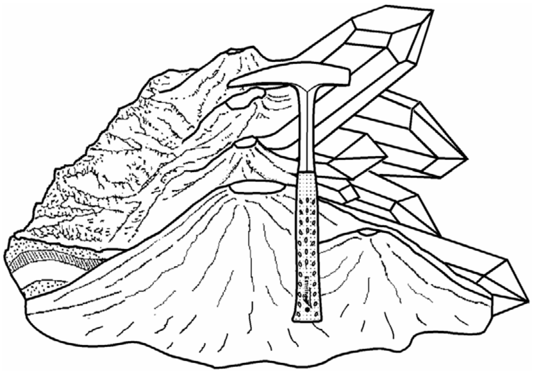

Geocene

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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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COMPACTION AT AIREDALE REEF FOSSIL FOREST, TARANAKI

Bruce W. Hayward and Brent V. Alloway

In early May 2021, a group of 25 Geoclubbers visited the well-known Airedale Reef fossil forest on the coast just north of Waitara, Taranaki (see **https://www.geotrips.org.nz/trip.html?id=2**). After examining the in-situ tree stumps and fallen branches and trunks buried in carbonaceous mud and peat in the intertidal reef (Fig. 1), we moved slightly north to look at the sequence in the low cliffs at the back of the beach (Fig. 2). We could easily distinguish fossil tree fern trunks from other wood in the black organic mud deposit.

In the cliffs, the organic mud/peat layer contained wood and trees in-situ overlain by a 4 m thick debris avalanche deposit (Okawa Debris Avalanche – Newnham & Alloway, 2004; Alloway *et al*., 2005). Many of the trees were buried in the mud and had died a long time before the avalanche came down, but others could have been hit and partly knocked over by the debris avalanche from Mt Taranaki (Fig. 3). In the cliff, it also looked as if some of the vegetation and organic mud/peat layer may have been stripped off and carried away in the avalanche and occasional rip-up clasts of the carbonaceous mud were within the deposit.

Fig. 1. Geoclubbers examine the fossil forest partly exhumed from the peat on Airedale Reef, Waitara, 2021.

Fig. 2. The 8 m high cliffs behind Airedale Reef, Waitara, display the stratigraphic sequence above the reef peat (black) with the 4 m thick Okawa Debris Avalanche deposit overlain by layered volcanic soils and volcanic ash beds.

In the cliff, we observed that the main Airedale Reef fossil forest peat layer varied in thickness and not only because of the variable erosion on top. The layer thickened and thinned and clearly seemed to have been deposited in wet areas that initially filled depressions between the underlying sand dunes. It eventually, in many instances, filled these depressions with mud and then lapped onto and over the low dune crests (Fig. 4).

The main scientific account of this locality is by Newnham and Alloway (2004) who focussed on the sequence and

Fig. 3. Two in-situ tree stumps in the carbonaceous mud on Airedale Reef. The left hand stump is at a 45° angle and may have been knocked over by the incoming debris avalanche.

Fig. 4. Part of the cliff at Airedale Reef showing the variable thickness of the main peat layer in the base of the cliff overlain by the debris avalanche deposit. Photo: Julian Thomson.

age of the strata in the cliff section (Fig. 5), the pollen record of the young climate cycles (Fig. 6) and the impact of the many volcanic ash showers on the local vegetation. They concluded that the fossil forest was established on top of the undulating sand dunes deposited on top of the Last Interglacial highstand terrace of Marine Isotope Stage MIS 5e (~125,000 years ago). Below the debris avalanche deposit, the pollen record indicates that there was a podocarp-dominated forest typical of a warmer climate (MIS 5e) that was progressively replaced by cooler climate (MIS 5d) shrubland as the local depositional environment changed from podocarp swamp forest to a peat bog (Fig. 6).

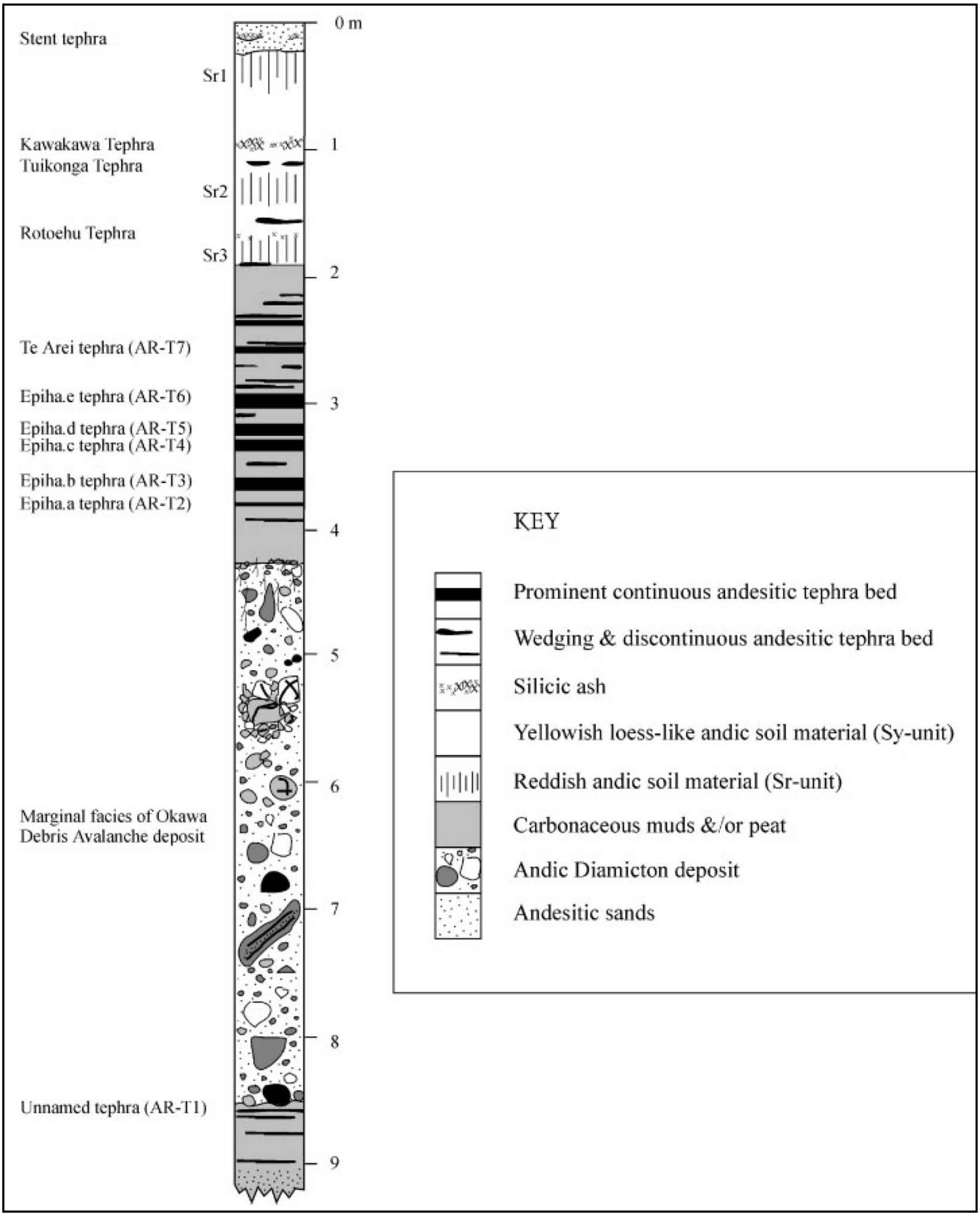

Fig. 5. Stratigraphic column for the cliffs at Airdale Reef (from Newnham & Alloway, 2004).

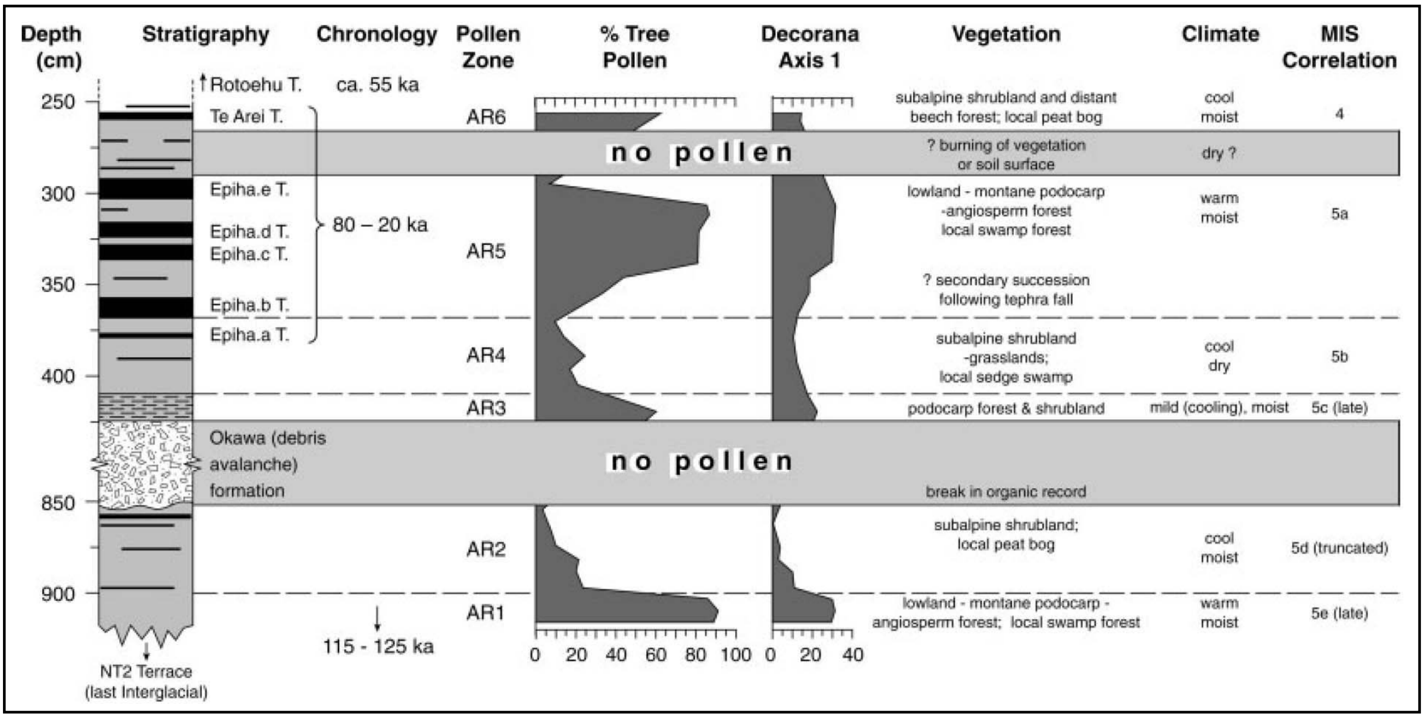

Fig. 6. Stratigraphic column, summary of pollen data and inferred MIS stages for the more carbonaceous parts of the cliff sequence at Airedale reef (from Newnham & Alloway, 2004).

In at least one place in the cliff, we observed that there was a younger lens (~1.5 m max thickness) of dark carbonaceous mud/peat deposited directly on top of the debris avalanche deposit that passed upwards into a more extensive layer (0.5–0.8 m thick) of mud with andesitic ash beds (Fig. 7). The upper 2 m of the cliff section was composed of reddish volcanic-derived soils with some more distinctive lighter-coloured rhyolitic ash beds from eruptions in the centre of the North Island (Fig. 7). Newnham and Alloway (2004) identified the distinctive Rotoehu Tephra (~45,000 yrs old, MIS 3) about 1.6 m below the modern surface. An amino acid racemisation age of 80,000 ± 20,000 yrs old (Bussell, 1988) for the level ~1 m above the top of the debris avalanche deposit indicates that the avalanche was emplaced ~100,000 yrs ago and pollen from just above it indicate a moderately warm climate (probably MIS 5c, Fig. 6).

As we walked along the cliff section, Geoclubber Wayne Syme pointed out that at one locality the Airedale reef organic mud/peat layer was tilted at 30° and disappeared beneath the beach gravel at the foot of the cliff (Fig. 8). How could this be? Was there a fault or slump or tectonic deformation we had not recognised? The answer was in the cliff in front of us. It was at this locality that there was the up to 1.5 m lens of younger organic mud on top of the avalanche deposit (Fig. 8). Newnham and Alloway (2004) had seen this too and noted “in part of the cliff section the formation appears to mimic the underlying topography, resulting in the development of a shallow concave basin on the upper surface” of the debris avalanche deposit that had filled with organic mud and peat. As they were focussed on the age and vegetation record of the section

Fig. 7. Cliff at Airedale Reef showing younger peat lens sitting above the debris avalanche deposit.

Fig. 8. The thick lower peat (bottom right) dips steeply into the cliff and beneath the beach gravel with the upper peat lens in the cliff to the left.
Photo: Julian Thomson.

they did not proffer an explanation for how this formation may have been created.

An explanation for the origin of the downfold and upper peat lens

Observations:

1. In the low cliffs, the Airedale Reef woody peat layer dips northwards at ~30° and disappears beneath the beach gravel.
2. ~20 m further north the same peat layer reappears and rises up from under the beach gravel at a similar steep angle.
3. In exactly the same place a younger upper peat lens (up to 1.5 m thick in the centre) fills a depression on top of the debris avalanche deposit (Okawa Formation).
4. The Okawa debris avalanche deposit appears to be the same thickness (~ 4 m) between these two peat layers and follows the fold of the depression.

Hypothesis:

1. At this locality there was a deeper depression between the sand dunes than elsewhere in the cliff section. Thus this interdune depression was a pond/swamp for longer than elsewhere and accumulated a much greater thickness of soft peat and mud. By the time the debris avalanche was emplaced this depression was full to its rim with organic sediment that extended as a much thinner layer over the tops of the surrounding sand dune crests.
2. The Okawa debris avalanche was emplaced in this locality as a sheet of uniform thickness (4 m).
3. Under the weight of the dense debris avalanche deposit, the soft spongy peat layers was compacted over a relatively short time (years to thousands of years).
4. Where the peat was thickest the peat was compacted the most (possibly down to as much as 0-3-0.2 of its original thickness). Over time the amount of compaction in the depression under study was ~1.5 m in the centre becoming less on either side. This compaction created the downfold not only in the Airedale Reef peat layer, but also in the overlying Okawa debris avalanche deposit.
5. As a result the ground surface on top of the debris avalanche deposit became a basin that in turn became a swampy pond that accumulated peat while the surrounding higher land was vegetated.
6. If we use the pollen-identified climate stages of Newnham and Alloway (2004) then all, or most, of the compaction occurred between mid MIS 5d (110,000 yrs) and end 5c (92,000 yrs) or less than 20,000 yrs, but probably much faster than that.

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TE TAROTIRI Ō TAKAMIRO/CUTTER ROCK IS FALLING DOWN

Bruce W. Hayward

Auckland Geology Club's first field trip was to Whatipu in December 1992. Since then, we have been there to look at the geology a further four times. The most recent was in May 2021. On the first trip, after visiting the abandoned sea caves, we all trooped over to examine Cutter Rock (Fig. 1), surrounded by sand off the mouth of the Whatipu Valley. On the last three occasions we have looked over at Cutter Rock from a distance (Fig. 2) - only about half the size of what it was when we first visited it in 1992.

Cutter Rock is made of weakly stratified volcanic conglomerate and sandstone of the Piha Formation. The stratification dips at 36° to the southwest (Hayward, 1983). The rock was a sea stack during most of the Holocene (last 7500 years), sometimes as an "old hat islet or stack" surrounded by sea water, even at low tide (Figs 3, 4), and at other times linked to the mainland by the sandy beach when the tide was out (Figs 5, 6). At these times, when the sand surrounding it was at mid tide level or lower, you could clearly see that the islet was surrounded by a high tide shore platform forming the brim of the old man's hat (Figs 3, 4, 7).

Fig. 1. Aerial view looking east over Whatipu Beach with Cutter Rock surrounded by vegetated sand flats (left), the Ninepin (far right) and larger Paratutai Island (middle right). Photo taken in early 2000s prior to the first collapse of Cutter Rock.

Fig. 2. Cutter Rock viewed from Caves Track in 2017. Photographer Bruce Hayward.

In the 1940–60s, sand build out the Whatipu sand flat seaward of the cliffs. From the 1960s on, Cutter Rock has been landlocked (Fig. 8), surrounded by the sand flat that extends one km or more out to sea. Since the 1990s, the sand flat between the cliffs and Cutter Rock has become progressively wetter and more vegetated (Fig. 9).

Cutter Rock had two near vertical sides (Figs 3–5), a steeply sloping seaward side (almost parallel to the dip of the conglomerate, Fig. 7) and the landward side had a distinct overhang that had eroded out at high tide level (Fig. 7), in the same way as the high-tide notch was eroded on the sheltered side of nearby Paratutai Island (Fig. 10). When viewed from the south, the rock appeared to have a distinct snout and head, which led to its nickname of "The Hedgehog" (Figs 7, 11).

On the night of 31st May, 2007, some of the people staying at Whatipu Lodge, approximately 1 km from Cutter Rock, were shaken awake by some unseen phenomenon.

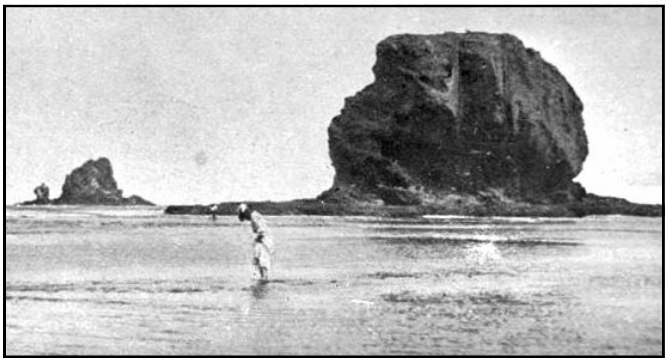

Fig. 3. Cutter Rock (right) surrounded by sea water in 1908, Ninepin Rock in distance (left). Photographer unknown, JT Diamond collection, Auckland Libraries.

Fig. 4. View south to Cutter Rock and Ninepin Rock (behind) in 1929 showing the rock surrounded by sea at mid-low tide. Photographer R. Middlebrook, JT Diamond collection, Auckland Libraries.

In the morning, Cutter Rock was seen to have lost about one third of its size with large blocks of rock strewn over the ground on the northern side (Fig. 12). There were two new intersecting vertical planes on the side of the rock where the blocks had fallen away (Fig. 13). The overhanging snout was still in place (Fig. 14).

The precise time and date of a second, smaller collapse is unknown, but occurred some time between 24–29th May, 2010. On this occasion, the overhanging eastern side of Cutter Rock also tumbled down (Marnie Hunter, Whatipu Lodge manager 2010, pers. comm. 2021). Once again, a new vertical planar surface was left where the blocks fell away (Fig. 15). After this second rockfall only about half of the pre 2007 Cutter Rock now remains standing (Figs 16–17). I wonder how long before we lose more.

So what happened? The Piha Formation is cut by numerous near-vertical joints and faults, and this was clearly true in Cutter Rock as well. In many places along the coast of the Waitakere Ranges, the base of the cliffs are littered with blocks of rock (large and small) that have fallen off the cliffs above, having split away along a planar joint or fault. In Cutter Rock, the main smooth joint plane that the rocks peeled off from is oriented at ~070° (ENE), parallel to the Whatipu Valley and northern shore of the Manukau Harbour entrance (between Paratutai and Little Huia). The second joint set that failed in Cutter Rock is oriented at ~170° (~NS), which is approximately parallel to the Waitakere's west coast. These two joint plane trends thus seem to be widespread in the Waitakere Ranges and probably played a significant part in controlling the shape of the present coastlines and stream orientations.

The steep joint and fault planes are clearly zones of weakness through the rock which preferentially fail. These failures could be due to earthquake shaking but no significant earthquake was recorded at the times of the rock falls and so this was not the trigger. Excess rain could potentially lubricate the joints and weaken them, but rainfall records do not indicate any unusually heavy rainfall at the times of the rockfalls or during the preceding month. Thus, one must conclude that the weakening of the joints was progressive and the rockfalls themselves were not triggered by any single event. The second rock fall, just three years after the first, was undoubtedly partly a result of the removal of some support by the 2007 collapse.

The fact that no similar block falls seem to have occurred in the centuries or every millennium prior to the 1950s,

Fig. 5. Cutter Rock joined to the mainland by sand at mid tide in the early 1950s. Photographer J.T. Diamond, Auckland Libraries.

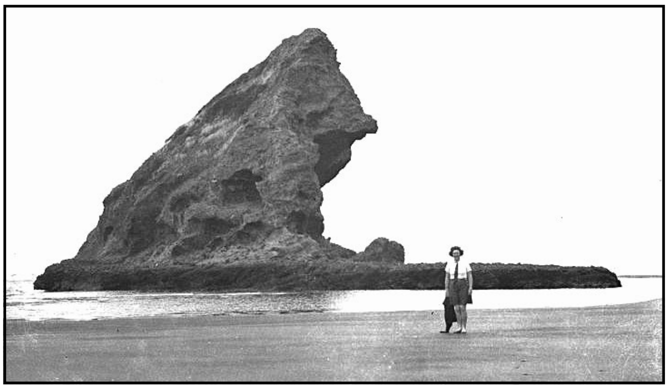

Fig. 7. Cutter Rock from the south in 1940, showing the wide high tide shore platform and notch eroded out on the east side (right). Photographer I. Hooker, Auckland Libraries.

Fig. 6. Cutter Rock (centre) surrounded by sand at high tide in 1958 with Whatipu Stream flowing in two branches either side of the rock and flooding the sandflats to the west of it. Photographer J.T. Diamond, Auckland Libraries.

Fig. 8. By the 1960s, the sand flat surrounding Cutter Rock was becoming colonised by sand-tolerant plants with cattle roaming freely over the new land. Photographer J.T. Diamond, Auckland Libraries.

Fig. 9. View from the southeast showing the extensive thick vegetation cover over the sand flats around Cutter Rock by 2007. Ninepin far left.
Photographer Bruce Hayward.

Fig. 10. The high tide notch and overhang on the sheltered side of Cutter Rock (Fig. 7) was formed by the same processes of wetting and drying as the notch on the inside of nearby Paratutai, seen here in 1993. Photographer Bruce Hayward.

Fig. 11. When viewed from the south prior to 2010, Cutter Rock had a profile that had earned it the nickname "The Hedgehog". Photographer J.T. Diamond, 1971, Auckland Libraries.

when Cutter Rock was a stack surrounded by the sea, suggests that sand build up around it may have created the conditions that resulted in joint plane failure. Once cut off from the sea, the stack would no longer have been frequently wetted by breaking waves and sea spray. As a result, the stack, including the joint planes inside, would have dried out more often and for longer periods of time, especially in summer. This may have promoted weathering of some of the rock minerals to clays along the joints and also resulted in more frequent wetting and drying cycles that promote frittering and potentially also weakened the joints.

Acknowledgements
I am grateful to John Walsh, Wayne MacKenzie and Marnie Hunter for alerting me to the rock falls and in providing information on the precise timings.

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Fig. 12. During the night of May 31, 2007, one third of Cutter Rock collapsed with large blocks spread around its northern side. Photographer Bruce Hayward, December 2007.

Fig. 13. Cutter Rock in Dec 2007 showing the joint planes that failed, particularly the one trending ENE towards the camera. Photographer Bruce Hayward.

Fig. 14. Even after the first rock fall, the overhang and "snout" were still in place.
Photographer Bruce Hayward, December 2007.

Fig. 16. After the two rock falls, Cutter Rock (viewed from the South) is only about half its original size.
Photographer Bruce Hayward, 2014.

Fig. 15. Cutter Rock after the 2010 rock fall which took away the overhang and face on the left side of the rock. The two joint faces and blocks from the 2007 rock fall occupy the right side of the rock.
Photographer Bruce Hayward, Nov 2010.

Fig. 17. Google Earth vertical photo showing the remains of Cutter Rock in 2017 with debris from the two rock falls strewn over the ground to the north. The 2007 rock fall produced the scalloped joint faces on the left half and the 2010 fall produced the scalloped face on the right half.

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SOME NOTES ON ERIONITE, A ZEOLITE 'ASBESTIFORM'

Martin Brook and Janki Patel

Introduction: Zeolites

The name 'zeolite' originates from the Greek words 'zeo' (to boil) and 'litos' (a stone). In contrast to asbestos, zeolite minerals are aluminosilicates, known as "molecular sieves", but some have similar fibrous properties to asbestos minerals, and can be characterised as "asbestiform". Zeolites typically form when silica-rich volcanic ash or aluminosilicate minerals are dissolved by groundwater percolation and recrystallised as zeolites within the pore spaces of rock (Marantos *et al*., 2012). Zeolites have some unique and outstanding physical and chemical properties, making them extremely useful in a variety of applications including agriculture, ecology, manufacturing and industrial processes (Brathwaite, 2017). Analytical procedures to characterise zeolites typically include XRD, SEM and TEM. An SEM-EDS image and spectra from an Auckland erionite sample is shown in Fig. 1.

Hazardous zeolites

While zeolites are different to the six regulated asbestos minerals, erionite in particular, is a fibrous zeolite "asbestiform", that can have similar health impacts to asbestos mineral exposure (Brook *et al*., 2020). However, erionite is not used for industrial purposes and is not specifically regulated (Gluckman, 2015), but is classified by the International Agency for Research on Cancer (IARC, 2012) as a Group 1 carcinogen (i.e., carcinogenic to humans). If inhaled and respirated, the long, straight erionite fibres are persistent in the lung and are toxic, leading increased risk of Malignant Mesothelioma (Carbone *et al*., 2019). In New Zealand, the management of asbestos in a place of work is governed by the Health and Safety at Work (Asbestos) Regulations (2016), with respirable asbestos defined as a fibre that is:

- < 3 micrometres wide;
- > 5 micrometres long; and
- has a length to width ratio of more than 3:1.

The implication is that fibres of this size could potentially make their way into the lung. Nevertheless, a key issue with erionite is that, unlike with exposure to manufactured asbestos in the workplace, the epidemiology of erionite exposure and subsequent health impacts can be complex. This is because of the long time-lag (sometimes >30 years) between exposure to an erionite fibre and development of Malignant Mesothelioma symptoms (Carbone *et al.* 2011). A further compounding problem is the genetics of people who come into contact with, and then inhale (and respire), erionite. Indeed, as with some other cancers, the presence of the BAP1 gene appears to make people more genetically pre-disposed to developing health issues from erionite exposure, such as Malignant Mesothelioma (Brook *et al*., 2020).

The first reports of the carcinogenicity of erionite came from studies in three villages in the Cappadocia region of Turkey in the late 20th century (Carbone *et al*., 2019), and subsequent cases have been reported in the USA (Ilgren *et al*., 2008). Indeed, in the 1970s and 1980s in Turkey, epidemiologists discovered a very high rate of Malignant Mesothelioma of 800 cases per 100,000 population, which is >1000 times the rate in the general population of industrialised countries (McBride, 2020).

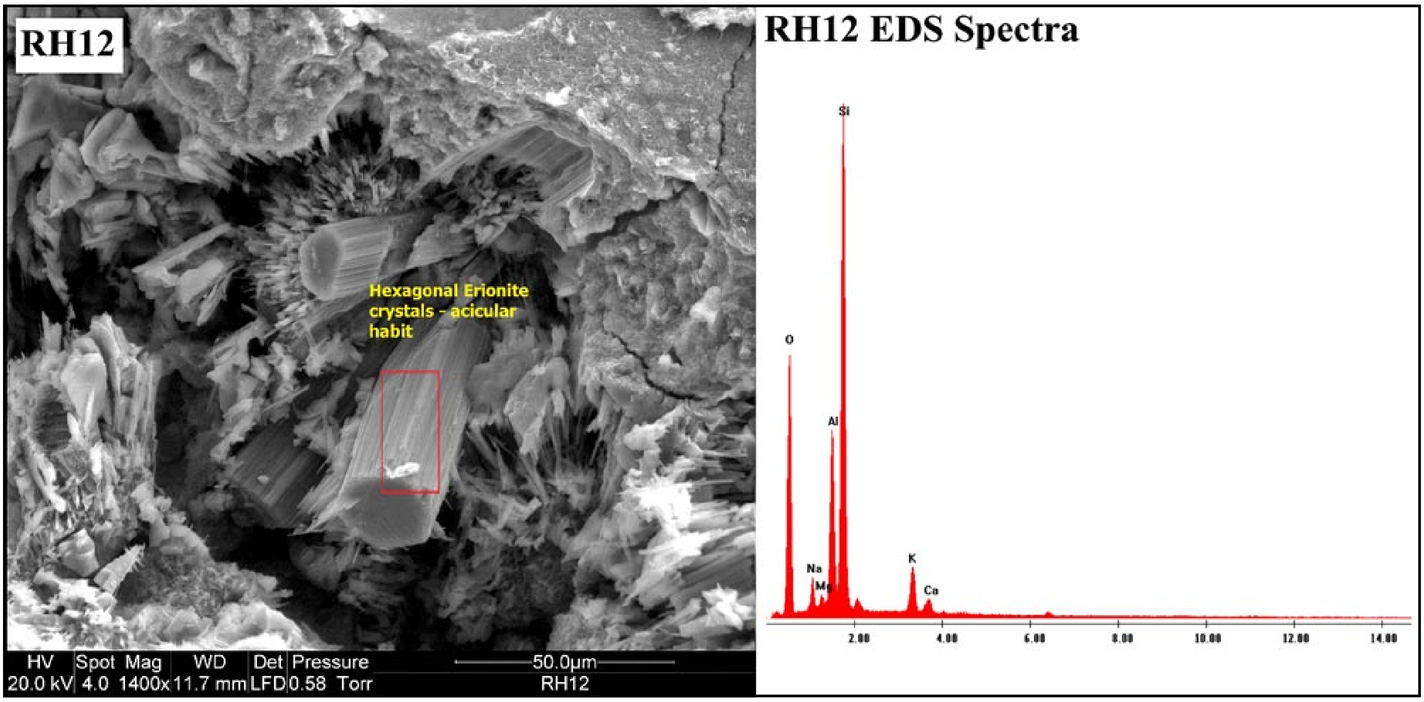

Fig. 1. Hexagonal elongate erionite fibres from the Waitemata Group, Riverhead.

Other zeolites such as mordenite and offretite can produce fibres, but work on the toxicity of these fibres is only just emerging in the international journal literature.

Asbestiform mineral toxicity

Asbestiform minerals can collectively include mineralogical asbestos as well as some zeolite minerals and other mineral fibres (e.g. palygorskite; Kirkman and Wallace, 1994). New Zealand is one of a number of high-income countries with elevated incidence of Malignant Mesothelioma (2.6 per 100,000). Countries with elevated rates are thought to be due to (1) mining of asbestos, (2) exposure to airborne asbestos fibres from manufactured products in occupational settings (Glass *et al.*, 2017) and (3) domestic DIY asbestos disturbance. An emerging 4th cluster is people presenting with "asbestos-type" exposure symptoms, but having had no known exposure to asbestos. In some cases, this may be due to workers bringing asbestos into the family home on overalls, and family members then inhaling fibres and later developing symptoms. Thus, New Zealand's asbestos-related disease has been described as an epidemic (Kjellstrom, 2004).

In addition, in recent years overseas, there has been an emerging focus of geologists and health professionals on the distribution of naturally occurring "asbestiform" (NOA) mineral fibres in rocks and soils, disturbance of the rocks and soils by human activities, and possible exposure pathways (e.g., Carbone *et al.*, 2019; Petriglieri *et al.*, 2020). This is because, as with the inhalation of processed asbestos products used in industry, the inhalation and respiration of NOA fibrous minerals can also induce severe diseases such as Malignant Mesothelioma, ovarian and lung cancer, as well as non-malignant illnesses such as asbestosis and pleural fibrosis (Carbone *et al.*, 2019). From in vivo (i.e. rodents) and in vitro (laboratory co-culture) studies, the toxicity of erionite is thought to be much greater than asbestos, possibly up to 600 times. Comparison "potency" factors of "asbestiform" minerals developed by Korchevskiy *et al.* (2019) are reported in Table 1. In terms of toxicity, erionite is orders of magnitude more potent as a carcinogen than asbestos minerals, according to this work.

Table 1. Potency of different types of mineral fibres with regard to mesothelioma (data from Korchevskiy *et al.*, 2019).

Mineral fibre	Potency factor
Amosite	0.07
Chrysotile	0.0006
Crocidolite (Australia)	0.26
Crocidolite (Cape Province	1.2
Libby amphibole	0.07
Anthophyllite (Russia)	0.017
Erionite (Turkey)	2.58

Where is erionite in New Zealand?

The presence of erionite in New Zealand has been known for some time (Sameshima, 1978; Davidson and Black, 1994), yet at present, possible public and occupational health implications remain unknown here (McBride, 2020). Erionite tends to form within altered ash layers in volcanogenic sediments, or in basalt vugs. Jack Grant-Mackie sent a sample of erionite from Kaipara in the late 1970s to the UK for toxicity testing on rodents, and the effects were reported in seminal papers by thoracic physicians at the University of Glamorgan (Wagner, 1982; Wagner *et al.*, 1985). Other known sites of erionite include the Waitemata and Waitakere Groups around Auckland, altered ash in the Taupo Volcanic Zone, volcanics in Coromandel, and sites in Canterbury and Otago (e.g. Waitaki District Council, 2018) in the South Island. There are likely to be other sites, and whether or not erionite is also present in soils is unknown at this stage. Erionite has been reported in some Pacific island countries and territories, such as Fiji, by former University of Auckland PhD student, Arishma Ram (Ram *et al.*, 2019).

Concluding remarks

We are at the start of a large 4-year project to study the presence and potential exposure pathways of erionite in New Zealand, funded by MBIE and the Royal Society of New Zealand. The paragenetic pathway of erionite is intriguing, but it appears to often be present with a more common zeolite, mordenite. We would be very keen to hear about specific occurrences of zeolitized ash beds and/or other zeolite localities or samples from the readership of Geocene.

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Geology field trip

ROAD CUTTING EXPOSURE IN PANMURE BASIN TUFF RING

Bruce W. Hayward

Geocene is a highly suitable place to lodge permanent records of temporary exposures of interesting rock features that will be weathered away or covered in vegetation or concrete within a few years of their being made. After many years of planning and consultation with local groups, work started in 2019 on widening Lagoon Drive through the east side of Panmure Basin explosion crater in the Auckland Volcanic Field. This was to provide sufficient carriageway width for two lanes of normal traffic, and a new two-lane busway and a cycleway. Various groups, including the Geoscience Society of New Zealand, successfully lobbied to prevent the road being extended out into the tidal basin and thus new, longer and higher cuttings were required to be made into the tuff ring on the eastern side of the existing road (Fig. 1).

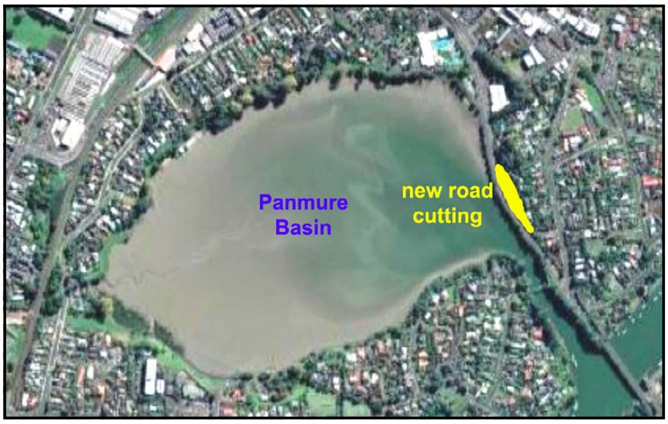

Fig. 1. Google Earth satellite photo of Panmure Basin showing the location of the new road cutting.

The new cutting was on the east side of the inner, basin end of the tidal channel through which sea water enters and exits the basin with the tidal cycles. The cutting was about 50 m wide and ranged between 6 and 12 m high. It was difficult to get access to it while it was being cut and to photograph it when it was not obscured by machinery. My best composite photograph of the whole cutting was taken from the far side of the existing road in Nov 2019 when some machinery was parked beneath it (Fig. 2). The other photographs were taken on the afternoon before New Zealand went into Covid-19 lockdown in March 2020 when all work had stopped and all machinery parked up (Figs. 3–10). At the time of writing, June 2021, the new road is close to opening and the cutting is still visible beneath its wire-netting protective coat, but becoming less crisp and more weathered.

Description

The 12 m thick section can be divided into four units.

1. The lower 2+ m unit at the northern end of the cutting consists of a bed of massive tuff breccia (Fig. 2) containing angular to subangular boulders (up to 60 cm), cobbles and pebbles of Waitemata Sandstone and occasionally Parnell Grit (Fig. 4). Rare bombs of fresh black basalt are also present (Fig. 5) sitting in the massive lapilli and ash matrix. This unit appears to be an in-situ phreatomagmatic explosive breccia that blasted out a mix of basalt tephra and fragmented country rock ripped from the wall of the volcano's throat within a few hundred metres of the surface. Although Pleistocene rhyolitic sediment and peat outcrop at the surface immediately beneath Panmure Basin tuff both inside and inside the basin (Hayward *et al.*, 2008), no recognisable clasts of this soft material were visible.

2. This lower tuff breccia is overlain by a 3–5 m thick unit of mm–cm bedded tuff that is broken up into numerous blocks by small intra-unit faults tilted at 30–60° to the north and spaced at 0.5–2 m apart (Figs 2, 6, 7). The tuff beds themselves dip at 20–30° to the south. There are also a few keystone faults indicative of pull-apart tension within some of the upper tuff blocks (Fig. 8).

3. On top of the disrupted blocks of bedded tuff there is a 0–3 m thick unit of chaotically mixed bedded tuff and tuff breccia (Fig. 2) with a wavy upper surface (Fig. 9), which is inferred to be the top of a slide/slump unit.

4. The uppermost unit in the cutting is 6 m of undisrupted bedded tuff that drapes the irregular wavy upper surface of the slump (Fig. 9), filling in the shallow hollows and then building up with a slope of 10–30° to the south (Fig. 10).

Conclusion

The large road cutting made in 2019–2020 beside Lagoon Drive exposed a 12 m thick section through part of the southeast corner of the Panmure Basin tuff ring. Within this section there is a 5–6 m thick slump unit containing disrupted blocks of bedded tuff and chaotically mixed blocks and tuff breccia. The slump unit overlies apparently in-situ tuff breccia and is buried by further airfall tuff that drapes over the undulating surface of the slump. This is an indisputable example of slumping on the slopes of the tuff ring during the period of volcanic eruptions from the Panmure Basin centres. There are no thick deposits of scoria within or exposed at the top of this cutting, which supports previous inferences that the scoria produced by dry fire-fountaining during the last phase of eruption of Panmure Basin either built a scoria mound within the crater or was blown to the northeast to build the Cleary Rd mound (Hayward 2019).

References

Hayward, B.W. 2019. How was the Cleary Rd hill built on the crest of Panmure Basin tuff ring? *Geocene* 19: 7–9.

Hayward, B.W.; Holzer, H.; Grenfell, H.R. 2008. Panmure Basin tuff ring. *Geocene* 3: 1–2.

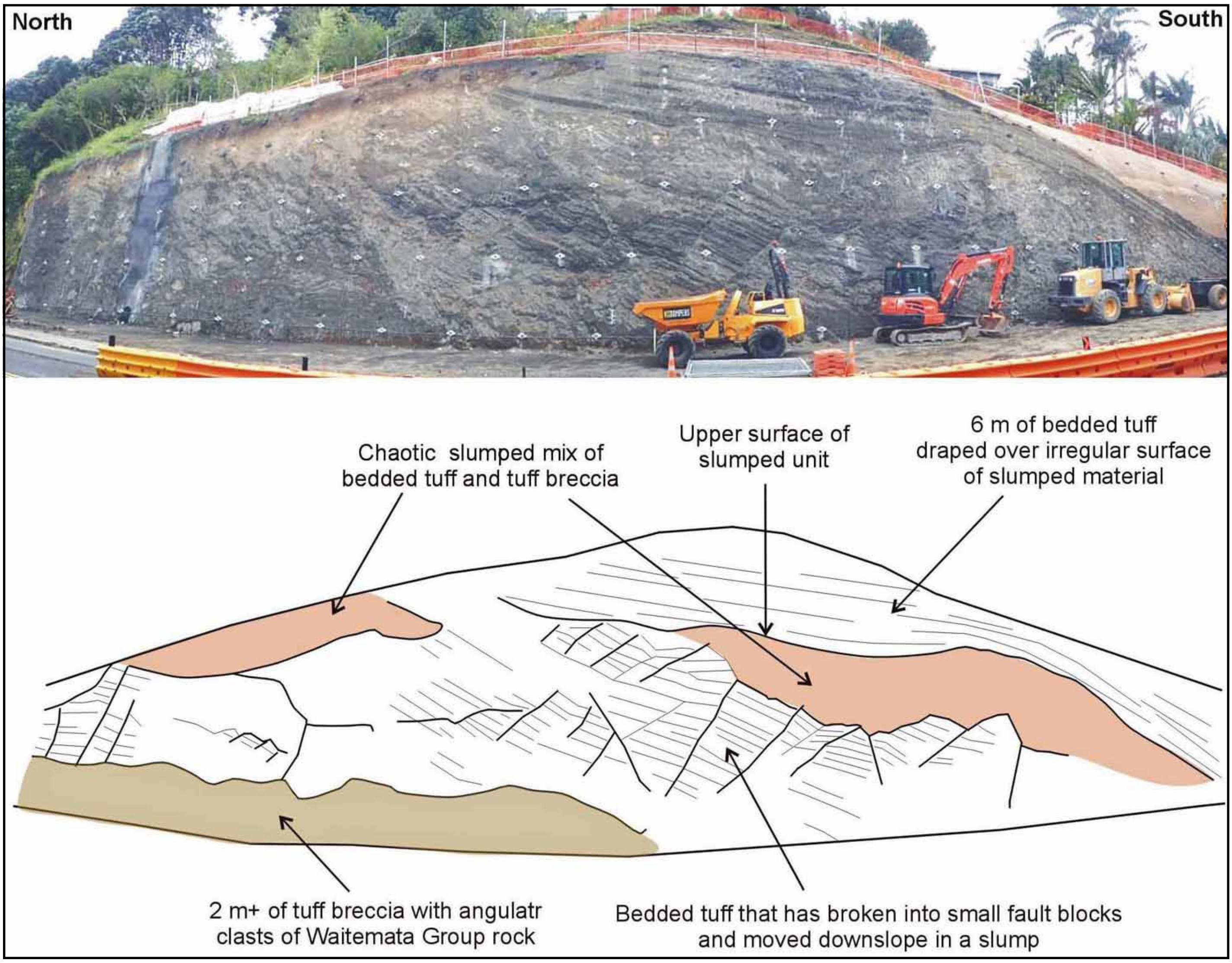

Fig. 2. Upper: Merged composite photograph of the new cutting taken in Nov 2019 soon after the wire-netting protection had been installed across it.
Lower: Overlay sketch of some of the more prominent geological features visible in the cutting.

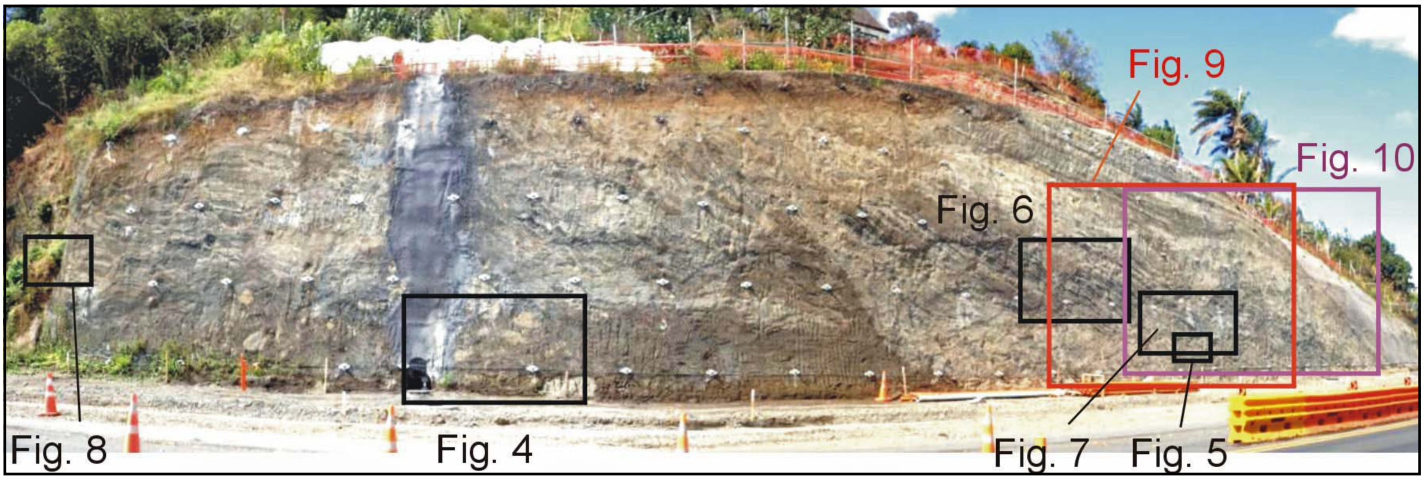

Fig. 3. Merged cutting photograph taken in March 2020 showing location of the close-up photographs presented below.

Fig. 4. The basal tuff breccia (unit 1) contains clasts of light-coloured Waitemata Sandstone and orange-brown Parnell Grit.

Fig. 5. A small black bomb of basalt within the basal tuff breccia (unit 1).

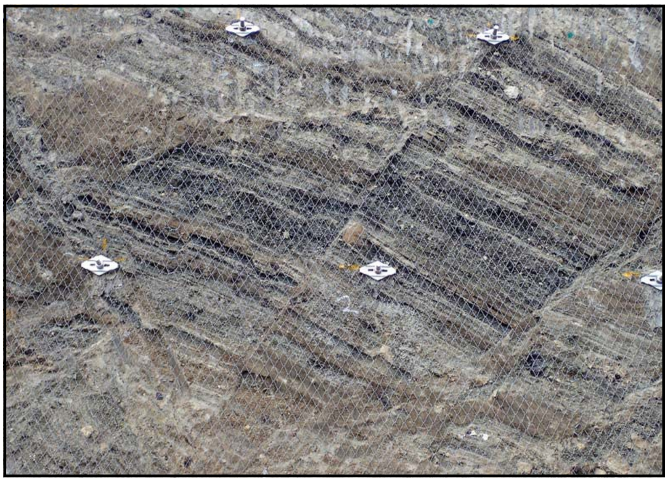

Fig. 6. Thinly bedded lithic and basaltic tuff (unit 2) broken into several north tilted fault blocks during downslope slumping.

Fig. 7. Contact between the slide blocks of tuff (unit 2) and the underlying tuff breccia (unit 1), showing that during slumping this contact was somewhat disrupted.

Fig. 8. Keystone faulting in disrupted tuff blocks of the slump unit 2.

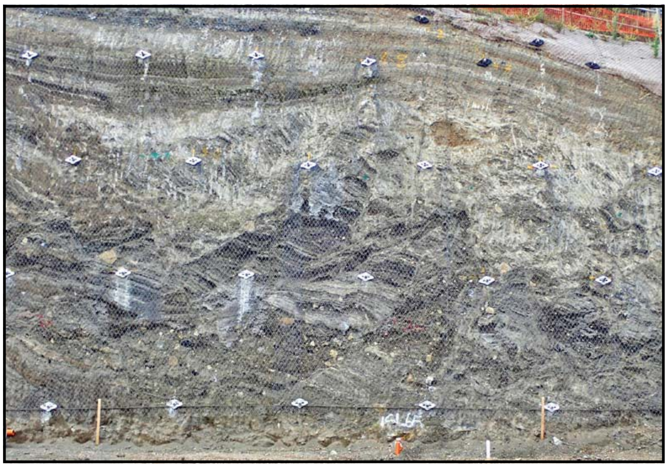

Fig. 9. Photo of the full height (~8 m) of the cutting towards its southern end showing all four units: the lower tuff breccia overlain by the disrupted blocks of bedded tuff, overlain by a chaotic breccia (unit 3) with an undulating upper surface, draped by further bedded airfall tuff (unit 4).

Fig. 10. The far southern end of the road cutting was already hidden beneath a concrete coat (right) but shows the bedded tuff of unit 4 draped over the slumped breccia and tuff blocks of units (2 and 3).

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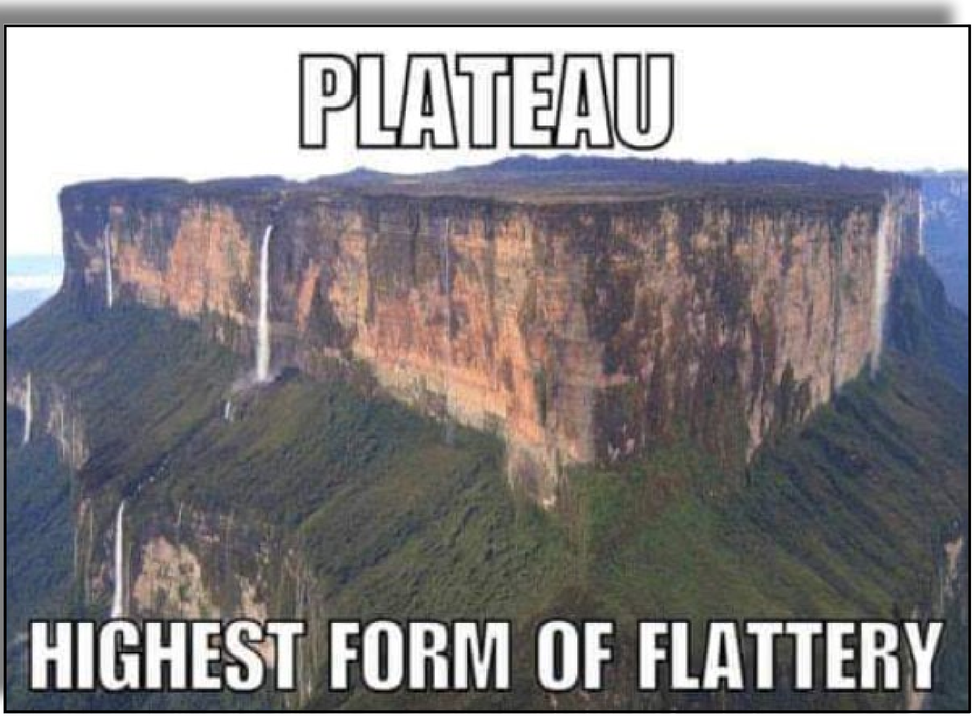

MAUNGAUIKA/NORTH HEAD LAVA FROTH (PSEUDO-RETICULITE)

Bruce W. Hayward

Basalt lava froth is sometimes erupted from Auckland's volcanoes and is a result of vast amounts of gas coming out of the magma as it nears the surface and is erupting. The froth cools and solidifies into highly vesicular basalt rock with 80–95% vesicles (gas holes) captured in it and may be called pseudo-reticulite or extremely light scoria. I formerly reported on pseudo-reticulite that occurred as a froth in the top of a dense lava flow from Maungarei/Mt Wellington and on the scoria cone of Otahuhu/Mt Richmond (Hayward, 2019), but recently recognised the same low density basalt rock with a polyhedral cellular structure on Maungauika/North Head.

On North Head, the froth does not occur within the upper part of a lava flow, but as rootless flows or blocks of rootless flow within fine scoria on the upper slopes of its scoria cone. In a 2 m high cutting into the scoria cone behind the 6 inch battery on the upper northern slopes (locality 1 in Fig. 1) there is a 30 cm thick disrupted layer of pseudo-reticulite (Fig. 2) within a rather chaotic deposit of fine and coarse scoria. I infer that the froth erupted out onto the upper slopes of the volcano between or during lava fountaining that produced the scoria. Essentially it was scoria with a greater amount of gas in it that was erupted during a phase of intense vesiculation (Mangan & Cashman, 1996). The froth was still fluid when it landed and amalgamated into a 30 cm thick layer of unknown extent, which then cooled and solidified into the rock. Sometime later, the scoria sequence that this layer was within has moved downslope a little and the layer has broken into a number of blocks. In one place, a 1 m wide part of the layer has remained together and just fractured into several blocks (Fig. 3), whereas elsewhere there is a heap of five blocks of the sheet within the deposit (Fig. 4).

On the upper southwestern slopes of North Head and exposed in the grassy road cut leading to the WWII buildings (locality 2 in Fig. 1), there is a more continuous, 30–40 cm thick layer of pseudo-reticulite close to the top of the scoria heap (Figs 5 & 6) and extending for at least 20 m along in the bank just above the access road. This is also a rootless lava flow, but in this instance it has not been disturbed by later slumping downslope.

Fig. 1. Google image of North Head showing the two localities where the basalt froth can be seen on its upper slopes.

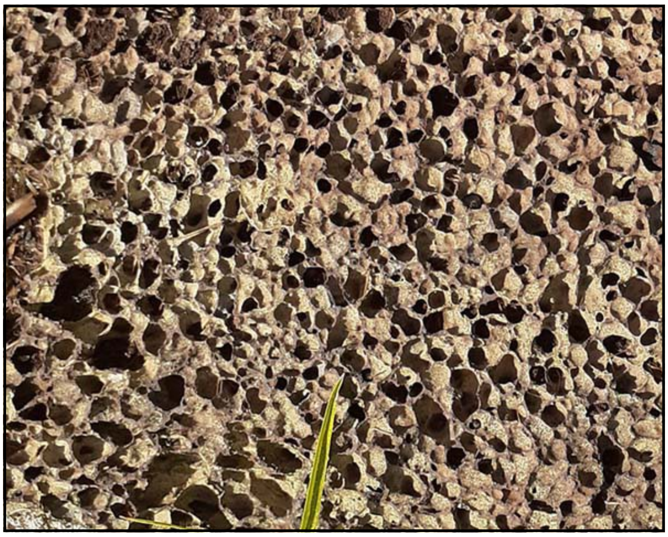

Fig. 2. Part of the pseudo-reticulite with its polygonal cellular structure seen at locality 1 on North Head. Photo 20 cm across.

Fig. 3. A 1 m-wide section of rootless, pseudo-reticulite flow within fine scoria at locality 1 on North Head.

Most likely, the two exposures are of lava froth that was erupted at the same time late in the eruption history of North Head scoria cone. Mt Richmond volcano in the Auckland Volcanic Field also has small blocks of pseudo-reticulite eroding from the surface of its scoria cone on its eastern side and is probably a second example of late stage lava froth eruption from an Auckland basalt scoria cone.

References

Hayward, B.W. 2019. Pseudo-reticulite (basalt foam) in the Auckland Volcanic Field. *Geocene* 19: 10–11.

Mangan, M.T., Cashman, K.V., 1996. The structure of basaltic scoria and reticulite and inferences for vesiculation, foam formation, and fragmentation in lava fountains. *Journal of Volcanology and Geothermal Research* 73: 1–18.

Fig. 4. A heap of broken blocks of a 30 cm-thick, rootless flow of pseudo-reticulite in the cutting behind the 6 inch battery (locality 1) on North Head. The heap is inferred to be a result of downslope slumping after formation.

Fig. 5. Some of the 20 m length of the exposed layer of pseudo-reticulite rootless basalt flow on the upper southwestern slopes of North Head (locality 2).

Fig. 6. Close-up view of some of the pseudo-reticulite at locality 2. Photo 15 cm across.

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FORMATION OF GEOCLUB

Bruce W. Hayward

Les Kermode and I first discussed the possibility of forming a geology enthusiasts' club in Auckland in September 1992 and I suggested we affiliate with Auckland Museum Institute where we could, at that time, get free use of the Museum's School Room for evening meetings, in the same way the Auckland Museum Conchology Section did. The stars aligned as I had joined Auckland Museum staff in April 1991 and Les had just retired from the NZ Geological Survey. Soon after Les retired, the Survey closed their Auckland office in Parnell and Les had to find a new base if he was to carry on with his life-long interest in Auckland's geology. I recognised that Les's immense knowledge of the local geology would be an asset to the Museum and I offered him Research Associate status that would give him access to the library, xerox facilities and a desk.

For several years Les had been presenting a series of evening classes on aspects of Auckland's geology for the University of Auckland extension. In association with these classes, he offered numerous field trips and had built up a following of a number of keen members of the public. He could feel that there was a desire among the group to provide something more for them. After my arrival at the Museum, the community education officer, Katrina Stamp, saw an opportunity to use me and my contacts with the local geological community to offer a series of three evening geology lectures as part of the programme for members of the Auckland Institute and Museum. These were so well-patronised in 1991 that a second set was offered in the latter half of 1992.

Les and I decided that we would launch the idea of a Geology Club section to attendees at the September geology lecture at the Museum. At the start of the meeting we asked anyone present who would be interested in joining such a club to put their contact details on a page that was being circulated. Twenty names and addresses were added: Bruce Hayward, Les Kermode, Pat Eden, Stephen Straka, Christine Scriven, Glenda Haueter, Linda and Norman McGregor, Joshua Salter, Ken Mickleson, Lynne McKay, Keith Tomlinson, Wayne Shinton, Trevor Clarke, Glenn and Rachael Carter, Mary Rose, Mary Sinclair, Warren Spence, John Hyde.

In October, Les and I prepared an invitation and sent it to the listed people plus others in Les's contact list. The invitation was to attend the inaugural meeting of the Auckland Museum Geology Club at 7.30 pm, Tuesday 3rd November, 1992, in the School Room, Auckland Museum. Entry via the West Door. The drawcard was a talk by Les Kermode titled "Do it yourself geological field trips around Auckland" in which he took us on a roller coaster ride around the region showing us in colour slides some

Fig. 1. Some of the participants on the first Geology Club trip to Whatipu in December 1992.

of the great geodiversity of our region. The invitation stated: *"We propose the establishment of a Museum geology Club to cater for the obvious vacuum in Auckland for amateur interests in geology. There is also an obvious need to create a support network for teachers, many of whom will shortly be faced with having to teach more earth science in the school science syllabus and to taylor (sic) it to our Auckland situation. We suggest a club that meets regularly/periodically with evening talks on a wide variety of topics/workshops at a suitable level. As geology is a field science, we also suggest that the club would run frequent field trips to geologically interesting areas. We currently have the names of 20 people who are interested in forming a Museum geology Club and we are sending out this general invitation to anyone else who wishes to come and see whether they wish to join us. Please bring this invitation to the notice of others."*

Joining the original 20 at the November meeting were another 14: Mike Eagle, Jorie Zwart, Kathy Prickett, Garry Carr, Struan Ensor, Ann Ros, Lola Gregory, Ivan Andern, Maureen and Mervyn Burke, Glen Prime, Kel Anglesey, Doug Denize, Lee Goffin.

The next advertised activity of the club was a Geological Field Trip to Whatipu on Sunday 6th December, 1992, led by Bruce Hayward. Car pooling met at the back of Auckland Museum at 9 AM with west Auckland residents meeting at Lopdell House, Titirangi, at 9.30 AM. We caused a traffic jam in Titirangi outside Lopdell House. Thirty-five people attended the Whatipu field trip. The second evening lecture was held in December, 1992, in which Bruce Hayward talked on "NZ building stones and their use in NZ historic buildings." The tradition of meetings on the third Tuesday of every month except January was established with the first two meetings and the subscription rate of $10 per member or family membership was also set and has not changed since then. Our name has changed, but that is another part of our history. By June 1993 numbers had swelled to 63 financial members, who we regard as foundation members. The first club committee was "elected" in 1993 and consisted of Kel Anglesay, Glen Carter, Struan Ensor, Bruce Hayward, Les Kermode and Linda McGregor.

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Geologists have their faults, of course. But actually they are misunderstood. The more they try to be gneiss, the more they are taken for granite.

Never lend a geologist money. They consider a million years ago to be recent.

A geologist is the only person who can talk to a woman and use the words like "thrust", "bed", "orogeny", "cleavage" and "subduction" in the same sentence without facing a civil suit.

Geologists are amazing. They know hundreds of words for different sorts of dirt and hundreds of words for things it does when left alone for a few million years.

If rocks aren't romantic, then why is there carbon dating?