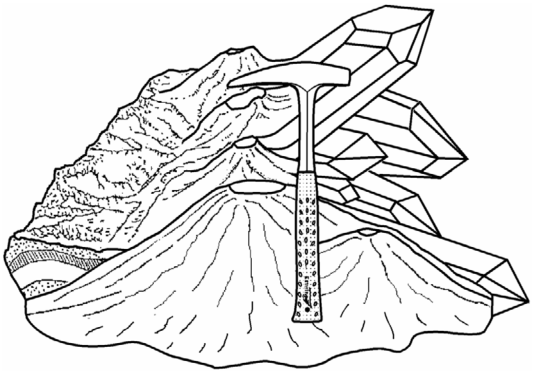

Geocene

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CONTENTS

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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NEW ^{14}C RESULT CONFIRMS 28,000 YEAR OLD MAUNGAWHAU / MT EDEN ERUPTION AGE

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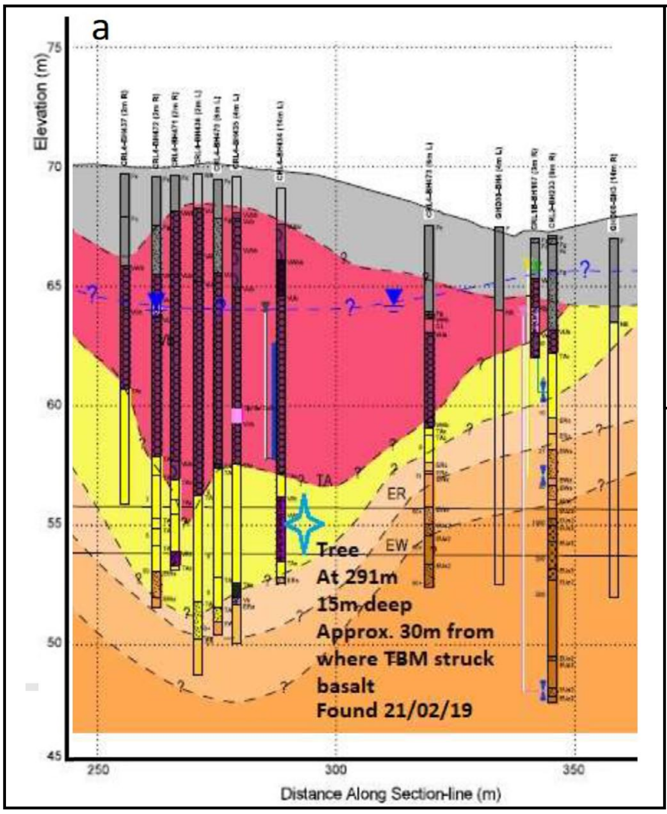
[2] Geomarine Research
[3] City Rail Link

In February 2019, City Rail Link (CRL) reported that their micro-tunnel boring machine "Jeffie" became entangled in a large tree at 15 m depth, approximately 50 m north of the rail line between Mt Eden Rd and Shaddock St in Eden Terrace, Auckland (Fig. 1). The tree was found 1–1.5 m below lava flows from Maungawhau/Mt Eden, as extrapolated from nearby boreholes by CRL (Fig. 2).

The large obstruction (>1 m diameter in a 2 m drill hole) caused Jeffie to veer off course. CRL removed the wood fragments and pulled them to the surface (Fig. 3). Select samples of wood were chosen by **DE**termining **VO**lcanic **R**isk in **A**uckland (DEVORA) researchers for radiocarbon analysis during a visit to CRL offices in April 2019. The tree fragments were in variable states of preservation,

Fig. 1. The CRL tree was found at 15 m depth, approximately 50 m north of the rail line between Mt Eden Rd and Shaddock St in Eden Terrace, Auckland. Image from Google Earth Pro. Location data from CRL. The buildings around where the tree was excavated are all now demolished as part of the tunnel portal work.



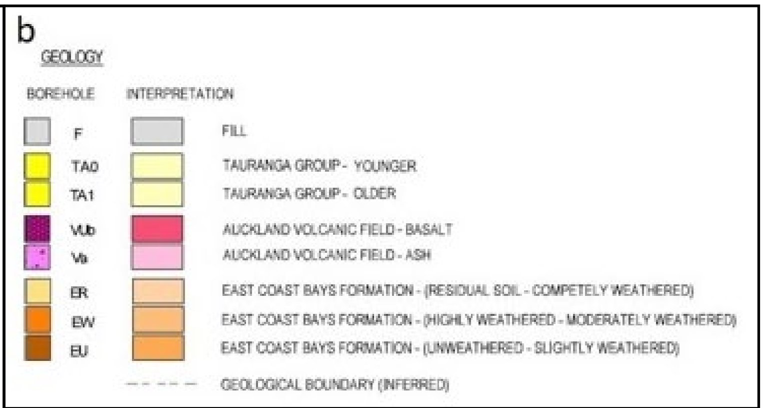


Fig. 2a. Cross-section excerpt of the area where the tree was found by CRL (turquoise star);
Fig. 2b. Legend for stratigraphy shown in cross-section. Cross-section and legend courtesy of CRL. It is not necessary to be able to decipher the borehole information, but rather to get an idea of where the tree was found and its proximity to the basalt lava flow.
Simplified - grey is fill, dark pink indicates basalt, yellow represents Tauranga Group sediments, and shades of orange are all Waitemata Group sediments.

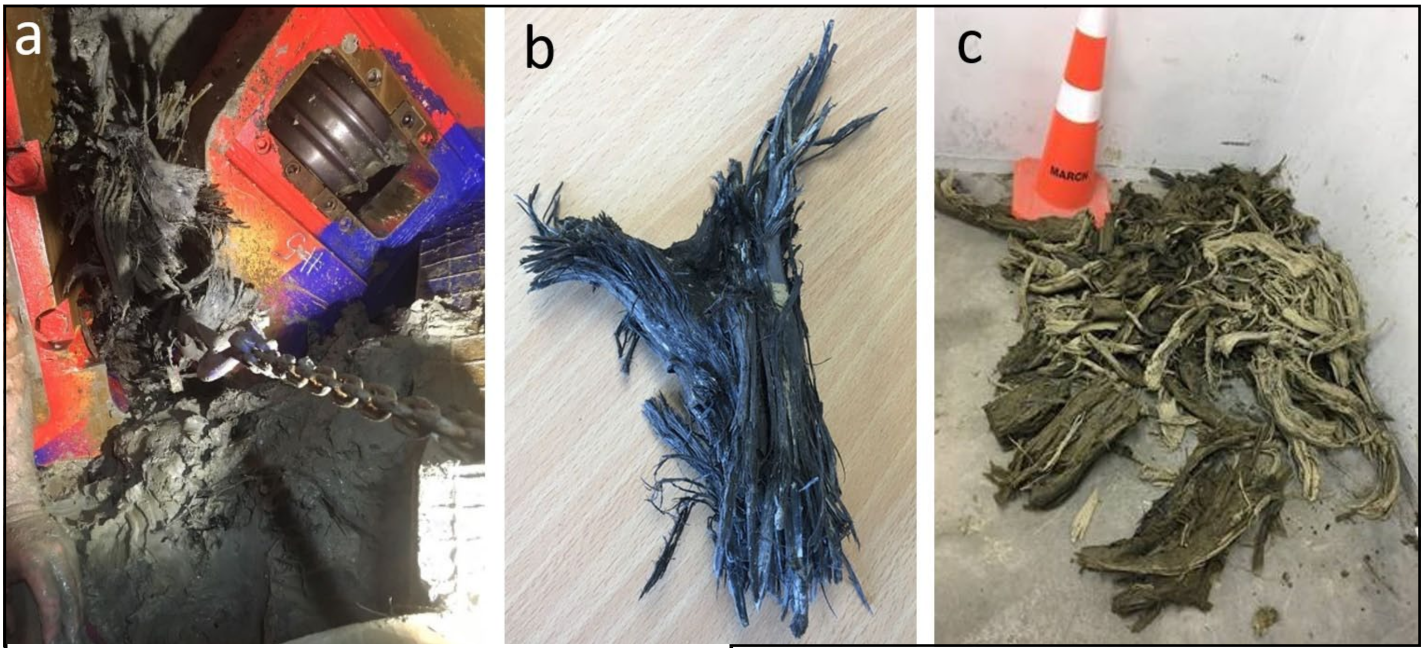


Fig.3a. Tree in soft mud or tuff entangled in the City Rail Link micro-tunnel boring machine near Maungawhau. Figs b & c. Fragments of tree brought to the surface. Fig. d. Tree samples chosen for radiocarbon analysis. Photos a–c courtesy of CRL: https://www.facebook.com/cityraillink/posts/1160953177398200
Photo d by Elaine Smid.

from well- to poorly-preserved, with apparent light charring or carbonisation evident on portions of some fragments.

Tree identification, growth environment and likely demise

Samples were provided to RW, who determined that dense wood from two species was present: a) well-preserved tōtara (*Podocarpus totara*) (Fig. 4), and b) wood of a broadleaf species (angiosperm), too decayed to identify. The latter wood was dense and therefore could not have been from a whau tree, as previously postulated, as whau has a density less than that of cork (Kirk, 1889). Fragments examined by RW were not charred by a heat source. It is not possible to tell if the wood was from sub-surface roots or from above ground portions of trees.

From borehole information and geologists' accounts during drilling, the trees were likely growing in a forested valley that was later filled in by Maungawhau's lava flows. The trees were found approximately 1.2 km from Maungawhau's main vent (Fig. 5). There is no indication if the trees were standing in place, had already fallen over, or were knocked over when the volcano started erupting.

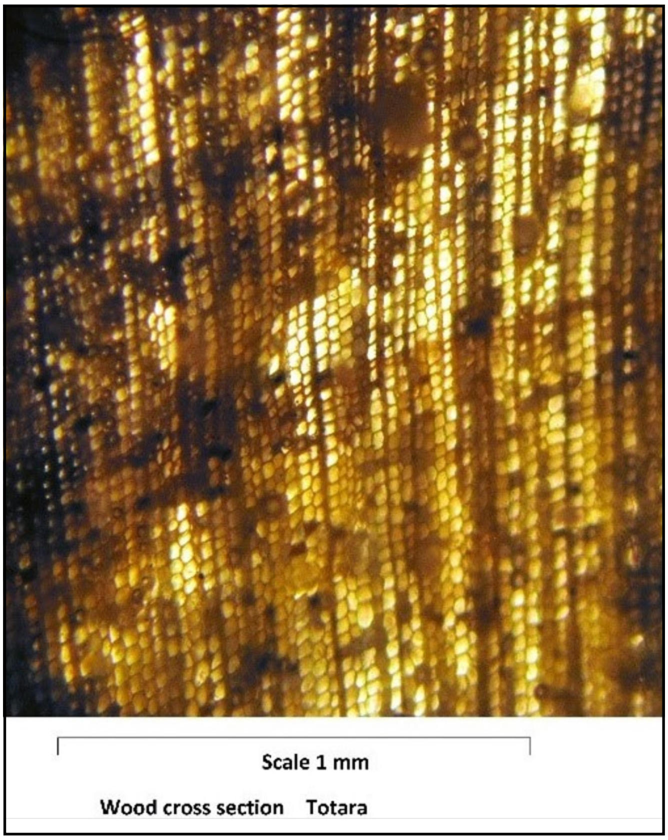


Fig. 4. Image of well-preserved tōtara wood taken from the City Rail Link tunnel in February 2019. Image taken by Dr Rod Wallace.

Fig. 5. Locations of radiocarbon samples used to date Maungawhau's eruption. These include: 1. a tōtara log buried in tuff found during construction of buildings within the Mt Eden Corrections Facility; and 2. the CRL tree (see text for details). The trees were discovered ~1.1 and ~1.2 km from Maungawhau's main vent, respectively, and are roughly 0.5 km apart. Image from Google Earth Pro.

The wood was found in what looks to be soft mud or tuff (Fig. 3a). The presence of tuff from Maungawhau has been inferred in Auckland maar cores (Hopkins *et al*., 2017) and reported within the site description of a previously-dated tōtara log, found during construction of two Mt Eden Corrections Facility buildings (Fig. 5; Table 1; East and George, 2003). The mud pictured may not be *in situ*, however, as Jeffie is a slurry microtunnelling boring machine and copious amounts of drilling mud was used.

The uncertainty about what material surrounded the trees leads to several potential scenarios for the trees' demise. The lack of charring on the wood indicates that it was not impacted by the eruption products, either base-surge-derived tuff or lava flows, and was likely buried and/or insulated by sediment. This sediment cover may have been tuff, *in situ* soft mud in a pond-like environment that the trees fell into up to several hundred years prior to the eruption, bulldozed in front of an advancing lava flow, or soil cover if the wood found was root material. The apparent lack of black, organic-rich mud at the tunnelling site indicates that the sediment was not associated with a swamp or peat bog.

Another possibility is that the wood post-dates the Maungawhau eruption, and grew on top of the lava flow, with roots reaching 1–1.5 m below the flows. However, the agreement of the resulting age of this wood with other ages for Maungawhau, the large size of the obstruction encountered by Jeffie, as well as the thickness (~10 m) of the lava flows above the layer where the trees were found make it unlikely that the wood was emplaced post-eruption.

Tree age and implications for Maungawhau eruption age

The GNS National Isotope Centre's Rafter Radiocarbon Laboratory (sample ID CRL-1; NZA 69409) returned a result of 23,916 +/- 172 yrs BP (conventional age), with a calibrated 2-sigma age range of 27,666 to 28,274 cal yrs BP. This new result places the eruption age within error of two previously obtained ages: 1. A tōtara log found within tuff and 2. ash layers within five maar cores, sourced to Maungawhau via geochemical correlation, with an average estimated age calculated from sedimentation rates (Table 1). The former was discovered 1.1 km north of Maungawhau's main vent and 0.5 km from where the CRL tree was found (Fig. 5).

Ages obtained using other techniques (e.g. thermo-luminescence; K-Ar) were deemed unreliable (McDougall *et al*. 1969; Lindsay *et al*., 2011). Overall this find and radiocarbon result confirm the age of the Maungawhau / Mt Eden eruption at ~28,000 years BP.

Table 1. Known reliable ages for Maungawhau samples.

Sample ID	Description	Location [a]	Age	Error (years)	Source
NZA-69409; CRL-1	Wood in soft mud or tuff	36°52'3.73"S, 174°45'36.03"E; 15 m depth; 50 m N of Rail Line between Shaddock St & Mt Eden Rd, Eden Terrace; 1.2 km NNW of Maungawhau	27,970 [b]	304	This study
WK-7136	Tōtara log buried in tuff	36°52'3.58"S, 174°45'56.90"E; under the Administration Building at Mt Eden Corrections Facility; 1.1 km N of Maungawhau	28,386 [b]	345	East & George, 2003; Lindsay *et al.* 2011
AVF12	Geochemically correlated ash layers within maar cores	Ōrākei Basin; Hopua; Onepoto; Pupuke; Pūkaki	28,030 [c]	260	Hopkins *et al.* 2017

[a] Coordinates in WGS 84 Web Mercator.
[b] Radiometric age in calibrated years before present.
[c] Estimated average age in years before present, calculated from sedimentation rates in five cores.

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Return to contents page

FORTY-SEVEN YEARS OF EROSION AND WEATHERING OF LION ROCK BOMB, PIHA

Bruce W. Hayward

Back in 1973, I recognised a spindle-shaped volcanic bomb embedded in volcanic breccia 2 m above sand level on the south side of Lion Rock, Piha (Figs 1–2). I took a photo and have used it for years as some of the best evidence for the subaerial volcanic vent origin for Lion Rock about 16 million years ago (Hayward, 1977). Thirty years later I was a little surprised to still find the bomb looking not too different from when I first photographed it (Fig. 3). Since then I have taken many groups, including Geoclub on several occasions, to see this volcanic bomb and rephotographed it each time (Fig. 3). I now realise I have a series of photographs that show its slow marine erosion and weathering over the past 47 years. In 2011, I estimated the rate of marine erosion in volcanic sandstone at Muriwai at 15 cm/100 years, based on my rephotographing a distinctive flame structure that I had also identified and photographed for the first time in the early 1970s (Hayward, 2011).

On the south side of Lion Rock, the rock containing the bomb is about 2 m above Mean High Water, almost the same elevation as the flame structure at Muriwai. Both features are oriented side on to the waves and I suspect that most erosion would be due to wetting and drying and frittering more than direct wave impact. Looking closely at the set of six photographs of the Lion Rock bomb, the first thing to notice is that erosion/weathering has been considerably less than at Muriwai and appears to have varied between 0.5 and 2 cm in 50 years = ~ 1-4 cm/100 years or about 10–25% the rate of the Muriwai sandstone. At this locality, the amount of retreat totals ~0.7-3 m in

Fig. 1. Lion Rock from the south with the location of the bomb indicated by the green oval.

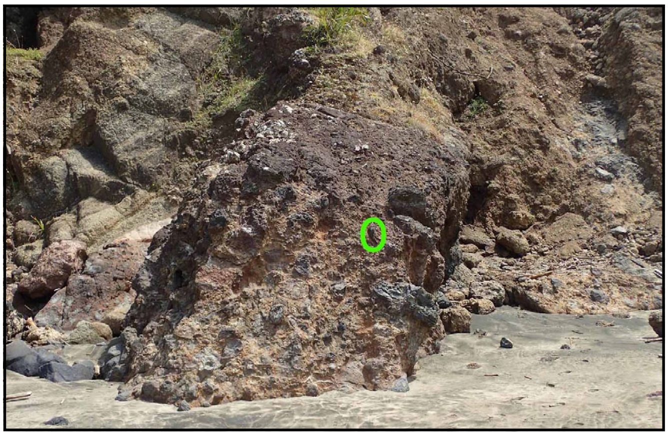

Fig. 2. Photograph of the lower middle portion of the south side of Lion Rock with the volcanic bomb indicated by the green oval.

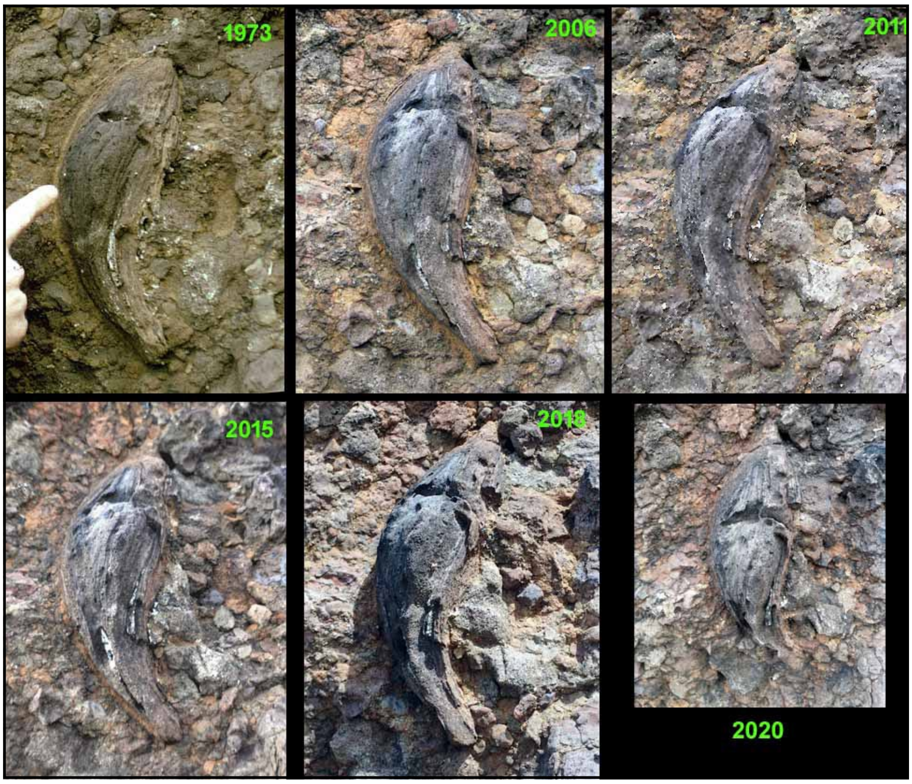

Fig. 3. Series of six photographs of the Lion Rock volcanic bomb 1973–2020.

7300 years since sea level returned to this height after the end of the Last Glacial. But much of the marine erosion here would have been rapid initially as soil, scree and weathered surface rock was first removed when sea level rose. Subsequently, erosion was probably episodic with rapid erosion along fractures and soft rock, with consequent block and cliff failures. The rate of erosion being recorded by the bomb is of retreat of unfractured faces of relatively hard volcaniclastic breccia.

Looking closely at the series of bomb photos, the most obvious change has occurred in the last 2 years when the tail at the bottom of the bomb has broken away following 45 years of only slow degradation of the tail. In 1973, the bomb had a horizontal fracture 75% of the way along its length. Most of the widening of this fracture occurred between 1973 and 2006. Looking at the breccia matrix around the bomb, one can also see that a number of small clasts have eroded out in the first 33 years, with minimal change between 2006 and 2018 and a phase of rapid erosion in the last two years, when the bomb tail was lost.

Why has there been a sudden rise in erosion rate? In the last 1–2 years there has been a large increase in the amount of sand on and around South Piha Beach. When I took the 2020 photo of the bomb, the sand level in the small embayment on the south side of Lion Rock was higher than I ever remember by at least 1 m and the sand level was only 1 m below the bomb in the rock. I wonder, could this be a coincidence or has the increased erosion been due to the increased sand being swept across the face of the rock and bomb by large storm swells at high tide?

Will this bomb still be recognisable in another 50 years?

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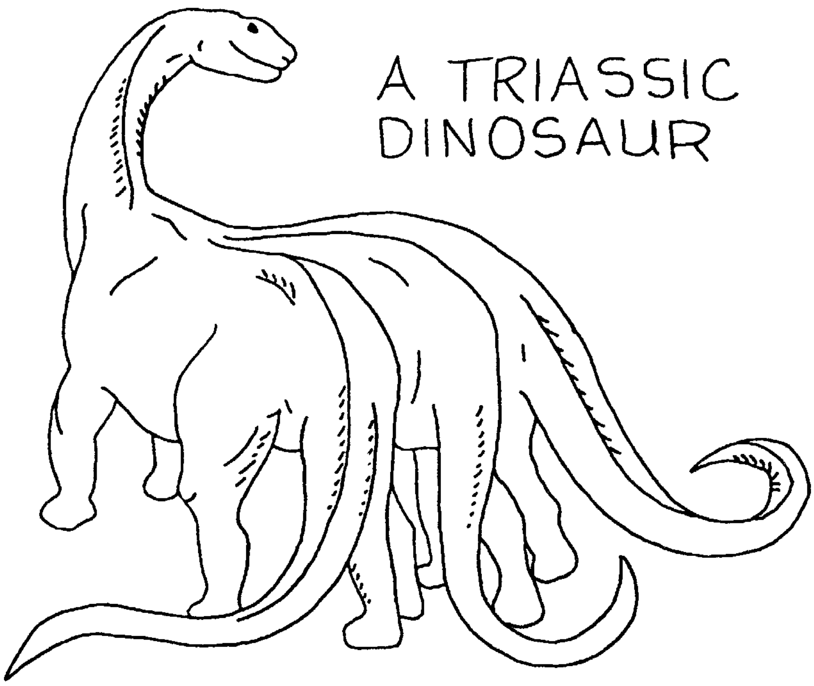
Return to contents page



MAORI BAY MICROMINERALS

Tim Saunderson

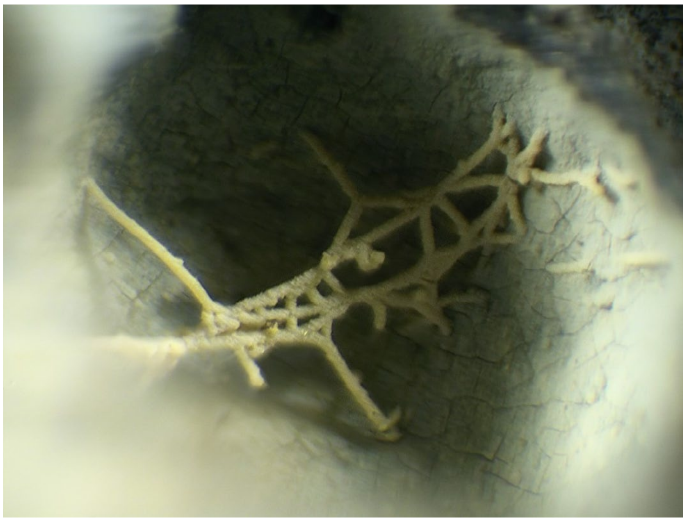
Early in September, a friend and I decided it would be nice to get out of the house and go for a walk somewhere. It just so happened that we ended up at Maori Bay, Muriwai. I had neither hammer nor loupe with me but I picked up four rocks, each about the size of an apple. Frankly, I wasn't expecting to find very much in these but on closer inspection at home, I was pleasantly surprised.

This article is hardly an exhaustive study on the micro-minerals of Maori Bay but it does cover a few of those that occur here, based on what I have found in these four rocks. Firstly, the tide was almost fully in, so I only went about 200 m from the path down to the beach and collected rocks near the high tide mark. Most of the rocks I collected had a thin crust of crystalline material on one or more surfaces (possibly deposited in fractures prior to the rock being broken apart during erosion/ weathering). One very interesting specimen was collected about 40 m above the beach, beside the path leading down to it. This proved to be rhyolitic crystal tuff probably originating from the Taupo volcanic zone. It might be from a very old eruption because the tuff seems to be altered by hydrothermal activity in much the same way as the zeolitized material from the Waitakere volcano. So perhaps it is from an ashfall that accumulated on the ocean floor. This tuff is whitish in colour, porous and very light. It contains many fragments of glass-clear feldspar and a few crystals of beta quartz (or more correctly, alpha quartz paramorphs of beta quartz). Beta quartz is restricted to high-silica acid lavas such as rhyolite (Maori Bay lavas are andesitic). Technically, beta quartz is stable only above 573 degrees centigrade and once the temperature drops below that, the crystals revert instantly to alpha quartz with no change to external appearance. Beta quartz generally exists as hexagonal dipyramids and frequently has both liquid and gas inclusions in the crystals.

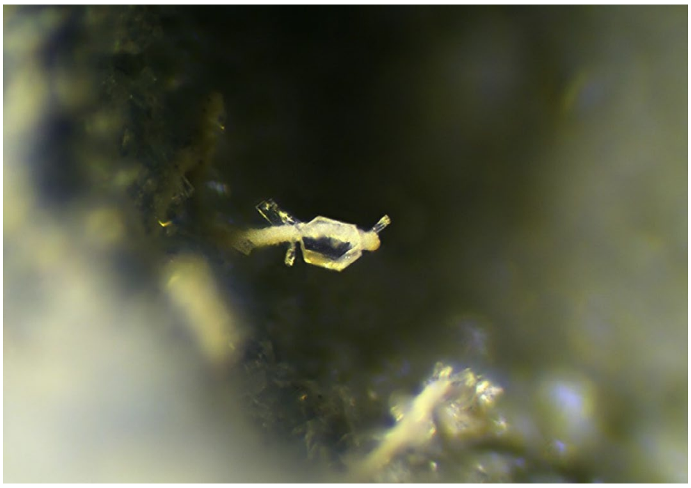
The feldspar crystals/fragments in this tuff have been somewhat etched and reduced in volume by some 10–30% but despite the etching, are still very glossy and polished and highly textured on all surfaces.

Minerals in the other rocks I collected include the zeolites heulandite, stilbite and thomsonite; also present are baryte, limonite, manganese oxides, siderogel, opal and clay group minerals (possibly montmorillonite or kaolinite). These clays form as hot mineral-rich water cools and the iron, magnesium and some of the aluminium drop out of solution, leaving a thin coating on fractures in the rock or lining vesicles. Sometimes the clay minerals form bizarre, branching structures or tangled masses of thin 'noodles'. Colours are usually pale - white, grey, yellow, tan or even sky-blue.

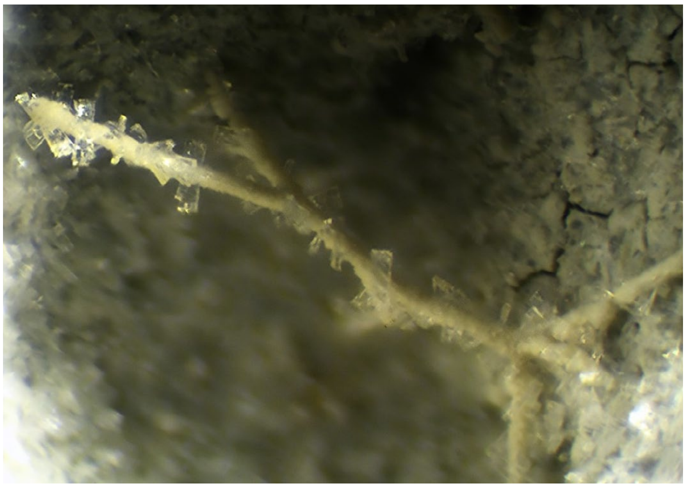
The field of view (FOV) in these photos is 1.2 mm unless stated otherwise.



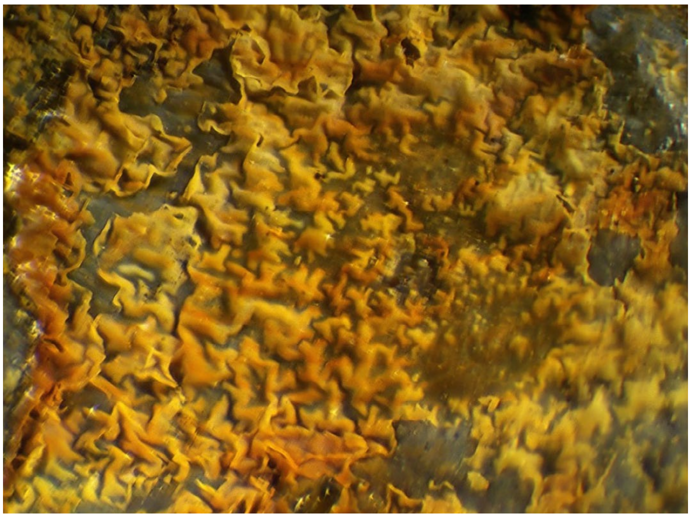
Fragile white clay structures about 2.5 mm across.



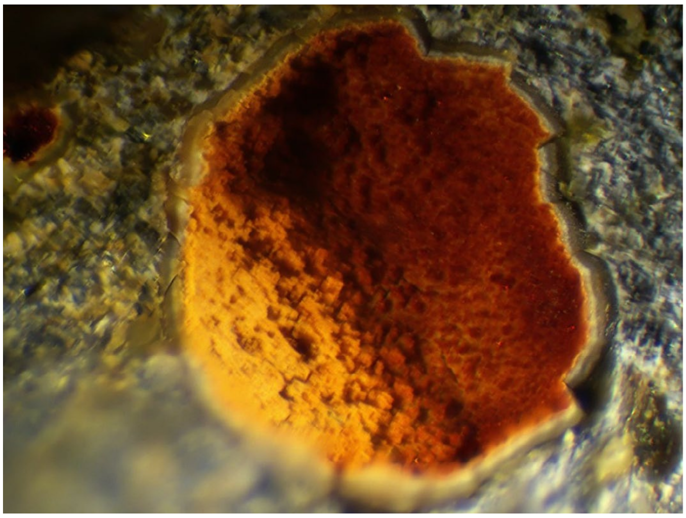
Very clear tabular heulandite and tiny thomsonite crystals on a white clay thread.



Very tiny thomsonite crystals on white clay threads.

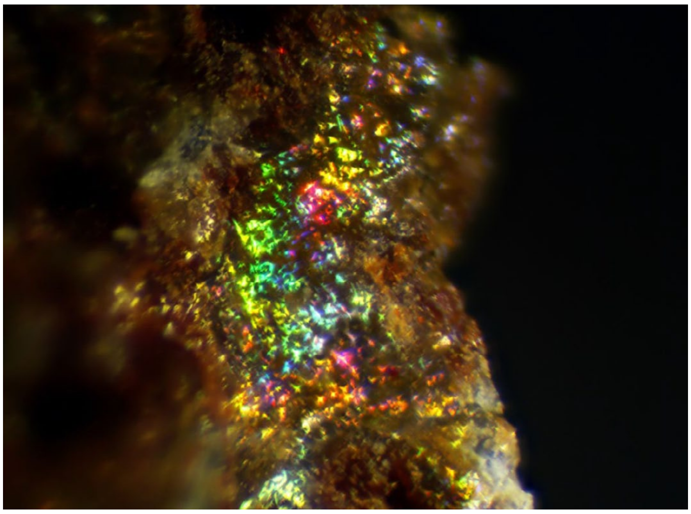


Yellow limonite as a thin, wrinkled crust on a fracture surface. FOV 2.08 mm.

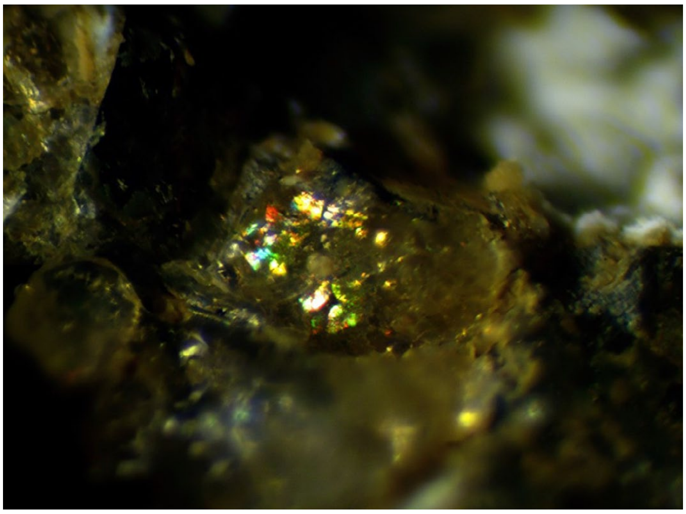


Cavity lined with iron-stained clay; very tiny ruby-red siderogel spheres on right. FOV 1.79 mm.

Siderogel and limonite are iron oxyhydroxides which form from oxidation of iron minerals such as pyrite in a wet environment, although here I have not found any indications of pyrite.

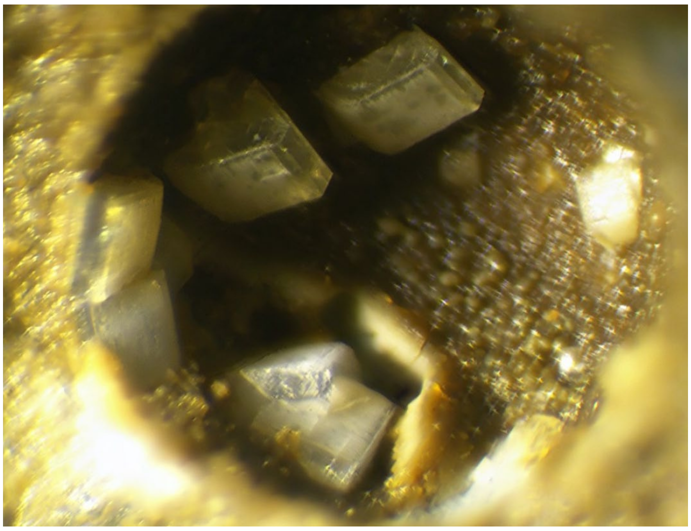


Very small patch of opal as a thin layer over clay minerals. FOV 1.5 mm.

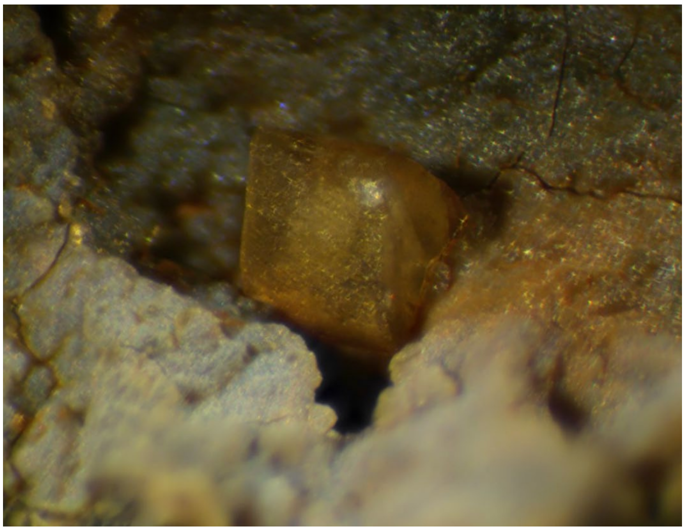


Another tiny patch of opal as a thin layer over feldspar.

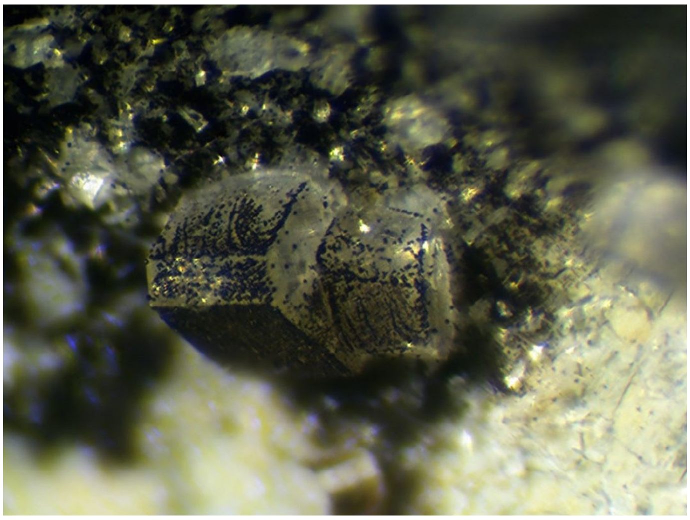
I found opal to be fairly common but except for these two tiny patches, it occurs as a thin glassy colourless layer, which gives the rock a wet look. Colourful opal is always likely to be extremely rare and very small, only visible with a microscope.

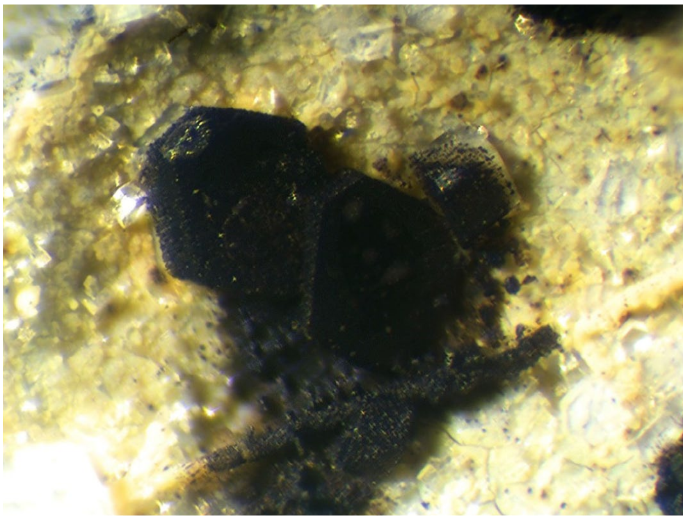


Heulandite crystals with whitish phantoms just under the surface. FOV 2.08 mm.

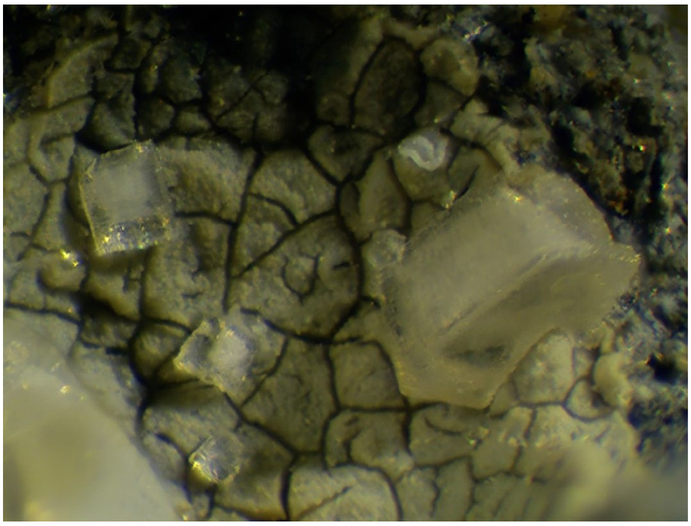


Yellow heulandite crystal. FOV 1.79 mm.

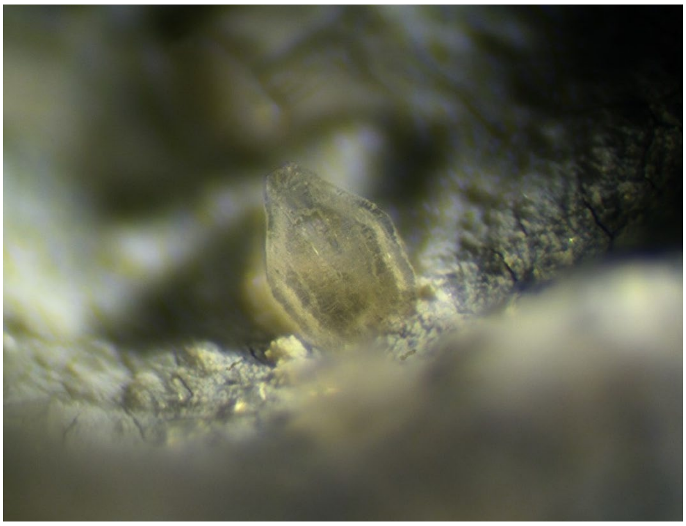




Heulandite crystals with black manganese oxides on the surface.

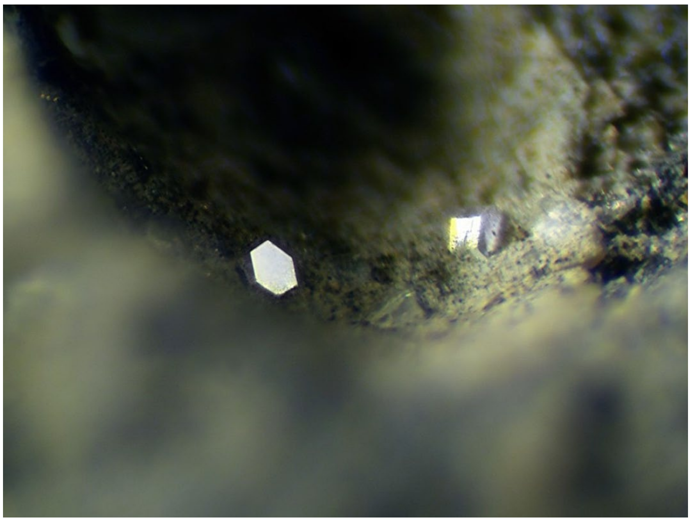


Heulandite crystals with whitish phantoms just under the surface. FOV 1.3 mm.

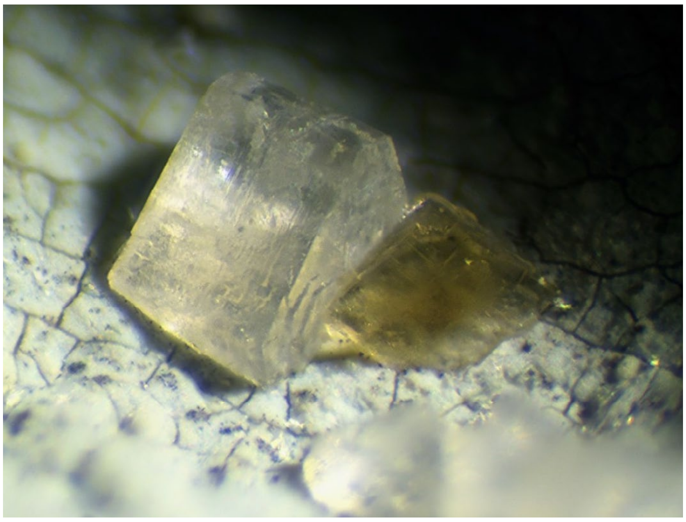


Heulandite crystal with whitish phantoms just under the surface on left and right sides.

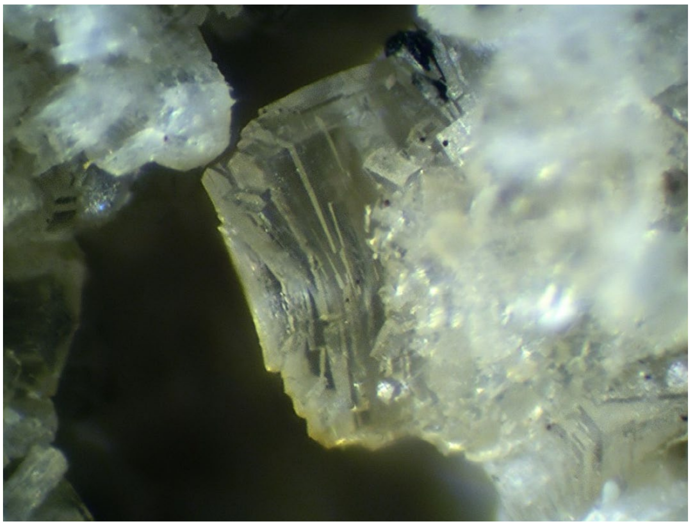
The phantoms in the heulandite crystals are a thin hazy layer and appear to be due to some alteration/deterioration of selected faces of the crystal before a second growth phase has deposited a new layer of heulandite over the top.

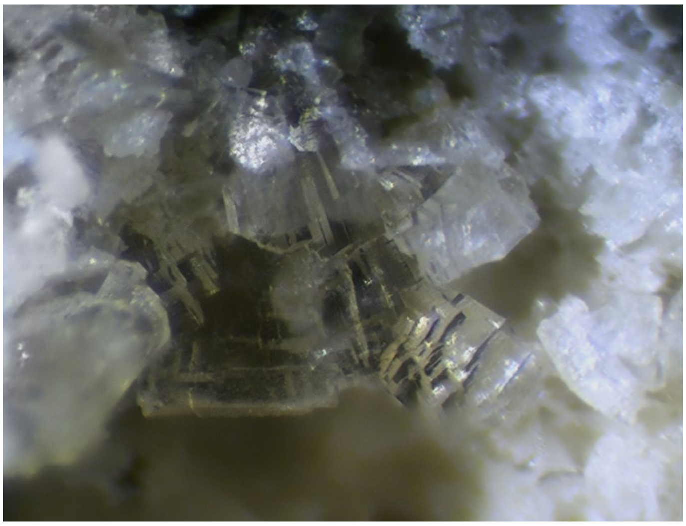


Pseudohexagonal heulandite - an unusual habit (slightly elongated on B axis).

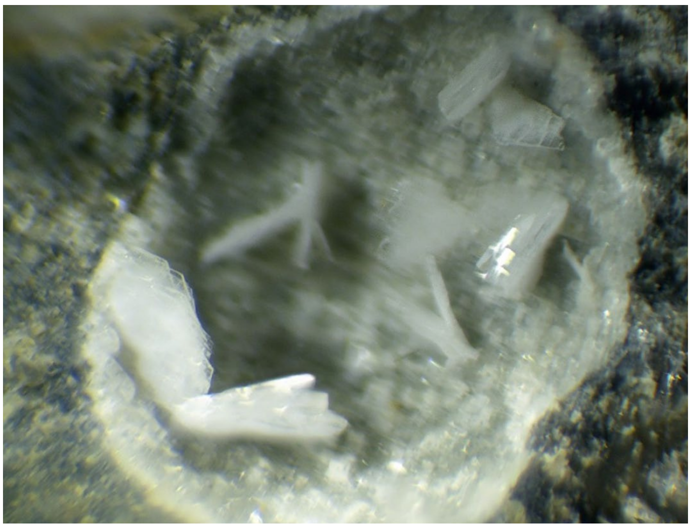


Heulandite crystal with yellowish unidentified blocky crystal to the right.

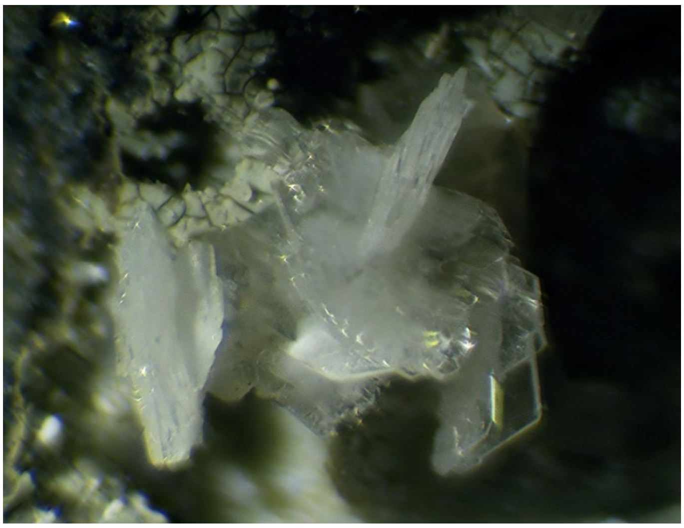




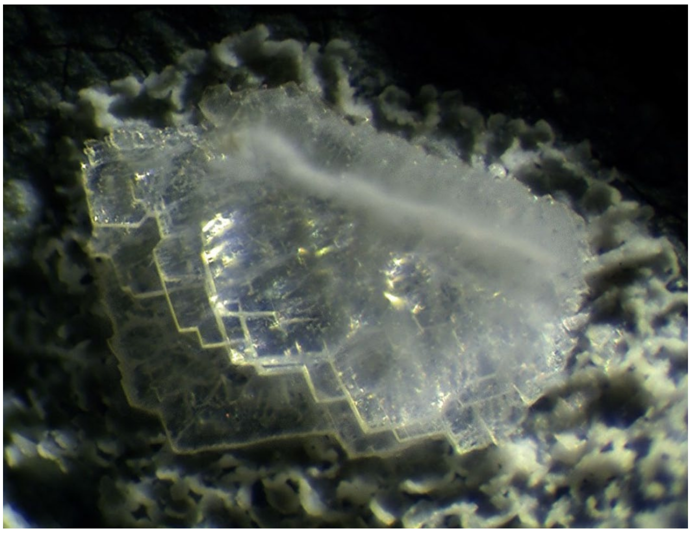
These appear to be stilbite crystals stacked side-on forming thick aggregates. The more whitish crystals are somewhat degraded and etched heulandite. They form the crystalline crust on the outer surface of some of the rocks I collected.

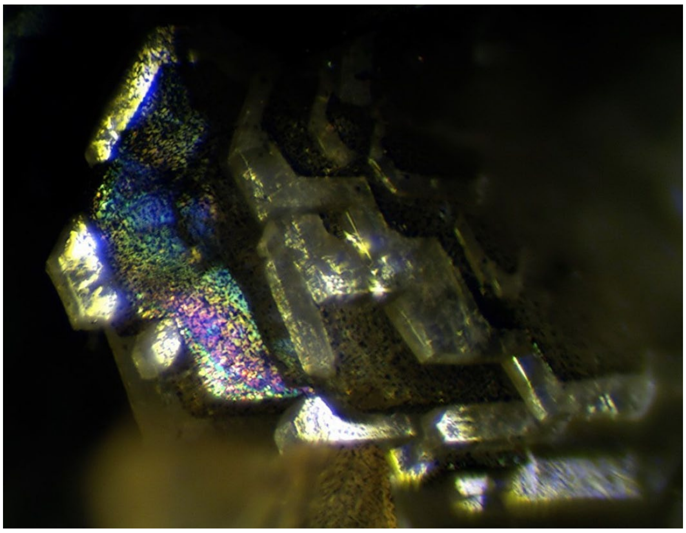


Baryte crystals on degraded heulandite. FOV 3.7 mm.

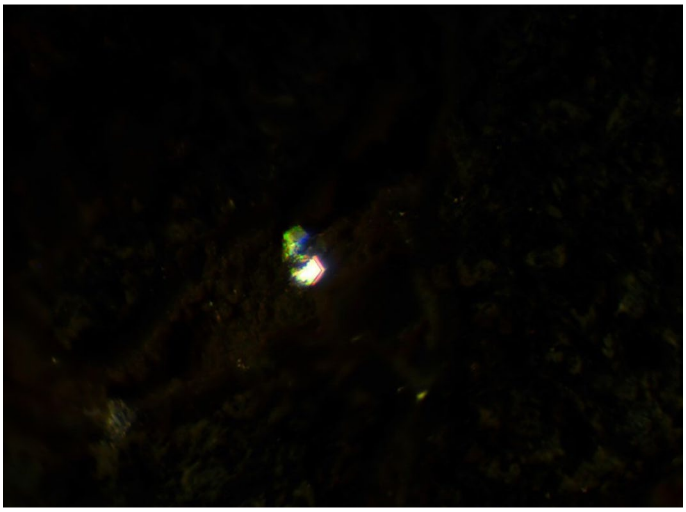


Baryte crystals. FOV 1.79 mm.

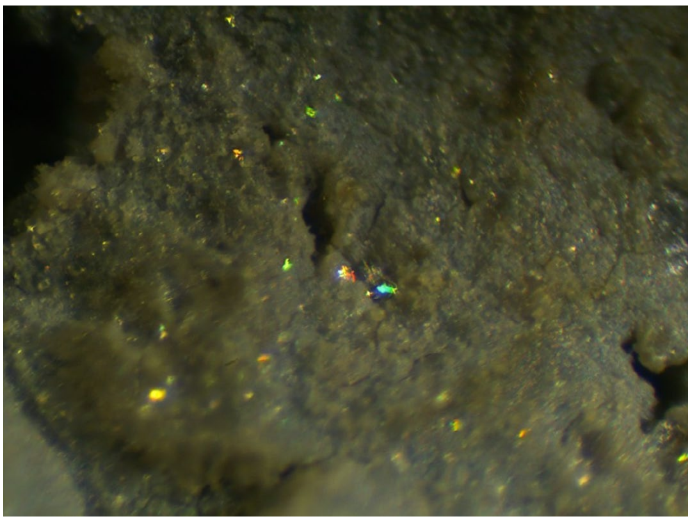

Baryte crystals on white clay.

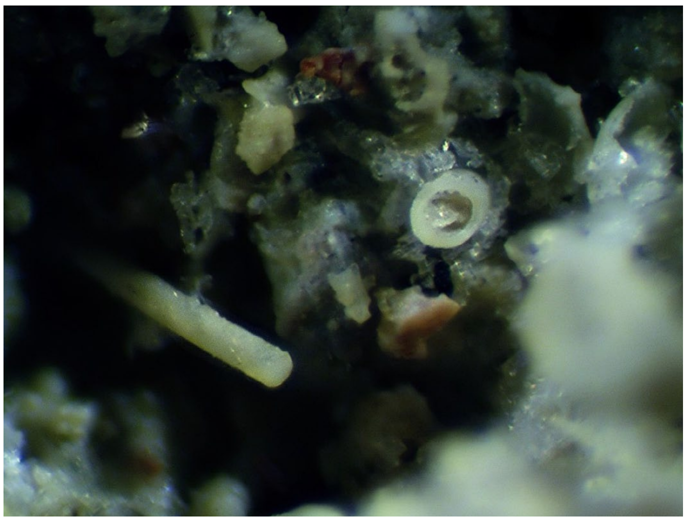

Baryte crystals with iridescent coating.

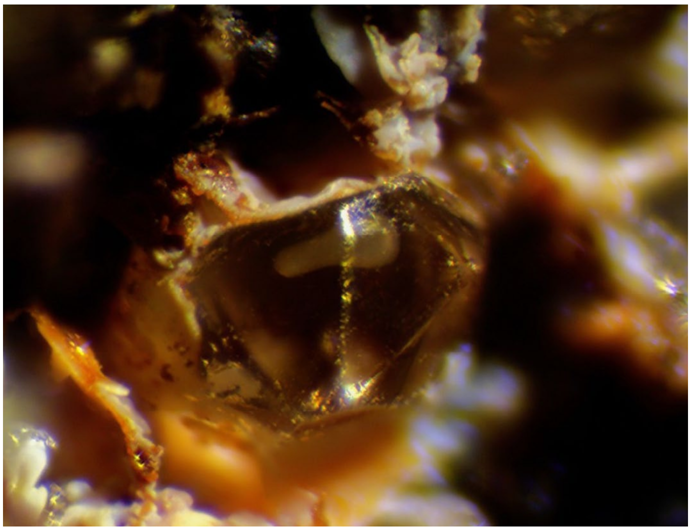
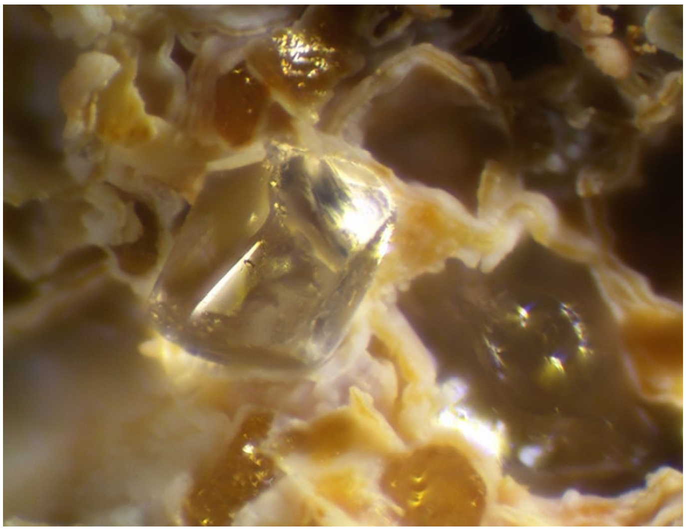

Small, very clear baryte crystals.


Ultra-thin baryte crystals about 0.015 mm long.

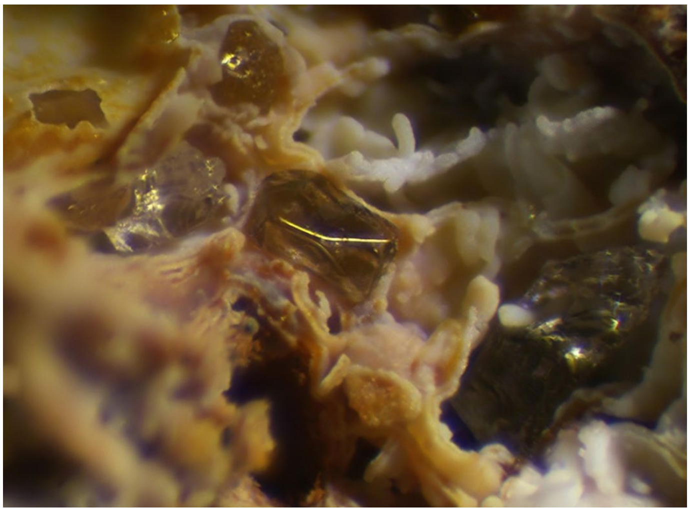
Several of the rocks I found had hair-line fractures in them in which very tiny glass-clear baryte crystals had formed. They are so thin that a phenomenon called “thin film interference” occurs, causing bright iridescent colours similar to what we see in soap bubbles or oil films on water. Some of the fracture surfaces have hundreds of these minute baryte crystals dotted all over them. Cavities in the outer parts of the rock contain somewhat larger baryte crystals as seen in the photos above.


Tiny iridescent baryte crystals.

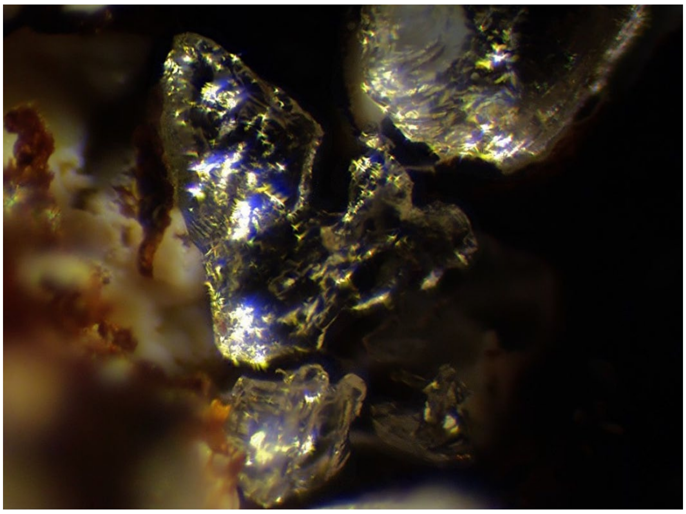

Marine fossil fragments in cemented ash.

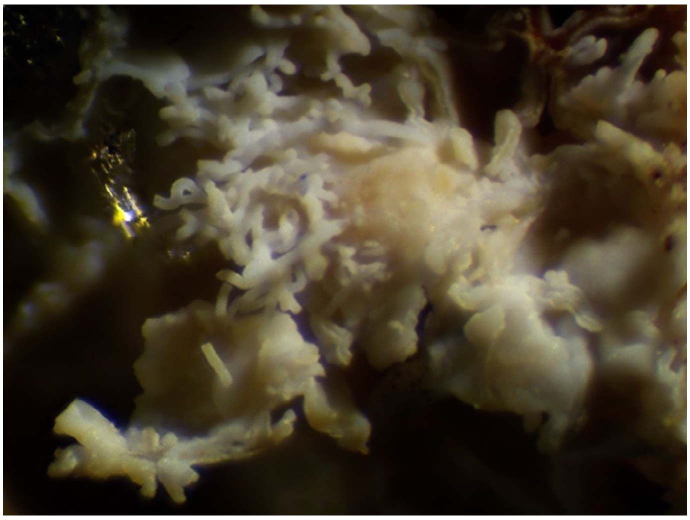
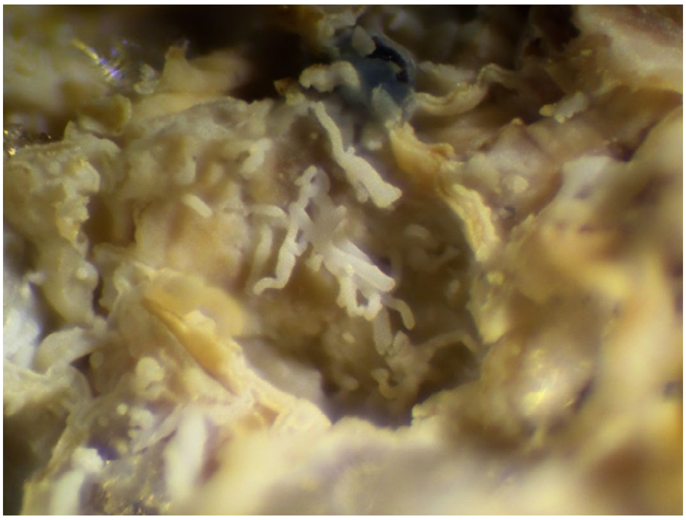
Iron-stained beta quartz crystal with white inclusion and a glassy-clear one, both embedded in hydrothermally altered rhyolitic crystal tuff.



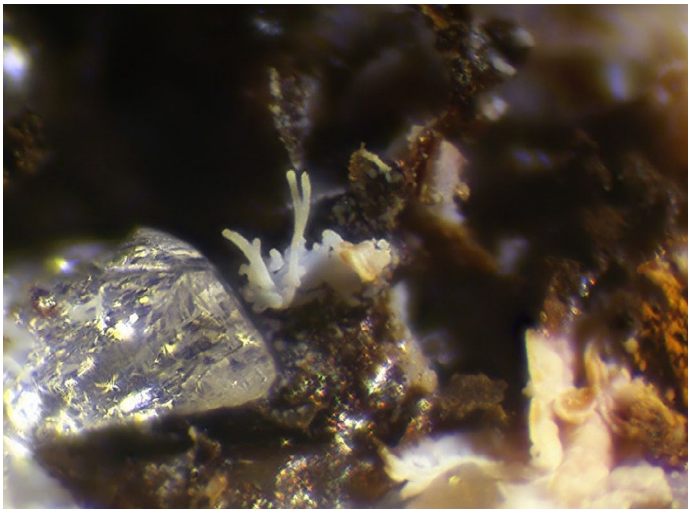
Yellowish beta quartz crystal.



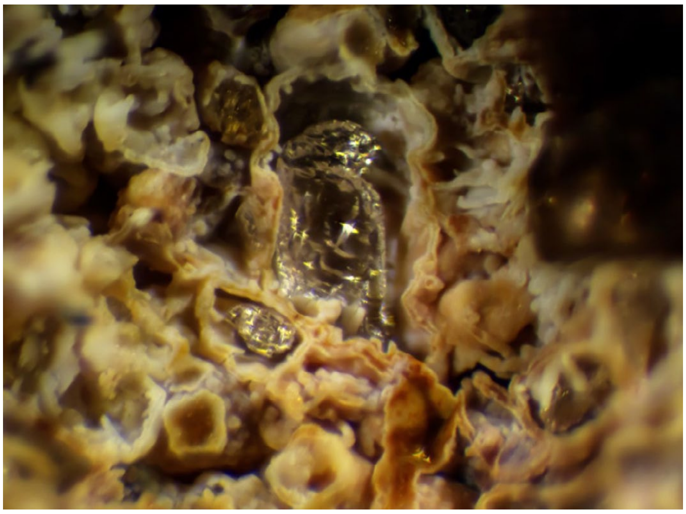
Highly etched feldspar fragments.

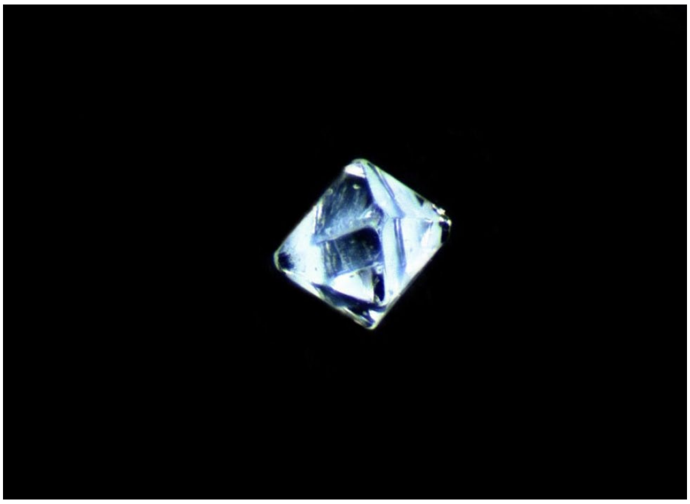
Delicate white clay structures in hydrothermally altered rhyolitic crystal tuff.



Etched feldspar fragment and white clay structures.



Etched feldspar fragments (note size reduction).



Beta quartz crystal, 0.7 mm across, from the nearby beach sand. These are quite common in the beach sands along the west coast. They originate from the Taupo Volcanic Zone and are deposited via the Waikato river.

Return to contents page

PROXY EVIDENCE FROM TAMAKI DRIVE FOR THE LOCATION OF SUBMERGED STREAM VALLEYS BENEATH HOBSON BAY, AUCKLAND CITY

Bruce W. Hayward

Early in 2020, contractors began work upgrading Tamaki Drive where it crosses Hobson Bay on the Auckland waterfront of the Waitemata Harbour. In so doing, they are repairing the subsided road and footpath and also raising them to combat rising sea level. This work will undoubtedly destroy the proxy evidence that has existed for many decades for the location of two late Pleistocene stream valleys, prior to the sea level rise between 18,000 and 7500 years ago, after the end of the Last Glacial period. When sea level was more than 30 m lower than present, the Purewa and Portland Rd-Newmarket Park streams flowed separately through/under what is now Hobson Bay to join the main Waitemata River somewhere off Devonport. On several occasions in the last 25 years Auckland Geoclub field trips have stopped on Tamaki Drive to examine and discuss this proxy evidence.

The proxy evidence for the location of these two former stream channels consists of two sections of Tamaki Drive that have subsided further than the rest (Figs 1–3) and periodically flood during king high tides. This extra subsidence is most probably due to the extra compaction associated with the greater thickness of Holocene mud that fills the channels compared with the mud that buries the ridge in between. The Auckland City Council GIS contour map (Fig. 4) indicates Tamaki Drive was likely built to at least 3 m above mean sea level and the amount of subsidence of these two sections is to near 2 m (over Portland-Newmarket valley) and 1.5–2m (over Purewa valley) and the section of road in between has subsided a lesser amount.

These subsided sections of road provided tangible evidence for what had long ago (1950s) been determined from boreholes by the Ministry of Works, Auckland Harbour Board and Auckland Drainage Board about the location and depth of these stream valleys eroded into Waitemata Sandstone beneath the soft Holocene mud fill of Hobson

Fig. 1. View east along the outside of Tamaki Drive causeway showing the subsided section above the buried Purewa Stream valley, west of the bridge. Photo: July 2020.

Fig. 3. Photo of work underway to raise the section of subsided Tamaki Drive where it crosses the buried Purewa Stream valley. Note the added 50 cm height of the new gutter. Photo: July 2020.

Fig. 2. View east along the outside of the Tamaki Drive causeway in the middle of Hobson Bay showing the subsided section above the buried Portland Rd–Newmarket stream valley. Photo: July 2020.

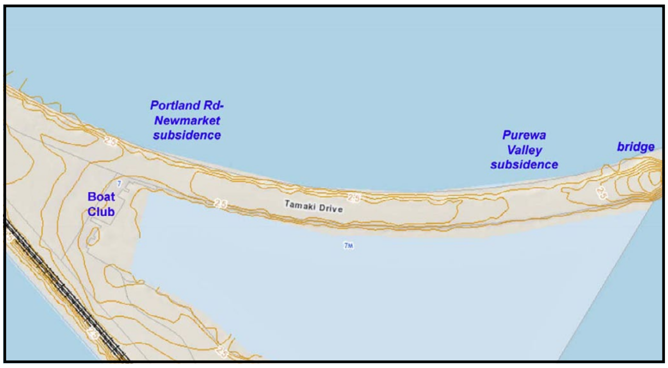


Fig. 4. Auckland Council GIS map of Tamaki Drive across the entrance to Hobson Bay on the south side of the Waitemata Harbour. Contours are in 0.5 m intervals. Note the two subsided sections between the bridge (right) and reclaimed boat club haul out area (left).

Bay (Figs 5–6), as published by Searle (1959). Searle noted that a close-spaced pattern of boreholes had been drilled by the Ministry of Works in preparation for proposed reclamation of the whole of Hobson Bay! The Drainage Board had undertaken detailed survey work along the line of the then sewer line that crossed Hobson Bay on stilts. This has recently been replaced by a tunnel beneath the bay.

Reference

Searle, E.J. 1959. Pleistocene and Recent Studies of Waitemata Harbour. Part 3 - Tamaki Head to Mechanics Bay. *New Zealand Journal of Geology and Geophysics* 2: 479–488.

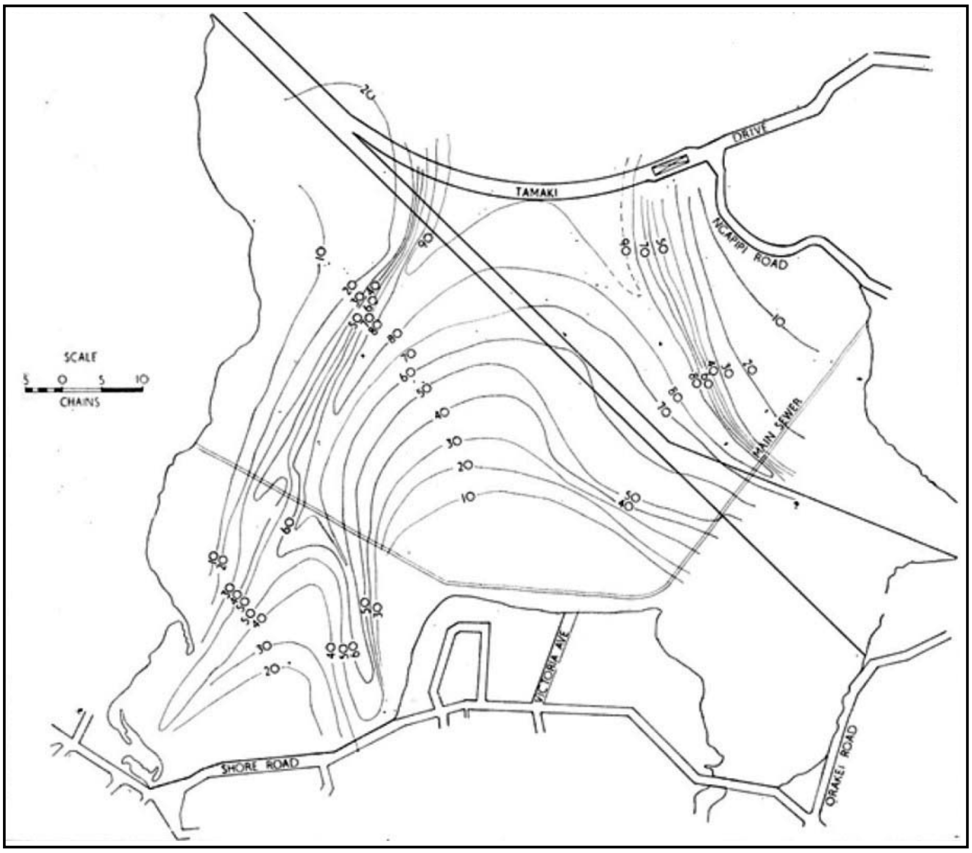


Fig. 5. Contour map of the Waitemata Sandstone–Holocene mud contact beneath Hobson Bay, which approximates the land surface contours prior to about 12000 years ago when sea level was 30 m or more lower. From Ministry of Works in Searle (1959). Contours in feet, scale in chains.

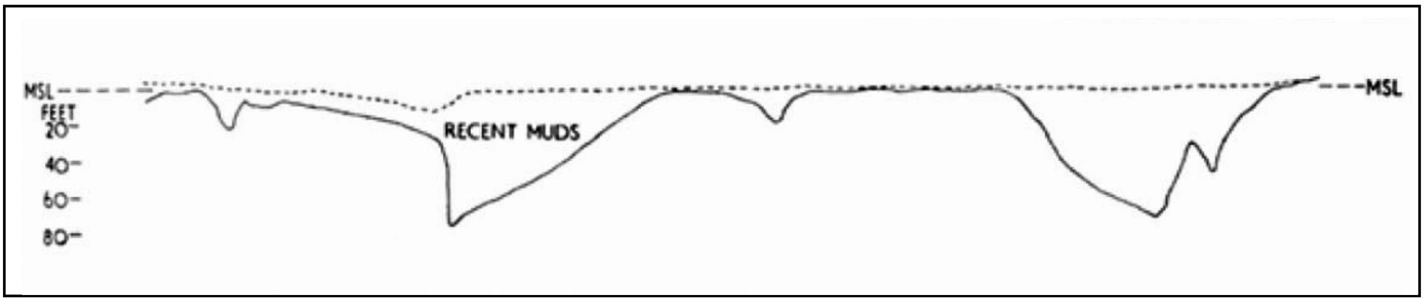


Fig. 6. East (left) to West (right) cross-section across Hobson Bay along the route of the former sewerage line. The solid line is the top of the Waitemata Sandstone and the pre-12000 years ago topography, whereas the dotted line is the present day surface of Holocene mud that now fills Hobson Bay. From Auckland Drainage Board in Searle (1959).

Return to contents page

THE FIRST EXPLANATION IS NOT ALWAYS THE BEST

Bruce W. Hayward

During covid-19 lockdowns, we have been walking a lot more locally. We have been walking more on the Tamaki Drive along the southern shore of the Waitemata Harbour in Auckland's eastern suburbs. Early in 2020 there were several storms that moved even more of the imported sand from the west ends of Mission Bay, Kohimarama and St Heliers beaches and deposited it at their eastern ends. This lowered the level of the sand above high tide mark at the west end of Kohimarama Beach and exposed more of the small, unused, concrete boat ramp adjacent to the pedestrian crossing that leads across to the Café on Kohi.

Now exhumed from underneath the sand was a 20–30 cm-wide and up to 5 cm-thick, irregular band of hard concrete-like, shelly, sandy rock extending almost right across the width of the boat ramp (Fig. 1). That is odd, I thought. So I took a closer look (Fig. 2). The band was well-cemented and seemed to consist of the same sand and shells that now form the beach. I knew the sand and shells had been dredged from 40 m depth off Pakiri and spread over the beach about 20 years ago, as also happened at St Heliers and Mission Bay (e.g. Morley *et al*., 1996). Now the shells that came in with the Pakiri sand were dominated by scallops and tuatua shells, which were not present on the original beach (mostly cockles and pipi). So it was obvious that this cemented band had formed in just the last 20 years.

Fig. 1. Horizontal band of cemented calcareous rock being exhumed from beneath the beach sand at the boat ramp at the west end of Kohimarama Beach in 2020.

I was well aware of many beach localities at about this high tide elevation around northern New Zealand where we have identified beach rock (e.g. Kear and Bowen, 1970), believed to have been cemented naturally over a nebulous period of time in the Holocene (last 7000 odd years) by solution and recrystallisation of the shell component of shelly sand. Wow, if this is beach rock as I suspected, then here was evidence of how rapidly it could be cemented – less than 20 years! Sand had blown over the cemented band when I came back to photograph it, so I waited until after heavy rain, which washed it clean for my first photographs. I wandered along the rest of the west end of the beach but could not find any more "beach rock". Maybe it was something to do with the concrete substrate of the boat ramp that influenced its formation?

Fig. 2. Close-up view of the hard, cemented rock at Kohimaramara Beach boat ramp showing it is mostly cemented Pakiri beach sand and shell.

In our walks we also visited the west end of Mission Bay beach where even more sand had gone walkabout and there, plastered on the man-made basalt groin, was a 1 metre "slug" of hard calcareous rock (Fig. 3) at about the same height as the band at Kohimaramara that also had been buried by beach sand. I sauntered over for a closer look but to my disappointment it contained angular pebbles of basalt, but also set in a hard calcareous matrix of Pakiri sand and shells.

This set me to thinking, could this and my Kohimarama "beach rock" be concrete? But their matrix seems to be the local sand and shell. Could workmen have used the local sand and mixed it with cement and water for local jobs in the last 20 years? I went back for more of a look around for evidence of fairly recent concrete work at Kohimarama that might have utilised the local beach sand. The artificial rock groins that kept the sand from being washed away were made of solid concrete – no evidence of local sand use, and besides, they were made

Fig. 3. Large "slug" of concrete against the basalt groyne, exposed when the sand was washed away from the west end of Mission Bay in 2020.

Fig. 4. Two rounded pebbles (of quartz and argillite) and a basalt cobble in cemented rock at Kohimaramara boat ramp.

Fig. 5. Exposed aggregate pavement of rounded quartz and occasional argillite pebbles, Kohimaramara.

before the sand was brought it. The basalt retaining wall had been repaired in several places quite recently, but the concrete mortar had not used local sand and shell either.

I went back to the cemented band on the boat ramp yet again and this time even more sand had washed off. My walking companions were not going to wait, so I had to look fast. This time I found an angular cobble of basalt in the rock. Mmm. Then, just as I was about to leave, there were two well-rounded pebbles of white quartz and grey argillite also cemented in the rock with the sand and shells (Fig. 4). Rounded quartz pebbles do not occur naturally around Auckland, I thought. Just a few metres away I then found the pavement had been replaced with exposed aggregate made of rounded and polished quartz and occasional argillite pebbles set in fine concrete (Fig. 5).

My first explanation that this cemented rock band at Kohimarama was beach rock no longer seemed acceptable and alas, I did not have an example of amazingly fast beach rock cementation. I now hypothesise that the exposed aggregate footpath was laid after the Pakiri sand and shells had been added to the beach. It would seem the concrete was probably mixed at the top of the boat ramp and when they had finished they washed spilled cement off the path and down the ramp into the shelly sand. Here it cemented the beach sand into the band that is now exposed, which does indeed look like hardened cement washings. The Mission Bay "slug" is also probably cement washings that workmen washed off into the sand, never thinking it would harden into this rock and be exposed years later by beach sand erosion.

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Kear, D., Bowen, F.E., 1970. Beachrock at Marble Bay, Northland, New Zealand (N8), *New Zealand Journal of Geology and Geophysics* 13:3: 729–733.

Morley, M.S., Thompson, F., Smith, N., Stace, G.A., Hayward, B.W., 1996. Mission Bay sand replenishment from Pakiri dredging. *Poirieria* 18: 27–40.

Return to contents page

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Return to contents page