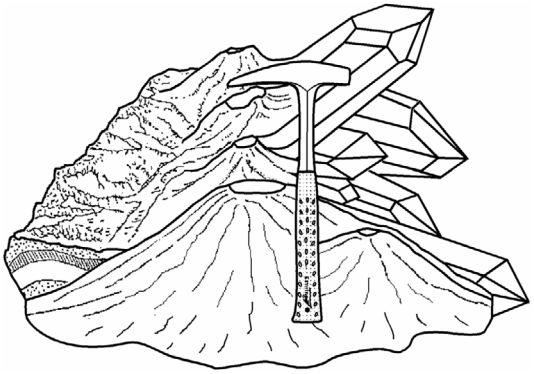


Geocene

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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.

Please contact Jill Kenny <jill.kenny_at_xtra.co.nz> (substitute @ for _at_)

FIRST MACROFOSSIL FOUND IN THE CAPLES TERRANE OF THE NORTH ISLAND – A PERMIAN SEA LILY

Bruce W. Hayward, Liz Hoskins and Mike K. Eagle

In November 2016 a group of 38 Geoclubbers were touring Northland looking at examples of most of the different kinds of rocks. The only easily accessible place to see the Caples Terrane rock types was in the dry gravel banks in the bed of the Waipapa River adjacent to the picnic area at the end of Forest Road (Fig. 1). This locality (NZ Fossil Record Number P05/f298) is at the mouth of the Waipapa River gorge where it emerges from the Omahuta-Puketi Range. All of the catchment of the Waipapa River drains from the Puketi Range, which is predominantly composed of mapped Caples Terrane basement volcanic greywacke suite with a minor amount of overlying late Eocene sedimentary rocks (Edbrooke and Brook, 2009). In the middle of the range the Waipapa River is joined by the Mangapa River, which flows right through the uplifted Omahuta-Puketi basement block from north to south. North of the uplifted Caples block is late Eocene in-situ Te Kuiti Group sedimentary rocks overlain by various Cretaceous to Oligocene displaced rocks of the Northland Allochthon (Brook *et al*., 1988).

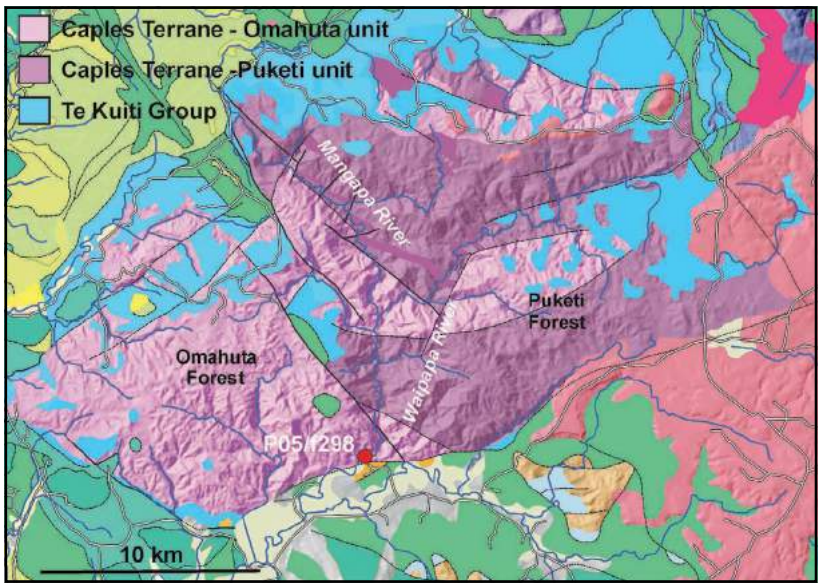


Fig. 1. Location of the fossil crinoid find in river gravels at the mouth of the Waipapa River Gorge. Base map is modified from GNS QMap geology.

In the gravel, Liz Hoskins found a small rounded pebble containing unusual circular shapes a few mm across (Fig. 2). She showed the specimen to Bruce Hayward who recognised that it was something different, as macrofossils have not been recorded from these Caples Terrane rocks before. He took it home to examine under a microscope, where it became apparent that the pebble was composed of plates and ossicles of a fossil sea lily (crinoid). At this point the specimen was passed on to crinoid specialist, Mike Eagle, to examine and see if he could identify it and perhaps get some idea of its age.

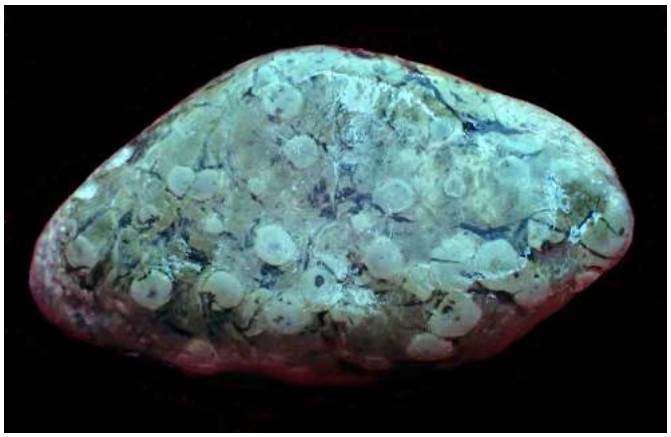


Fig. 2. Photograph of the pebble containing our fossil cladid crinoid of Permian age.

Geology of the Omahuta-Puketi forest blocks (Waipapa horst)

Geochemical, petrographic and zircon studies (Jennings, 1991; Black, 1994; Adams *et al*., 2009, 2013) have shown that this uplifted block (horst) of basement rocks differs significantly from the basement rocks of east Northland and Auckland (Waipapa Terrane). The Omahuta-Puketi rocks lie between the Junction Magnetic Anomaly (Dun Mountain Ophiolite Belt) in the west and Waipapa Terrane (Torlesse equivalent) in the east – a tectonic setting analogous to that of the Caples Terrane in the South Island, with which they have been correlated (Black, 1994; Isaac, 1996; Edbrooke and Brook, 2009). Jennings (1989) mapped the area and divided it into a western Omahuta unit of interbedded volcanic-rich greywacke sandstone and argillite with rare conglomerate and breccia horizons, and an eastern Puketi unit consisting of massive basalt, basalt pillow lava, red and green tuffs, siliceous argillite, chert and minor mudstone and sandstone (Jennings, 1989, Edbrooke and Brook, 2009). The Waipapa River gorge cuts through both Omahuta and Puketi units and thus our fossil could be from either.

These Waipapa horst rocks have been metamorphosed in the Jurassic to prehnite-pumpellyite and pumpellyite-actinolite facies (Black, 1994), probably during deep burial associated with collision and suturing of the Caples Terrane to Gondwana.

The fossil crinoid (sea lily)
The rounded 4 cm x 3 cm x 3 cm pebble consists of partly crushed plates of the calyx (cup) and disarticulated ossicles of its single arm and arm brachials. Close examination suggests it probably belongs to the late Paleozoic crinoid order Cladida, which has a global age range of Carboniferous to Permian. A fuller description is to be published elsewhere by MKE. If the identification is correct, this is the first fossil cladid crinoid recorded from New Zealand. Cladid crinoids are inferred to have lived attached by a stem to a hard substrate on the sea floor in relatively shallow water (?shelf depths of 0–100 m). This important specimen will be lodged with the National Fossil collection at GNS Science, Lower Hutt.

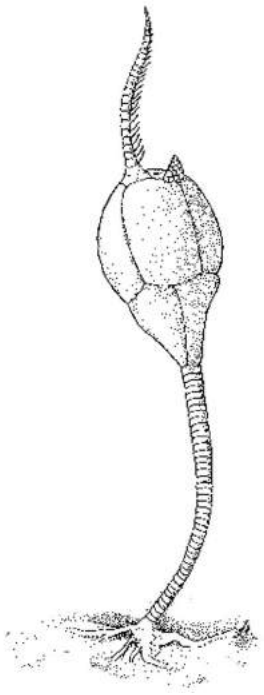


Fig. 3. Example of a reconstructed single-armed cladid sea lily. Adapted from Ausich *et al*. (1999). Height about 12 cm.

Age of Caples Terrane in Northland
No macrofossils have previously been recorded from the Caples Terrane in Northland and rare macrofossils of Permian to Jurassic age have been recorded from Northland and Auckland's Waipapa Terrane. Cherts within the Puketi unit have yielded poorly preserved radiolaria of late Paleozoic (Permian) to possibly early Mesozoic age (R. Hori in Black, 1994).

Studies of the ages of detrital zircons in the sediments of one sample from the Omahuta unit on Kauri Sanctuary Rd showed a dominance of zircons of late Triassic age (220–230 myr) and a few of late Permian age (290 myr) (Adams *et al*., 2009). The younger zircons were inferred to be derived from contemporaneous volcanism and to indicate a late Triassic age for these rocks – they certainly cannot be older. Most Caples Terrane sedimentary rocks in New Zealand that have been dated by zircons appear to be Triassic (Adams *et al*., 2009), but the terrane is still generally considered to range in age from Permian to Triassic (e.g. Mortimer and Campbell, 2014).

Paleoenvironment
Geochemistry of the Puketi unit basalts shows they are part of a tholeiitic oceanic andesite association, quite distinct from basalts in other basement rocks in northern New Zealand, and are inferred to have accumulated in an oceanic rifting environment similar to the present day Galapagos Rift (Jennings, 1991; Black, 1994). The dominant late Triassic zircons in the Omahuta unit sample have been inferred to be derived from contemporaneous Caples volcanism along the plate boundary at the edge of Gondwana (Adams *et al*., 2009).

Conclusions
The limited age information suggests that the Omahuta unit may be younger (late Triassic) than the Puketi unit (late Permian) and if this is correct, then our Permian crinoid most likely was derived from the older Puketi unit. This age dichotomy is similar to the situation in the Waipapa Terrane of northern Northland, where the ocean-floor basalts and associated chert are late Permian–early Triassic in age and the overlying terrigeneous greywackes and argillites are middle-late Triassic (Spörli *et al*., 2007). Both situations are suggestive of eruption of the basalts at mid-ocean spreading centres or rifts with the slow accumulation of oceanic sediment (chert, multi-coloured argillite) on top of them as they were rafted along by seafloor spreading towards the edge of Gondwana. As they came close to the eroding edge of Gondwana in the late Triassic, terrigeneous sediment (Omahuta unit) accumulated on top of them before they collided with, and were sutured onto, the side of the supercontinent.

In the Waipapa Terrane, all the chert, multi-coloured argillite and terrigeneous greywacke and argillite are accepted as accumulating at considerable water depths – bathyal or abyssal (probably >500 m water depth). The one anomaly is that the Marble Bay pillow basalt is associated with carbonate sediment containing fossil reef corals and large fusulinid foraminifera. These two fossil groups are believed to have hosted commensal photobionts (photosynthesising algae) like their modern counterparts, and therefore would have lived in the photic zone at water depths no greater than 100 m. Thus we infer that some of the ocean rift basalts erupted to form seamounts that rose to shallow depths or even formed islands (like the Galapagos, Azores or Iceland do today). Thus a similar setting may explain the presence of our cladid crinoid in with the basalt lava flows of the Puketi unit, although marble or limestone have not previously been recorded from the Omahuta-Puketi Range.

Caples Terrane has also been recognised geochemically and petrographically from other Northland and Auckland localities at the western end of a number of basement greywacke blocks west of Whangarei, at Taipuha, Waipu Gorge and Pokeno (Adams *et al*., 2009). No obvious major terrane boundary or fault has been mapped or hypothesised separating these localities from Waipapa Terrane. Now, with the similarity in age range and lithologic

associations of the Caples and Waipapa terranes, one might ask whether the two terranes in Northland may not be combined, with the Triassic Caples terrigeneous association being deposited more proximal to volcanism on the edge of Gondwana than the Waipapa terrigeneous sediments were.

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ELEVATION OF LAVA FLOW QUENCH ZONE CONFIRMS TECTONIC STABILITY OF NORFOLK ISLAND

Bruce W. Hayward

Norfolk Island pokes out above the waves at the north end of the Tasman Sea, midway between North Cape and New Caledonia. Norfolk Island, and its two small offshore islets, are the only parts of a large compound basalt volcano that protrude above sea level at the present time. The 6 km-diameter Norfolk Island is near the centre of a 100 x 25 km flat-topped plateau that is nowhere deeper than 200 m (Fig. 1). The plateau rises ~750 m above the crest of the Norfolk Ridge, on which the predominantly submarine volcano has been built. The top of Norfolk Island is 320 m above mean sea level, which gives a minimum elevation for the volcano of 1000 m. It is probable that all the top of the plateau was once capped with a much higher basalt volcanic island or islands, but since their eruption they have been eroded away by the waves.

Basalt lava flows outcropping around Norfolk Island indicate two periods of local eruption at 3.1 myr ago (east end) and 2.6–2.3 myr ago (most of the island)(Jones & McDougall, 1973). The full age range of the Norfolk Island volcanic plateau is unknown, although shallow-water

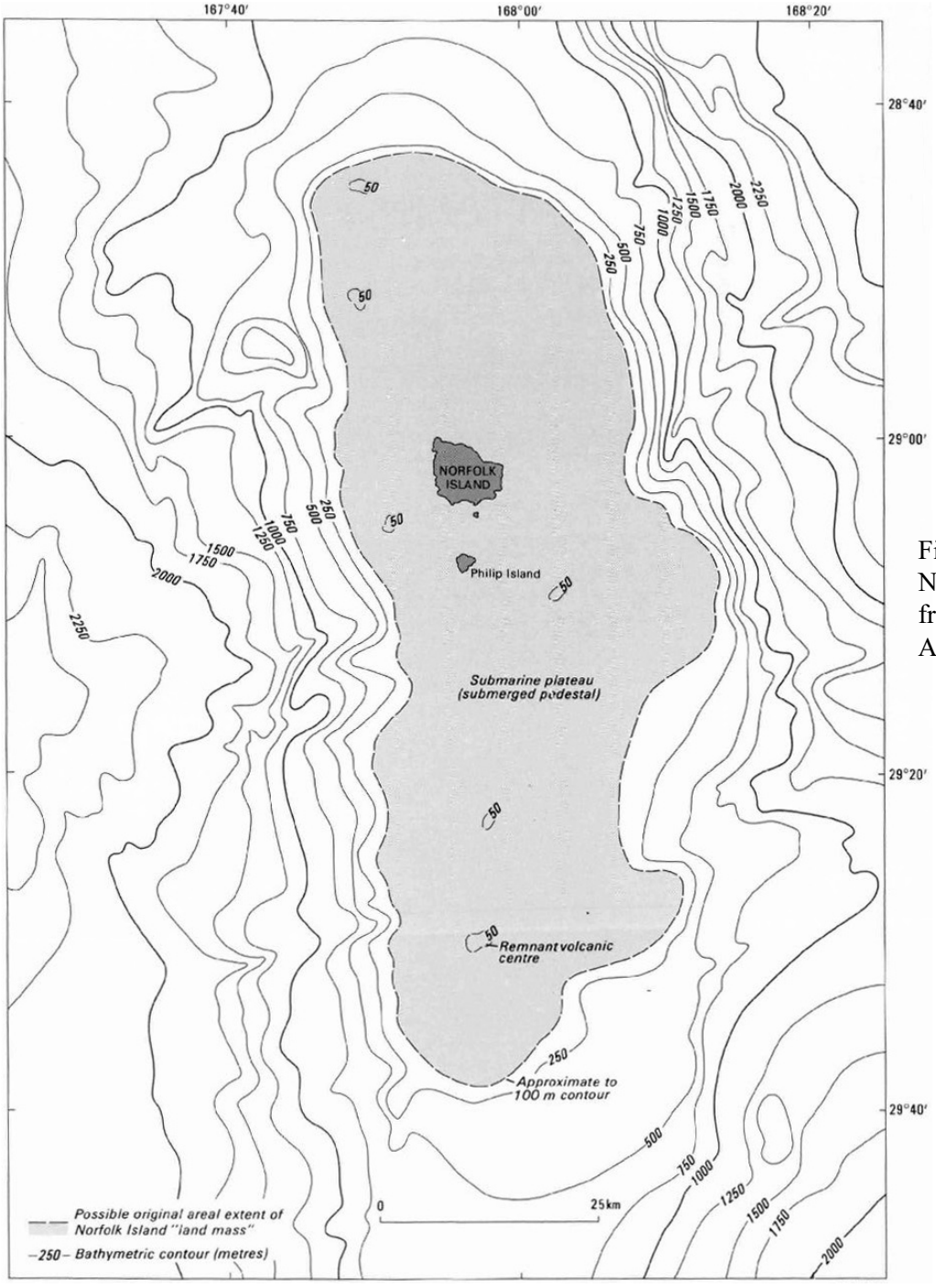


Fig. 1. Bathymetric contour map of Norfolk Island plateau. Simplified from Main & McKnight (1981) by Abell & Falkland (1991).

foraminifera of early Miocene age have been recorded from limestone inclusions in tuff on Philip Island (Coleman & Veevers, 1971). The two small offshore islets are Nepean Island, which is composed of cemented dune-bedded calcareous sandstone of Pleistocene age, and Philip Island, which is the eroded remnants of several Pliocene basalt eruption centres, with scoria, tuff, lava flows and intrusives (Jones & McDougall, 1973).

In November 2015, a group from Auckland Geology Club spent 7 days on Norfolk Island and visited many different outcrops that were easily accessible from the land. The most instructive exposures (Fig. 2, coastal section A), however, were seen on our first day, when we took advantage of calm weather to circumnavigate all the islands in a 7 m power boat.

Basalt flows dominate in the cliffs (Fig. 2), but lenses of tuff occur within the sequence in several places (Jones & McDougall, 1973). Most of the basalt exposures we saw on Norfolk Island were of sheet-like lava flows (Fig. 3), which were relatively fresh in coastal cliffs and bluffs, and mostly deeply weathered in road cuttings. These have features consistent with eruption and flow on land. There are two exceptions: A. in the cliffs from Anson Bay to Duncombe Bay; and B. in the lower part of the huge road cutting behind the wharf in Cascade Bay.

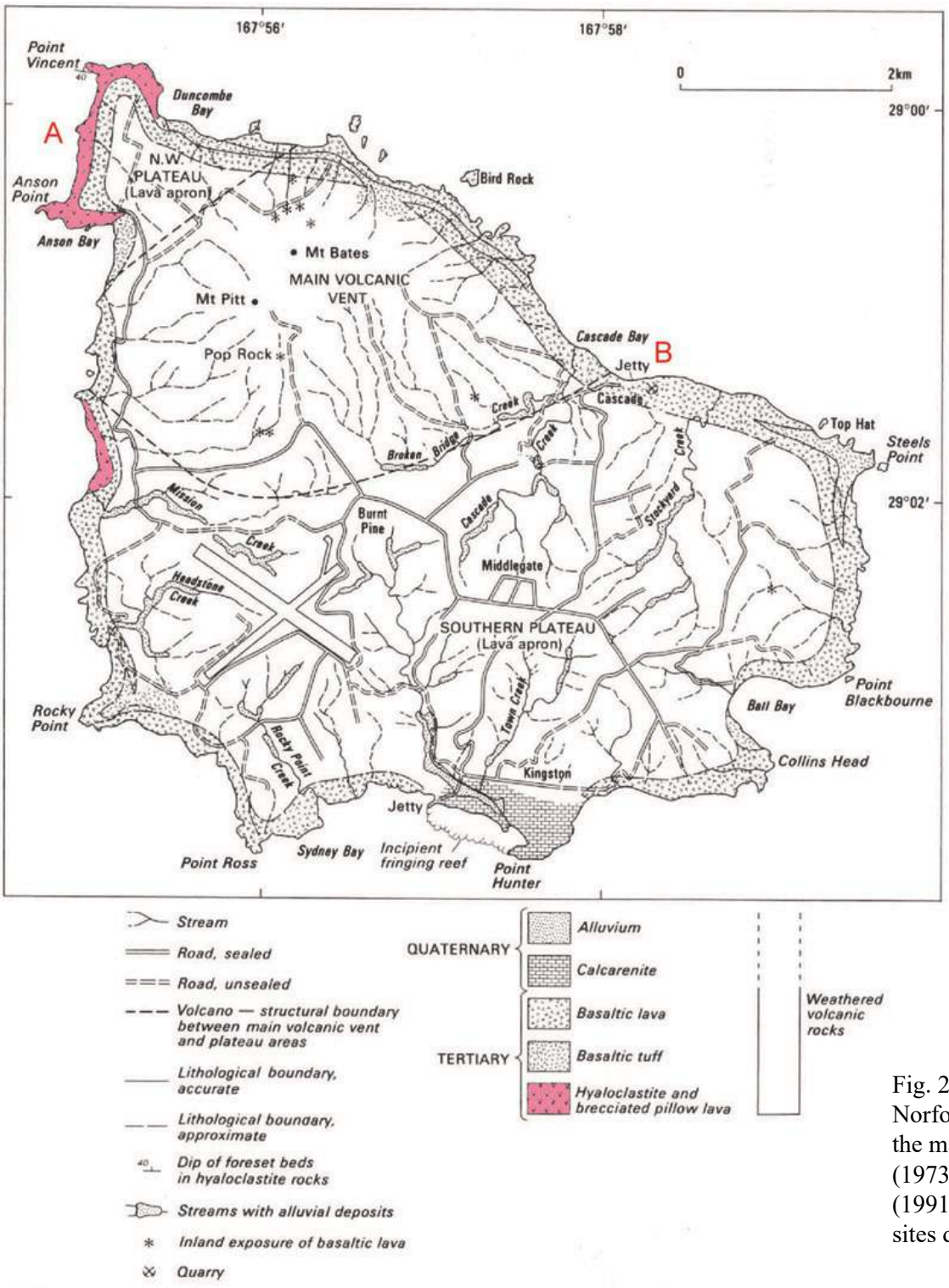


Fig. 2. Geological map of Norfolk Island. Simplified from the map by Jones & McDougall (1973) by Abell & Falkland (1991). A and B are the two sites described in detail herein.



Fig. 3. 10 m-high sea cliff on the west coast of Norfolk Island, showing 1-3 m thick basalt flows, some with vertical columnar joints. Note the paleovalley between the edges of two flows near the centre of the photo. A later flow has come down and solidified in the paleovalley.

A. Anson Bay-Duncombe Bay sea cliff exposures

The lower 5-10 m of these cliffs is composed of hyaloclastite breccia, with gnarly lumps of basalt, having full-height foresets tilted at 30–50° to the north (Fig. 4). This unit extends for 1 km around the base of the cliffs (Fig. 2) and is overlain by thick, columnar-jointed (terrestrial) lava flow sheets (Fig. 4). Hyaloclastite is fragmented glassy lava that was formed by sudden quenching of molten lava as it entered cold water. In some places the hyaloclastite breccia includes pillow lava lobes of various diameters and lengths (Fig. 5). This unusual basal unit is inferred to have formed as molten terrestrial lava flows entered the sea, were rapidly quenched bringing them to a stop, and progressively built their front out into the sea with a steep slope. Some of the lava was completely fragmented, some broke up into hackly lumps (Fig. 6), while some just cooled on the outside forming a glassy selvedge around internally molten pillow lobes.

Bedded basaltic tuff at the base of the cliff at the south end of Anson Bay has current ripples (Fig. 7) that show that it was deposited in moving water. Up the Anson Bay



Fig. 4. 10 m-thick hyaloclastite breccia with foreset bedding, underlying thick terrestrial basalt flows in the sea cliffs south of Pt Vincent, Norfolk Island.



Fig. 5. The upper 3-4 m of this hyaloclastite breccia unit is full of pillow lava lobes of various diameters. Flow direction is towards the photographer and slightly to the left. Pt Vincent cliffs.



Fig. 6. Hackly lumps of pillowed basalt within hyaloclastite tuff matrix, Anson Bay, Norfolk Island.



Fig. 7. Ripple-drift-bedded tuff, south end of Anson Bay. Photo 50 cm across.



Fig. 8. Weathered pillow-lava flow overlying bedded tuff, beside Anson Bay access track, Norfolk Island.



Fig. 9. The large cutting at Cascade Bay wharf, Norfolk Island, with four sheet-like terrestrial basalt flows overlying, with an irregular wavy contact, a unit of pillow lava, hyaloclastite and tuff that accumulated on the edge of the island, where the flows entered the sea.

access track at an elevation of ~15 m above sea level, a 5 m thick weathered pillow lava flow overlies bedded tuff (Fig. 8).

B. Cascade Bay cutting

Since Jones and McDougall (1973) described the geology of Norfolk Island, a large cutting has been cut in the steep hillside at the back of Cascade Bay to create vehicle access to the island's main wharf. This cutting exposes four, thick, lava flow sheets overlying a 5–8 m thick unit of hyaloclastite pillow lava breccia and tuff (Fig. 9). The lowest sheet flow has a wavy contact on the pillowed breccia unit (Figs 10, 11), which was probably pushed up into a wavy surface as the more voluminous lava flow arrived. Some parts of the pillowed unit contain 1–4 m-diameter, irregular lobes of solidified lava "floating" in orange-brown hyaloclastite breccia (Fig. 10). In other places the breccia is more massive and contains few pillow lobes (Fig. 11).

At the south end of the cutting, the breccia overlies a 4 m-thick lens of bedded, yellowy tuff (Fig. 11), which contains three rounded boulders of basalt (up to 1.3 m diameter) and a number of rounded cobbles (Fig. 12). These boulders and cobbles are similar to those that occur intertidally at the foot of some of the modern sea cliffs of Norfolk Island. The boulders are buried by bedded tuff, some of which has ripple-drift bedding indicating deposition under the influence of moving water. As with the Anson Bay-Duncombe Bay unit, it seems clear that the Cascade Bay hyaloclastite pillow lava and tuff was deposited on the edge of the island, where lava flows entered the sea and were rapidly quenched and came to a standstill.



Fig. 10. Lower part of the Cascade Bay cutting composed of large irregular pillow lobes embedded in orange-brown hyaloclastite breccia, overlain by more massive basalt flow sheets. Width of photo 20 m.



Fig. 11. Lower part of southern end of Cascade Bay cutting consisting of yellowy tuff overlain by heaps of massive hyaloclastite breccia. The breccia's upper contact has been rucked up into large waves by the incoming of the lowest sheet-like, terrestrial lava flow. The next highest sheet flow is separated from the lowest by 1 m of red-brown subaerially-deposited tuff. Width of photo 25 m.

Lava flow quench zone rocks as a proxy for former sea level

The recognition of lava flow-derived rocks that were deposited in the quench zone where the lava entered the sea, provides a proxy for sea level at that time. At Cascade Bay and around the north end of Norfolk Island, these quench zone rocks extend up to 10 m above present sea level. Numerous K-Ar dates on the lava flows in these areas indicate that they were erupted between 2.6–2.4 myr ago (Jones & McDougall, 1973). However, these basalts have normal magnetic polarity (Jones & McDougall, 1973), which suggests that they must be older than 2.58 myr. The most recent estimates of sea level around the world at 2.7–2.58 myr ago (Fig. 13) suggest that there were 40,000 yr-long climate cycles, with sea level alternating between warm period highstands up to 10 m above present and cool period lowstands around 40 m below present. The dating of the rocks is too imprecise to know when in the climate cycles the lava flows were erupted. If the estimated sea-level curve (Fig. 13) is correct (and that is far from certain), then the quench zone proxy indicates that Norfolk Island may have been uplifted between 0 and 50 m since the lava flows were erupted, ~2.6 myr ago.

Considering the imprecision of the dating and of the sea-level estimates, the best conclusion is that Norfolk Island has been tectonically stable or has been slightly uplifted since the volcano last erupted at the beginning of the Pleistocene (2.6 myr ago).

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Fig. 12. Rounded boulders and cobbles of basalt buried by bedded tuff, in the base of the cutting at Cascade Bay.

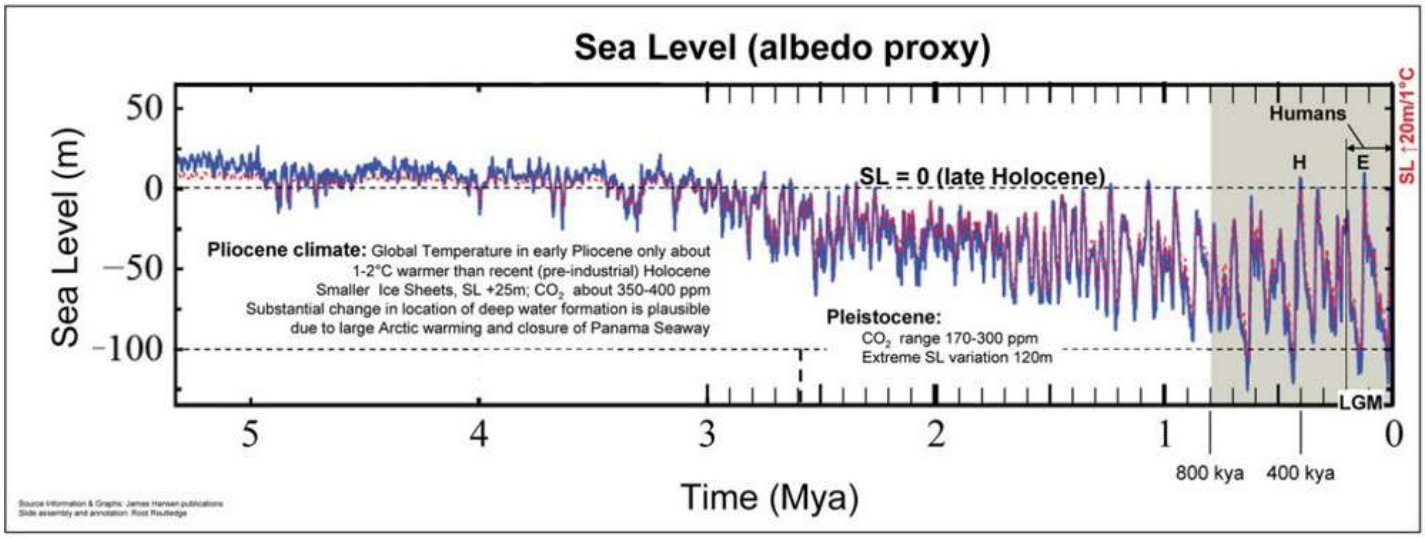


Fig. 13. Estimated global sea-level curve for the Pliocene and Quaternary, last 5.3 myr.
Source: Root Routledge. https://www.e-education.psu.edu/earth107/node/901

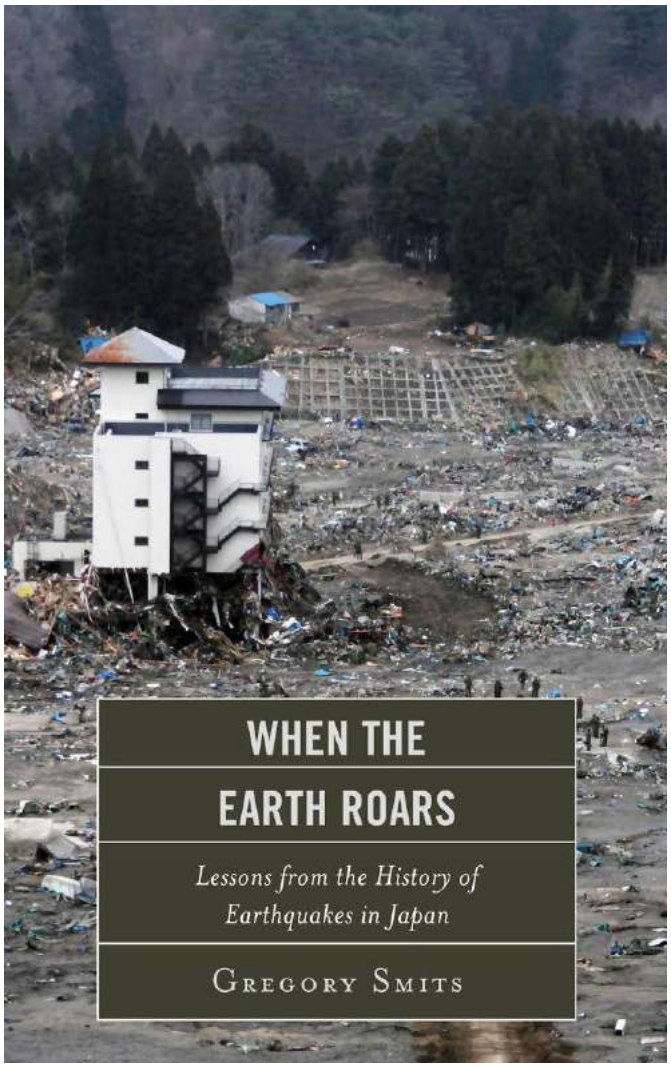
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BOOK REVIEW by Wendy Goad

"When the Earth Roars: Lessons from the History of Earthquakes in Japan"

Gregory Smits, 2014. Rowman & Littlefield, Maryland, USA

A hard copy (book) is available from Auckland Libraries.



"Japan is among the most earthquake prone regions of the world … and despite advances in earthquake-related safety technologies, the destructiveness of the magnitude 9.0 quake and tsunamui that struck in March 2011 (3/11) raised profound questions about how societies deal effectively with seismic hazards". The author is associate professor of history and Asian studies at Pennsylvania State University and a specialist on Japan. He researches the history of earthquakes in Japan, both with respect to the impact of earthquakes on history and society and from the standpoint of the history of earthquake science in Japan and elsewhere. This book compares the societal response to large earthquakes from 1611 to 2011 and provides an overview of the development of seismic science in Japan and the limitations associated with earthquake predication or forecasting.

Whilst focused on Japan (New Zealand doesn't rate a mention) the book provides interesting insights into how societies and governments respond to seismic events and how they don't appear to learn from history. The author focuses on the east coast as this is the area that has historically been affected by megathrust undersea earthquakes and the tsunamis these generate – 3/11 is just one in a long line of similar events, but the most destructive for 1000 years.

The first chapter sets the scene, outlining the generation of earthquakes and tsunamis, explaining the hazards Japan is exposed to, and the historical attitude of Japanese citizens, scholars and government officials to the risks. The emphasis was on planning for earthquakes of similar size to those experienced in the 19th and 20th centuries. Whilst large tsunamis were known about, the general consensus was that they occurred with large gaps in time.

The second chapter starts by considering the tendency for citizens to regard the previous earthquake and tsunami as characteristic and to act, or not, accordingly. They would rebuild in tsunami-prone areas, rather than retreating to a safe distance/height, putting too much faith on sea-walls. The 1611, 1793 and 1856 earthquakes and tsunamis are reviewed, followed by a consideration of the 1828 event and the development within Japanese society of the belief in precursors (e.g. unusually large fish hauls, changes to water in wells, cloud formations). It also reveals how, before the period of the internet, it was possible for governments to downplay the effects of earthquakes and tsunamis, and in doing so misleading citizens as to the probable outcome of a repeat event.

Chapter three considers and compares the 1891 and 1923 (the Great Kanto earthquake, Japan's deadliest seismic disaster) quakes and how these contributed to the advancement of seismology in both Japan and worldwide and to the advancement of anti-seismic engineering. This is an interesting chapter reviewing, as it does, societal reactions at the time.

Chapter four reviews the earthquake/tsunami combinations of 1896 and 1933 and considers both their roles as agents of social history and as agents of change in the history of science and technology. The 1896 event stimulated intense debate over the cause of tsunamis and the author looks at this debate in some detail. The 1933 event, as an apparent repeat of the 1896 tsunami, had a large impact on society as a whole as it was no longer possible to regard large tsunami as rare events that would not reoccur for hundreds of years. In the wake

of the 1896 tsunami some communities relocated, but many rebuilt in the same low-lying areas as before, in part thinking that no serious tsunami would come along until centuries into the future. The 1933 tsunami shattered that illusion, but replaced it with the illusion that barriers could offer protection from a wrathful sea!

The chapter reviews these two quakes in more detail than previous chapters and includes 'beautiful and ugly disaster stories', some of which are remarkable. The main thrust of the chapter is to review social and scientific challenges thrown up by these disasters.

Chapter 5 looks at the Japanese attempt to predict/ forecast earthquakes and tsunamis and considers the effort and money invested in this, and continues to be invested, despite the obvious unpredictability of these events. The author states that 'repeatedly in Japan's past, periods of relative seismic calm have led to overconfidence …" – perhaps the same could be said for Christchurch!

In the final chapter, the author makes the comment, that "much like generals fighting the previous war, societies tend to prepare for the previous natural disaster". The chapter concludes by examining several problems, successes, and possible future changes in policy and makes the point that although focused on Japan, many of these issues are applicable to other societies. He concludes that the best hope for future disaster mitigation is anti-seismic engineering and flexible disaster-relief capabilities.

RECOMMENDATION:
An interesting and at times entertaining read. Whilst New Zealand and Japanese societies differ, there are parallels that can be drawn, especially with regards to complacency of the general population. There are some good explanations of tsunami earthquakes and slow earthquakes, and because he is not an earth scientist, the book is very readable for the non-expert. With its emphasis on subduction zone-related tsunami earthquakes, this book may well make you reconsider retirement to Papamoa or Gisborne!!

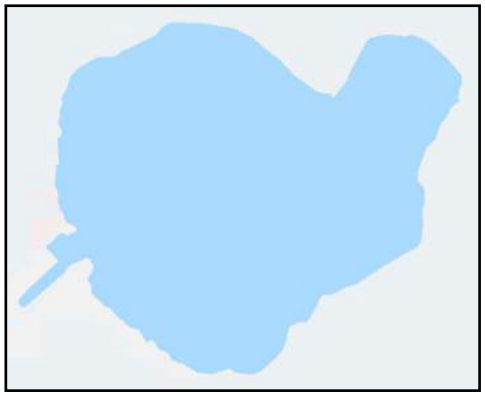
A dragon suddenly rears up from the sea floor
The headlong flood of a massive tide
Ten thousand cries of suffering, no time to flee
Rows of villages swept away in an instant, silent
The air full of bitterness, cruel rains fall from heaven
Cries blanket the earth, an apprehensive wind blows
What is the crime of these countless souls?

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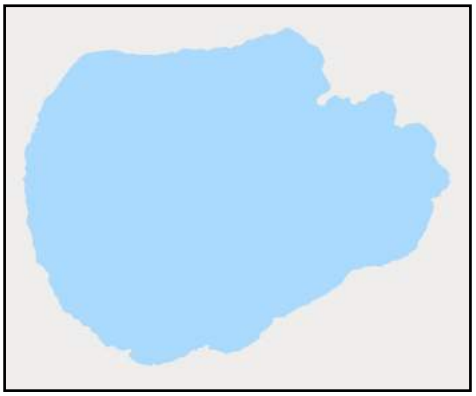
QUIZ

Know your lakes. Match maps 1 – 11 with lake names A – K.
(Answers on last page)

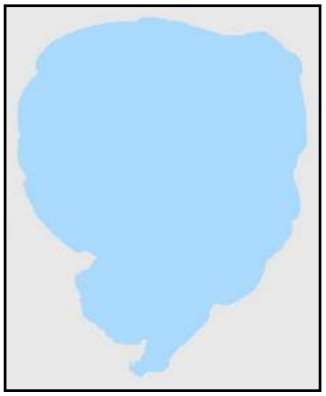
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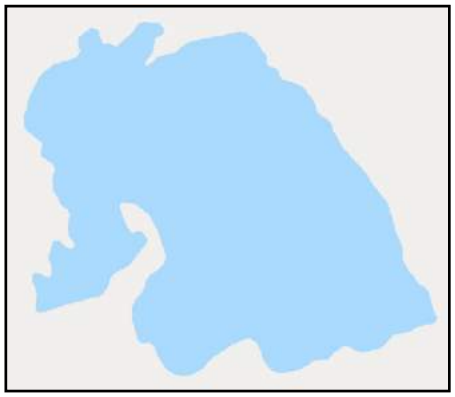
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7.



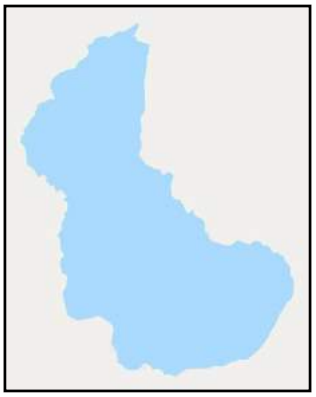
8.



9.



10.



11.



Possibilities to choose from:-

A Lake Omapere, Northland
B Lake Pupuke, Auckland
C Lake Waikare, Waikato
D Lake Rotorua
E Lake Okareka, Rotorua area
F Lake Rotoaira, Taupo area
G Lake Horowhenua, Manawatu
H Lake Wairarapa
I Lake Brunner, Westland
J Lake Ohau, Mackenzie Basin
K Lake Hayes, Queenstown

MANGANESE MINES IN THE HUNUA DISTRICT

Ian Simpson

Introduction

Manganese oxides have been used from ancient times in glass manufacture to make glass more transparent by the oxidation of impurities. In the 19th century the principal use was in the production of chlorine. Manganese dioxide (and related oxides) with hydrochloric acid gave chlorine ($MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$) and this was used for the manufacture of calcium hypochlorite used as bleaching powder. It had also been found that an alloy of steel and manganese, ferromanganese, produced superior strength steel. The greatest use of pure manganese dioxide today is in dry cell batteries including alkaline batteries where manganese dioxide forms the cathode and zinc the anode.

Within the Waipapa Group there are a number of manganese deposits derived from deep water volcanism and "black smokers" in the paleo-Pacific Ocean. The deposits are part of the oceanic sequence and are associated with siliceous argillites ("red rocks"), radiolarian chert and altered oceanic basalt (spilite) (Reed 1960). The deposits have a high percentage of manganese oxides, which is unlike the larger world deposits that are mainly silicates and carbonates.

The problem with the Waipapa deposits is that they occur as pods, lenses, nodules and veins and so mining has always been unpredictable and limited (Edbrooke 2001).

History

Numerous manganese deposits are known throughout the Waipapa Group, ranging from the Far North to the Hunua Ranges. The first commercial manganese mine in New Zealand was on Kawau Island in 1842, but this changed to mining the more valuable copper ore in 1844. In 1888, J. A. Pond (1888) reported to the New Zealand Institute that manganese was first mined on a large scale on Waiheke Island at Awaawarua Bay, then at Tikiora Hill in the Bay of Islands, Parua Bay near Whangarei, and Pakihi Island. In the 19th century manganese ores were mainly used for the production of bleaching powder and could be exported economically as ballast in sailing ships, but with the advent of steamships and falling prices, mining stopped at these sites before the turn of the century.

In the 1890s, P.E. Cheal, while surveying the Hunuas for the Government, found surface manganese deposits in the Otau district and surveyed claims for himself (Barton 1978). However, the price of Manganese had dropped and his claims were never worked. In the 1930s, the value of the ore increased as manganese was important for wartime steel making and for dry-cell batteries. Three sites in the Hunua District were mined between the 1930s and 1960.

Mining Sites

Paparata

A mine was worked on the Longshaw Farm at Pinnacle Hill, Paparata near Bombay by W. S. (Bill) Miller and about 500 tons of high-grade ore were produced from an open pit about 60 metres (m) long.

In the Appendices to Journals of the House of Representatives (AJHR) 1940, Miller is listed as living in Khyber Pass and it is stated that he was also engaged in developing a deposit at Moumoukai (on Piggott's farm).

Cloudesley Mine on Piggott's Farm at Moumoukai

Cloudesley Mine is on a ridge about 400 m above the Upper Mangatawhiri reservoir and dam. The ore was distributed over a 50–90 m strike distance and was superficial so it could be mined in a 4 m-wide open pit (Christie 2007). The problem was the distance from the road end. The NZ Herald, 31 October 1940, reported that the deposit was located in hilly country about two miles from the nearest road. A mile and a half of railway track had to be laid, many cuttings made and 28 bridges built. The railway was on Ernie St Paul's farm, which was later flooded for the dam. The railway had a petrol locomotive to move the skips. An aerial tramway about half a mile long was built to take the ore to the valley floor. It had two buckets loaded from a hopper and the full bucket returned the empty bucket to the top of the tramway by gravity. The lower quality ore went for wartime steel making in Australia and the high percentage manganese dioxide ore to Impex Ltd in Melbourne for dry-cell batteries. Some ore was also used in fertilizer in New Zealand. About 2000 tons of ore were extracted. The deposit was worked out after a few years and much of the equipment was sold to the government and the locomotive sold to the Auckland City Council for use in the construction of the Auckland water supply infrastructure in the Waitakere Ranges (Barton 1978).

Today the mine site can be reached at the end of Lilburne Rd some 5 km from the dam. From Piggott's campsite and hut at the end of the road, it is easily found on the track about 0.5 km further on up the ridge (Figs 1-3).

Otau Mine, Mirandite Products Ltd

About 3 km north of the Cloudesley Mine a larger deposit was licenced to Mirandite Products Ltd, a mining company registered in Christchurch. This mine was 2 km south of Plow's farm on Mine Road (Fig. 1). Mining started in 1938 and about 4000 tons of high quality ore were extracted by the time it closed in 1960. The mine was subleased to Mr W. Winter and the high grade ore was also sent to Impex Ltd, for dry-cell batteries. Mirandite Products Ltd went into liquidation in 1946 and the licence was taken up by

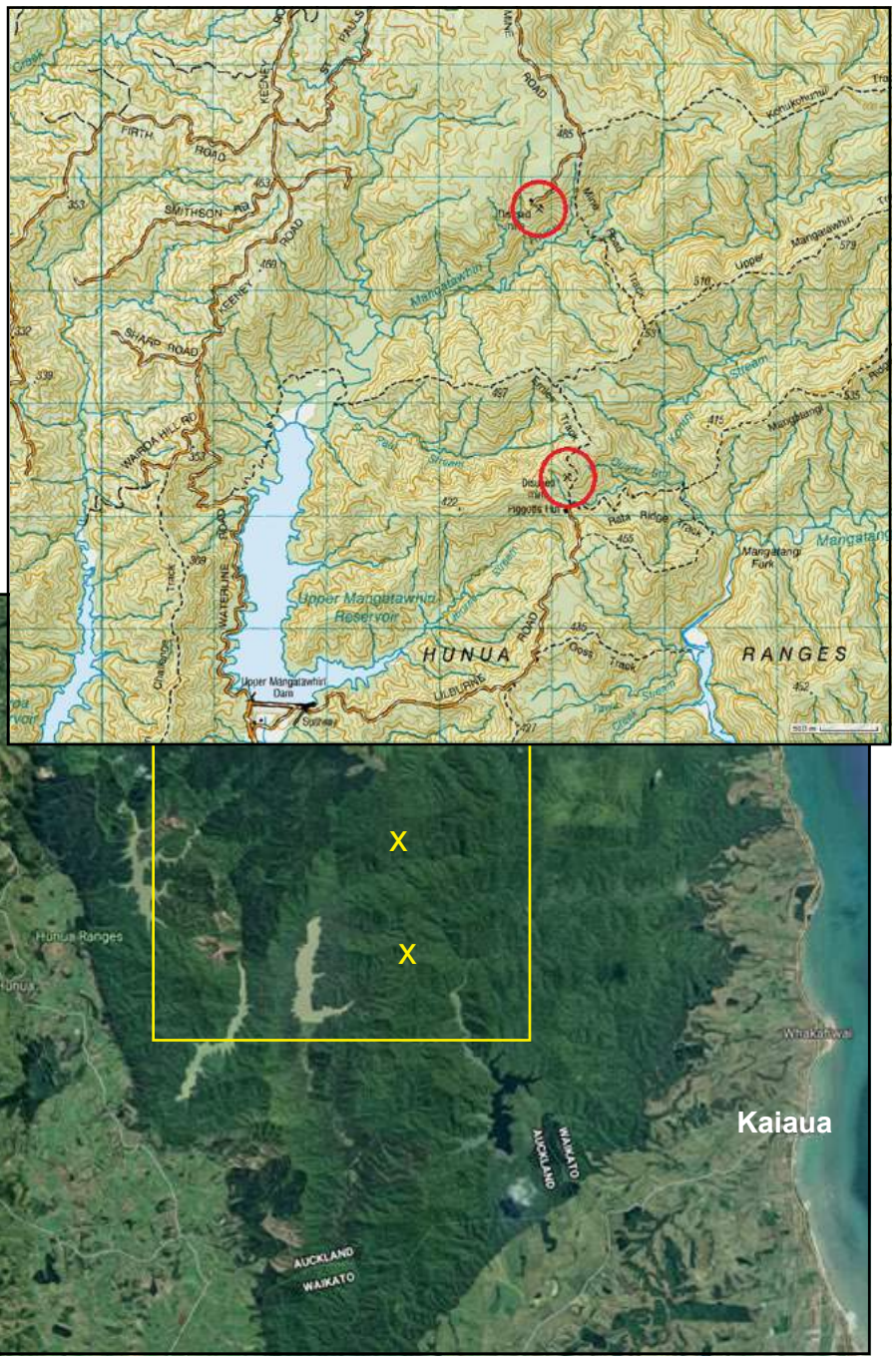


Fig. 1. Position of Moumoukai Mine (Cloudesley) (southern red circle and yellow cross) and Otau Mine (northern red circle and yellow cross). Topographic map is from NZ Topo Map (https://www.topomap.co.nz/NZTopoMap/nz7795/HUNUA-RANGES/Waikato). The lower image is from Google Maps. Location of the topography map in the Google Map is shown by the yellow rectangle.



Fig. 2. Upper Mangatawhiri Dam with arrow at approximate Cloudesley Mine site.



Fig. 3. Secondary pyrolusite nodules Cloudesley Mine trench.

Table 1. Manganese minerals found in the Hunua mines. Table modified from Christie (2007).

Name Formula	Colour	Hardness	Density	Crystal Structure
Braunite $3(Mn,Fe)_2O_3MnSiO_3$	Brownish black	6–6.5	4.8	tetragonal
Manganite $Mn_2O_3.H_2O$	Grey or black	4	4.3	orthorhombic
Psilomelane $BaMn_9O_{16}(OH)_4$ **Cryptomelane** $KMn_9O_{16}(OH)_4$	Grey or black	5–6	3.7–4.7	orthorhombic
Pyrolusite MnO_2	Grey or black	2–2.5	4.75	tetragonal
Wad Various oxides of Mn including Pyrolusite and Nsutite	Dull black, bluish, lead grey, brownish black	5–6	3.4–4.3	amorphous
Bementite (also Caryopilite) $Mn_8Si_{16}O_{15}(OH)_{10}$	Brownish black	6	3.0	monoclinic–prismatic

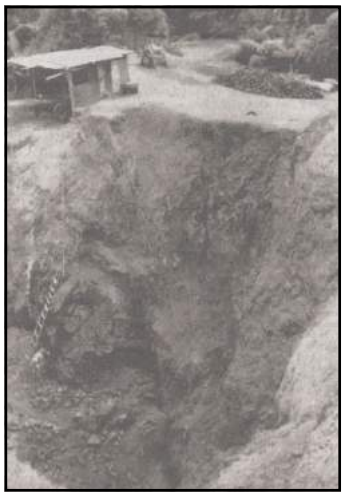


Fig. 4. Otau mine face from Reed (1960).



Fig. 5. Second growth bush over Otau Mine face 2017.

G.M. (Pat) Maning, who is listed as a mining engineer from 31 Eastbourne Rd, Remuera, but later he had addresses in Howick and Hunua. He apparently worked the mine until 1960 and reportedly had difficulties with flooding in the workings due to the heavy rain fall in that part of the Hunuas. Maning was an amateur ornithologist and published an article on kokako song (Maning 1960). He describes his observations as taking place in fairly thick bush surrounding the Manganese mine at an altitude of 1300 feet on the right bank of the Mangatawhiri head-waters. The kokako were reported to be indifferent to the noise of heavy blasting and working machinery.

The mine site today is covered with second growth bush, but there is machinery, trenches, an adit below the face and an old miners' hut still at the site. This mine is not easy to access because it lies in Watercare Services Ltd catchment area and there is no road access without permission. It is possible to visit the site using Ernie's Track (named after Ernie St Paul) off Waterline Road or Lilburne Rd and then the Mine Road Track, although this requires tramping experience and is very steep in places (Figs 4–7).

Manganese Minerals

The minerals present at the three Hunua sites are reported by Tony Christie (Christie 2007) to be braunite, psilomelane-cryptomelane, pyrolusite, manganite, bementite, wad and nsutite (Table 1). The nomenclature and classification of these minerals vary somewhat between different sources.



Fig. 6. Adit below face, Otau mine.



Fig. 7. Water pump near adit, Otau mine.



Fig .8. Psilomelane/Cryptomelane, Cloudesley mine.

The high percentage ores were hand-sorted in order to achieve the best prices. Some of the ore samples are shown in Figs 8 and 9. Qualitative manganese content was established in my hand samples by the addition of hydrochloric acid to powdered samples which gave a pink solution of manganese chloride.

Although there are a number of sites in the Waipapa Group that have appreciable reserves of good quality ore, the patchy nature of the reserves makes it unlikely that commercial mining will resume unless there is loss of access to other world supplies. However, the ingenuity and hard work of the men involved in all these mining ventures deserves recognition in our history. The terrain was often very steep and rough and, although some was on recently developed farmland, the other claims were in heavy bush. Today the Hunua mines are not obvious, having been taken over by second growth bush.

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Fig. 9. Manganite and secondary pyrolusite, Otau mine.

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CEMETERY CRATER REVEALED

Bruce W. Hayward

In 2011, Hayward *et al*. (2011a) recognised several additional volcanoes in the Auckland Volcanic Field. One of those, Cemetery Crater (Figs 1, 2), had originally been recognised and named by Ernie Searle (1961, 1964), but left off the list of officially recognised volcanoes in the preceding 20 or more years (e.g. Kermode, 1992; Allen & Smith, 1994; Hayward *et al*., 2011b). At the time, we knew of no oblique aerial or land-based historic photograph that showed what the crater and low tuff ring looked like prior to its intensive subdivision for houses in the 1970s–1980s. Recently a 1959 oblique aerial photo has turned up of the Papatoetoe Cemetery (Manukau Memorial Gardens), showing Cemetery Crater tuff ring in the background (Fig. 3). The far (eastern) inner slopes of the tuff ring are steep with an apparent small slump in one place. The nearer (western) slopes of the tuff ring are lower and less well-defined and show a small, overflow stream valley flowing away to the right (south).

The recent LiDAR contours, since subdivision bulldozer recontouring (Fig. 2), show Cemetery Crater is 250 m in diameter (crest to crest). The U-shaped tuff ring rim today rises to 29 m above MSL on the west and to 33 m on the east. By comparing the photograph and the LiDAR map it is clear that in preparing the subdivision, a major gap was bulldozed right through the east side of the tuff ring for Hillside Rd. Another bite was taken out of the NW part of the tuff ring for Lismore Place. It is also apparent that the SW motorway carriageway was built along the flattened crest of the western side of the tuff ring.

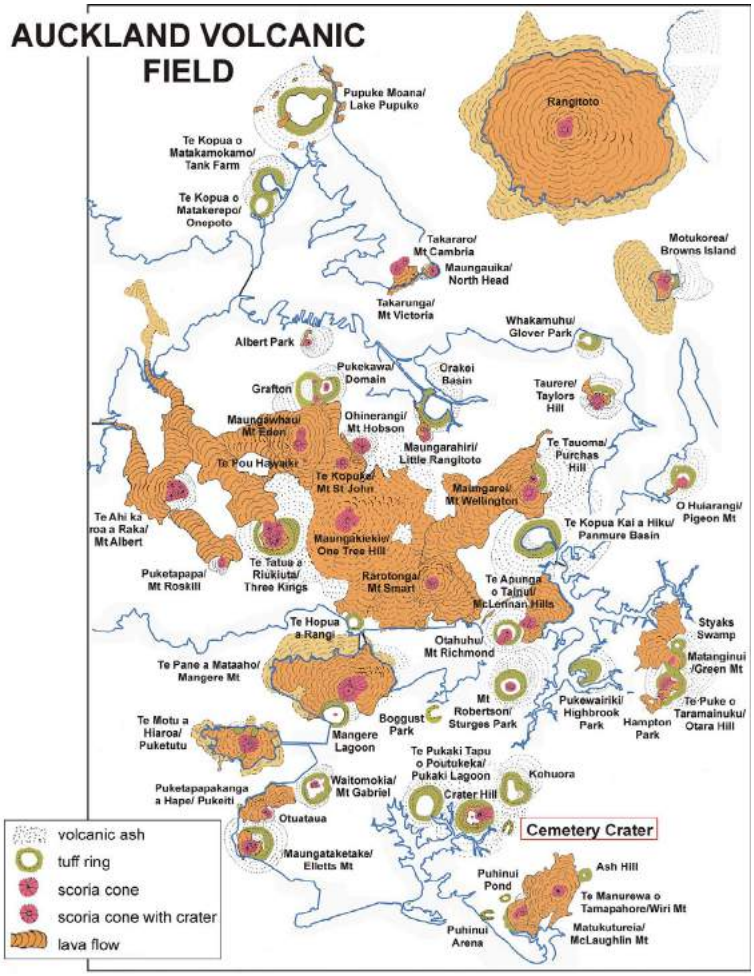


Fig. 1. Map of the Auckland Volcanic Field and the location of Cemetery Crater in Papatoetoe.
From Hayward (2011) updated after Kermode (1983).

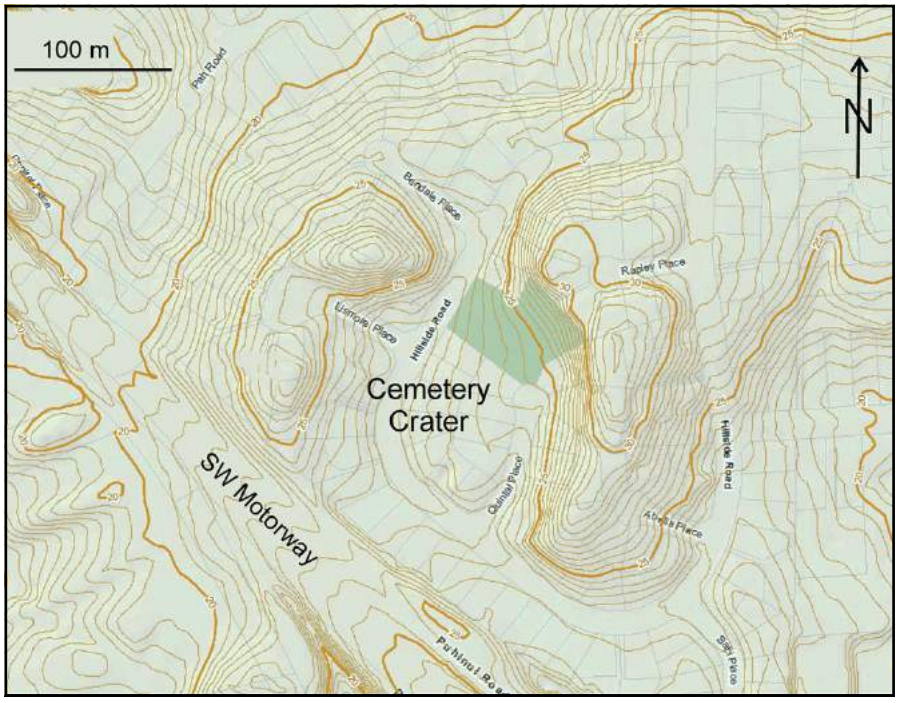


Fig. 2. Contour map of Cemetery Crater, Papatoetoe. 0.5 m contours from Auckland Council mapping, from http://maps.aucklandcouncil.govt.nz/AucklandCouncilViewer



Fig. 3. Oblique aerial photograph from the west over Papatoetoe Cemetery with Cemetery Crater beyond, 1959. Whites Aviation.



Fig. 4. Oblique aerial photograph from same angle as in Fig. 3, in 2015. From Google Earth. The position of Cemetery Crater is circled. The SW Motorway cuts across the photo, Puhinui Road interchange is top right corner and Manukau Memorial Gardens takes up the whole foreground.

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FOSSIL PHARYNGEAL TOOTH PLATE FROM AN EARLY MIOCENE FISH (?LABRIDAE), WAIHEKE ISLAND

Bruce W. Hayward

While on a University of Auckland 3rd year field trip to Fossil Bay (next to Church Bay), Waiheke Island in March 2017, I noticed an unusual small fossil in a loose boulder at the far northern end of the bay. The small boulder had obviously recently dropped out of the low cliff and was composed of shell-bearing sandy pebble conglomerate of the Kawau Subgroup (basal Waitemata Group of Early Miocene age, ~20 myr old). This shelly conglomerate sits unconformably against and over a greywacke paleo-sea stack and is part of a lens of conglomerate that has been labelled unit (or association) B by Hayward and Brook (1994) and its fossil content labelled as North Fossil Bay Sandy Gravel Fauna by Eagle *et al*. (1995).

Previous fossil records

This up to 1.5 m thick lens of conglomerate has over 50 macrofossil taxa recorded from it (Eagle *et al*., 1995). The fauna has been summarised as "This macrofauna appears to be an equal mix of taxa that lived in a moderately exposed hard rocky reef environment and those that lived in and on a sedimentary substrate. A range of sediment conditions is indicated, from stable pebble gravels, through possible muddy flats to more mobile sand. Some species were intertidal inhabitants, but the majority lived at shallow inner shelf depths (0–20 m)." (Eagle *et al*., 1995, p. 25). Microfossil foraminiferal faunas from this unit are dominated by *Notorotalia* and *Buliminella* and have been interpreted as accumulating in a "moderately high energy, possibly strong current environment, at deep inner shelf depths (c. 10–40 m), sheltered from oceanic influence (low planktic content). The considerable intersample variation in this association is suggestive of some possible post-mortem current mixing of tests from several source populations." (Hayward and Brook, 1994, p.16).



Fig. 1. Fossil pharyngeal tooth plate from Waiheke Island. Largest dimension 22 mm.

The new fossil find

When first found, the specimen looked like no other fossil I have ever seen at Waiheke or anywhere else. First impressions by myself and palaeontologist Neville Hudson, who was also present, were that it may have something to do with the tooth plate of some kind of fish or ray. The fossil is subtriangular in plan view (Fig. 1) with a maximum dimension of 22 mm. It consists of a tightly packed cluster of rounded peg-like teeth that are larger in the middle and smaller around the edge. The specimen is lodged in the fossil collections of the University of Auckland (catalog number V565). The fossil record number is R11/f191A. The fossil came from approximately 0.3 m above the greywacke unconformity at the far northern end of the unit B exposure under the horizontal pohutukawa branch in the 2010 photograph (Fig. 2). It occurs between rounded and subrounded pebbles of greywacke in a coarse sandy matrix (Fig. 1).



Fig. 2. Shelly pebble conglomerate of basal Waitemata Unit B at the north end of Fossil Bay, Waiheke, 2010. The fossil tooth plate was recovered in 2017 from a block that had fallen out of the cliff close to the white **X** on the photo.

What is it?

After trawling the net, it seems that this is the pharyngeal tooth plate of a fish. The plate is located at the back of the throat and the peg-like teeth are used to grind up food, such as shelled molluscs. "Pharyngeal jaws are a second set of jaws distinct from the primary (oral) jaws. They are contained within the throat, or pharynx, of most bony fish." (Wikipedia, 2017). The pharyngeal jaws have been modified into tooth plates in just a few fish families (e.g. labroid families Labridae, Odacidae and Scaridae, plus Sciaenidae, Carangidae and Diodontidae).

One of the more likely families is the Labridae or wrasses. They are common around shallow warm-water reefs and are scavengers and have similar looking pharyngeal tooth plates with rounded peg-like teeth (Fig. 3) to the fossil specimen.



Fig. 3. Four examples of pharyngeal tooth plates from wrasse species around the world. Photos from the internet. Note the similarities to the Waiheke fossil.

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QUIZ ANSWERS

Know your lakes.

1 = B Lake Pupuke, maar volcano, northernmost volcano in the Auckland Volcanic Field

2 = A Lake Omapere, a lake north of Kaikohe, central Northland, dammed by lava from the Kaikohe Volcanic Field

3 = D Rotorua, a caldera lake in the Taupo Volcanic Zone

4 = E Lake Okareka, located west of Lake Tarawera in the Okataina caldera of the Taupo Volcanic Zone

5 = C Lake Waikare, a shallow, swampy lake east of Rangiriri in the floodplain of the Waikato River

6 = I Lake Brunner, largest of the lakes in the lowlands between Greymouth and the Alpine Fault, in the Grey District of the West Coast

7 = G Lake Horowhenua, a dune-dammed lake west of Levin in the Manawatu region

8 = H Lake Wairarapa, south of Featherston in the southern Wairarapa, is the 3rd largest lake in the North Island, just smaller than Rotorua

9 = J Lake Ohau, glacial lake in the Mackenzie Basin, west of Twizel

10 = F Rotoaira, between Lake Taupo and Mt Tongariro, is now part of the drainage system for the Rangipo Power Scheme

11 = K Lake Hayes, enclosed by moraine and outwash gravels near Arrowtown

or Return to quiz questions

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