they really fossil? Fleming (1968) summarised those fossils then known, based mostly on the work of Dr J.A. Berry. One of them, the "Ohope Skull", was later written up by King (1983a) and then again by Churchill and Boessenecker, (2016). Worthy (1992) described numerous seal fossils from cave deposits of the Paturua area, south of Whanganui Inlet, northwest Nelson.

In 1886, James Park recorded that S.H. Drew collected four dorsal seal vertebrae from railway ballast pits in the Butler's Shell Conglomerate (Castlecliffian) near Kai Iwi. These were later considered by Dr J.A Berry to likely belong to *Arctocephalus forsteri* (the New Zealand fur seal) (Fleming 1952, 1968).

The Whanganui coastal sections are famous for their rich invertebrate faunas, and while Malcolm found plenty of those, the fossils described here were definitely not invertebrate and very rare (Fig.4). He collected 3 fossils closely associated and this article focuses on the most distinctive one because the rib fragments are not very diagnostic. Over the years, Malcolm had shown the fossils to others, but had no luck determining what they were. Because I (HRG) like a challenge, and one of the fossils had a very distinctive shape, I decided to try to identify it for him (Fig.4). On inspection, they were clearly vertebrate bone. This then raised the question: is it a marine and/or terrestrial vertebrate – avian or marine mammal (bird, whale, dolphin or seal) bone?

Fortunately, acting on instinct, I decided to go down the marine mammal path first and began searching. At the same time, I tried to contact researchers working on fossil marine mammals. Unfortunately, I had very little response from all researchers apart from Alan Tennyson (Curator of Vertebrates at Te Papa), who was very helpful and later able to confirm my identification.

So I started to search the literature and the interweb for any images of Recent articulated marine mammal skeletons. Looking at the specimen, I decided early that it had to have some relationship to an articulated series of bones (the large flattened, "jointed" base) and that it had approximately central attachment points for a symmetrical pair of something being attached, ? ribs. This helpfully ruled out quite a few bones such as limbs and appendages.

Finding the fully articulated skeleton of a Californian sea lion and similar images online finally clinched it for me. The bone in question is called the manubrium. It is the last bone forming the superior part of the sternum and has attachment points for ligaments, which can be clearly seen in the articulated sea lion skeleton (Fig.2). We have one too, although not quite as spectacular. *[Ed. – in humans, it makes up the top third of the sternum or breastbone.]*



Fig. 2. Articulated Californian sea lion skeleton and close up of the manubrium showing the ligament attachments (light grey colour). Photo courtesy of Museum of Osteology, Orlando, Florida.

This made it important to look at skeletal material from Southern Hemisphere pinnipeds living today, such as members of the Otariidae (eared seals) – the New Zealand or Hooker's sea lion (*Phocarctos hookeri*) and the New Zealand fur seal (*Arctocephalus forsteri*), and the Phocidae (true seals) – the Leopard seal (*Hydrurga leptonyx*). In otariids, the length of the manubrium is increased by a bony anterior extension at the point of attachment of the first pair of ribs. But in phocids, such as *Hydrurga leptonyx* and the walrus, the length of the manubrium is apparently increased by cartilage (King, 1983b). Since cartilage is not preserved, I was most likely dealing with an otariid seal fossil.

The entire Auckland War Memorial Museum, Land Vertebrate Department bone collections were searched for comparative material from Recent New Zealand pinnipeds. Unfortunately only limited *Arctocephalus forsteri* material with the manubrium present was found (Land Vertebrate Collection numbers LM484, LM747 and LM748). One of them was usefully a juvenile. It would be nice to have seen comparative material from the other otariid *Phocarctos hookeri* and the phocid *Hydrurga leptonyx*.

This is not intended to be a taxonomic article, but we can make limited comparisons with the *A. forsteri* material seen (Figs 3, 4). Although somewhat worn or abraded the fossil is well preserved. The fossil manubrium is comparable in size to an adult *A. forsteri* manubrium. Superficially the fossil is more "robust" than the Recent being generally broader and thicker in section. It is also more "bladed" down its length. It might be due to damage but the dorsal end of the fossil is not spatulate like the Recent specimens.

While the conclusions drawn here are limited this is first record of a fossil seal manubrium in New Zealand. The adult fossil manubrium probably represents a new Pleistocene species of the Otariidae. If King (1983b) is correct about the manubria of phocid seals we can likely rule them out. In any case a generic (and species) assignment is not possible for now without more comparative Recent material from *Phocarctos hookeri* and possibly other Southern Hemisphere otariid seals such as the Antarctic fur seal (*Arctocephalus gazella*), the sub-Antarctic fur seal (*Arctocephalus tropicalis*) and the Australian sea lion (*Neophoca cinerea*).



Fig. 3. New Zealand fur seal (*Arctocephalus forsteri*) manubrium (LM747, Auckland War Memorial Museum, Land Vertebrate Collections).

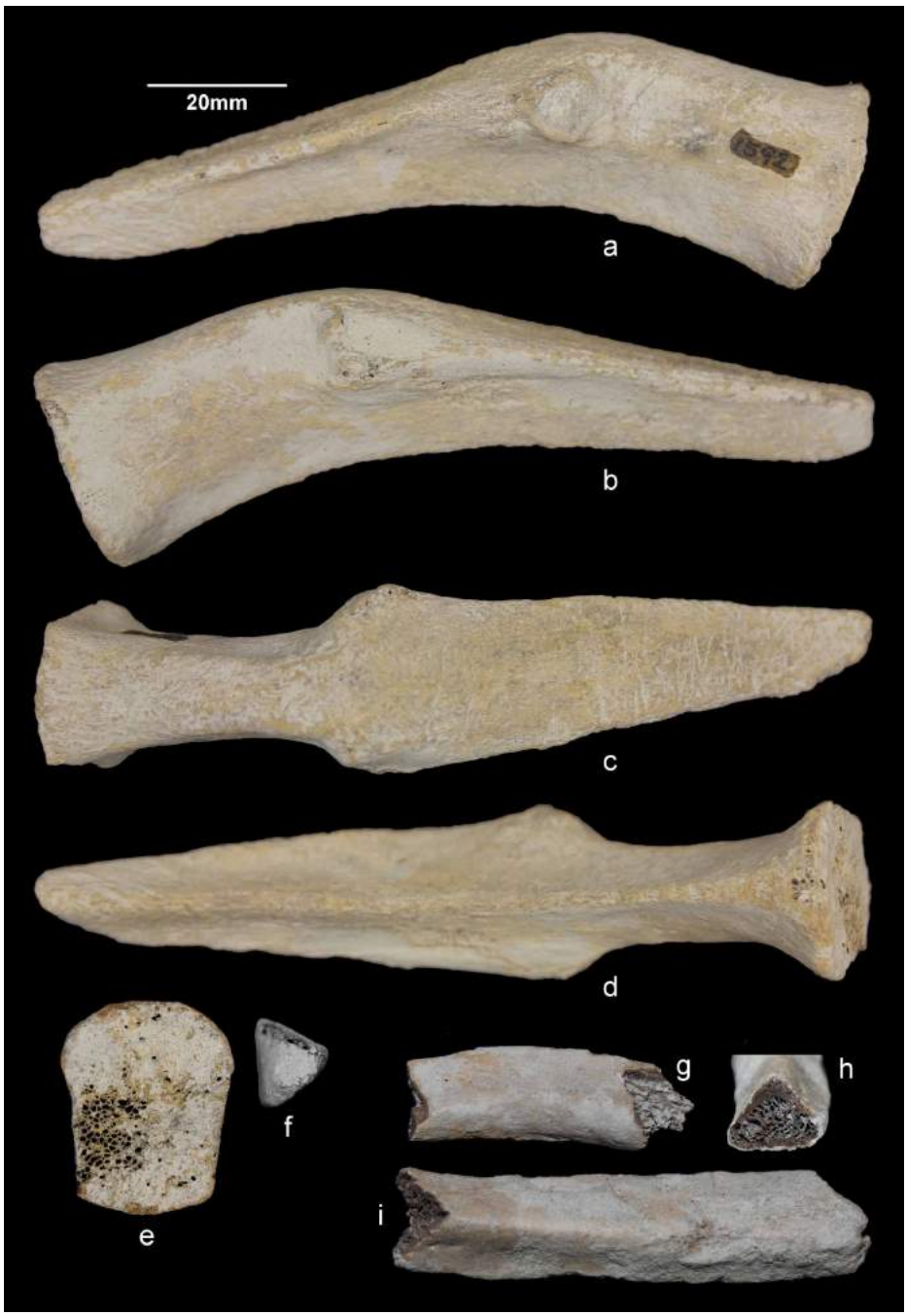


Fig.4: Various views of LM1592 fossils (Auckland War Memorial Museum, Land Vertebrate Collections). manubrium a-f, e basal view, f view of tip; rib fragments g-i (h cross section of g).

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ORIGIN OF THE BLACK SANDSTONE AT ONE TREE POINT, WHANGAREI HARBOUR

Bruce W. Hayward, Wendy Goad, Ross Ramsay and Andrew Clark

Introduction

Twenty-six members of Auckland Geology Club visited One Tree Point on the south shore of Whangarei Harbour (Fig. 1) in May 2019. We were primarily looking at the subtidal through intertidal to subaerial dune sand sequence and evidence for higher sea levels during the Last Interglacial (Nicol, 2002; Hayward, 2016). The sedimentary features and trace fossils within the uncemented intertidal sandstone are highlighted by the presence of laminae of black, titanomagnetite sand within the more abundant white quartz sand (Figs 1, 2; Gregory and Campbell, 2005). These cliffs expose an erosional face through a series of Last Interglacial sand dune ridges with thin lenses of peat on top of them. There is another belt of sand dune ridges of Holocene age 1–3 km seaward of these older dunes. During the Holocene, an extensive peat swamp existed between the two sand dune belts. This peat swamp is now drained, but thick peat underlies a swathe of flat, low-lying land south and inland of One Tree Point (Edbrooke and Brook, 2009).



Fig. 1. Google map of northern half of Bream Bay's prograded foreland barrier showing location of the One Tree Point cliff section immediately west of the boat ramp where the unusual black-stained sandstone occurs. Note the linear beach ridge lines.

Observations

The low cliffs, extending for about 100 m west from the boat ramp, are composed of more cemented and weathered or case-hardened sands (often tinged orange by iron oxide weathering; Fig. 3) than those forming the higher and fresher bluffs a further 100 m to the west. Initially we were perplexed by the dark, in places black, colour of the seemingly quartz-rich sands below high tide level in the more cemented cliffs near the boat ramp (Fig. 4). It was tempting to think that black colour was also from titanomagnetite grains, but the sands here were non-magnetic and the sand grains appeared to be quartzose.



Fig. 2. Laminae of white quartz and black titano-magnetite in the upper part of the Last Interglacial high-tidal beach facies, highlight the sedimentary features and trace fossils.

Upon closer examination it was clear that the black colouration was not a primary sediment feature, as the colouration cut across sediment packages. The upper limit of pervasive blackness approximated extreme high tide level through all these cliffs. Close observation suggested that the blackness was derived from fine black organic matter deposited between the sand grains. In one small point of more-cemented sand there were numerous irregular (in places branching) black veinlets of organic mud (up to 1 cm thick) intruding these black-stained sands (Fig. 5).



Fig. 3. The low cliffs 0–100 m west of the One Tree Point boat ramp are made of dark-coloured (lowest part), and orange iron-stained, weakly cemented sandstone. The higher black horizons are rich in magnetic titano-magnetite grains.



Fig. 4. Cliffs 50 m west of the One Tree Point boat ramp showing the lower black-coloured sandstone the nature of which caused considerable initial debate.



Fig. 5. Veinlets of black organic silt intruding weakly-cemented sandstone at about high tide level, about 100 m west of One Tree Point boat ramp.
Width of photo 50 cm.



Fig. 6. The nature and origin of the black-coloured quartz sand at and below high-water mark (lower one third of the photo) west of the boat ramp at One Tree Point caused considerable discussion amongst the visiting Geoclubbers.

Hypothesis

We infer that:

1. The fine organic matter that has infiltrated and stains the sand in the intertidal part of the cliff (Fig. 6) and fills the unusual black veinlets (Fig. 5) is derived from the thick Holocene peat inland to the south.
2. The organic matter has been transported up to 2 km through the highly permeable Last Interglacial sands by flowing groundwater. The elevation of the top of the groundwater would have been controlled near the coast by the tides, with the freshwater flowing through and out of the cliff sands in the intertidal zone (up to extreme tide level) when the tide was out.
3. Some of the organic matter has been trapped in the Last Interglacial sands or bound in with the oxidized iron oxide, resulting in the dark or black colouration of the originally white, dominantly quartz sand.
4. The movement of this organic-rich groundwater could have occurred only during the mid-late Holocene (about the last 5000 years) after the peat had started accumulating and after sea level had returned to near its present level after the end of the Last Ice Age.
5. Migration of, and cementation by, organic derived material has been documented elsewhere in Northland – Molloy (1988) notes that areas of old coastal sands have often developed podzol profiles under former kauri forest. In these places, organic-rich topsoils pass into leached E horizons. Below this white podzolised layer, sand grains have become cemented together by the migrating humic and aluminium compounds.

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