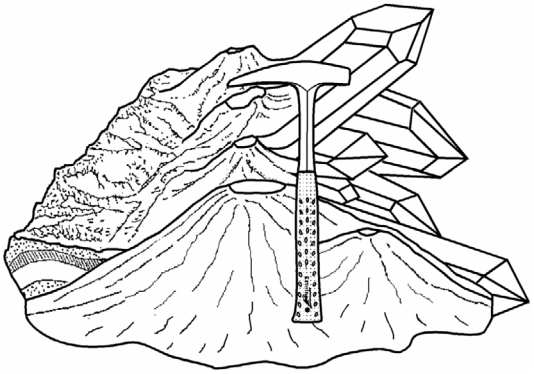


Geocene

Auckland GeoClub Magazine
Number 25, April 2021

Editor: Jill Kenny

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

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

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NOTES ON THE GEOLOGY IN THE VICINITY OF POKENO

Hugh Grenfell

Introduction

To paraphrase Battey (1949) and Kear (1961), there is a hell of lot going on geologically in the small area around Pokeno, just south of Auckland (Fig. 1). This includes Late Oligocene grey, calcareous sandstone containing crushed brachiopods (Battey, 1949, p.435), Miocene Mercer Sandstone (Waitemata Group), Late Pliocene Coromandel-sourced, fluvial Puketoka Formation, Pleistocene Taupo Volcanic Zone-sourced Tauranga Group (ignimbrites and rhyolitic sediments, c.1 Ma), South Auckland Volcanic Field (basaltic volcanics, 0.5–1.5 Ma) and a large fault. Battey had the benefit of relatively fresh outcrops in railway cuttings and the development of a proposed railway from Pokeno to Paeroa clearly visible in 1942 airphotos but never completed. Kear would have seen some of these outcrops and also had additional drillhole data and age estimates from microfossils. Many of the outcrops have deteriorated badly or no longer exist. I would like to add what I have observed from visits to outcrops near Pokeno and to the Puketoka Formation type section at Puketoka trig (Battey, 1949; Hayward & Grenfell 2010).

The Puketoka Formation

I first became aware of just how extensively the Puketoka Formation is "mapped" and used as a lithologic unit in the Auckland region looking at Kermode (1992) and Edbrooke (2001) and later, when I looked at Kear and Schofield's (1978) mapping of the Waikato. Since it was Hugh Battey, then geologist at the Auckland Institute and Museum, who named and described the Puketoka Formation (Battey, 1949), I wanted to visit his localities to see for myself. In taxonomy it pays to find out what the original author of a genus or species was illustrating and talking about rather than relying on the later interpretation of others. Lithostratigraphy is just the same and the original literature should be read (and reread) and type localities and sections should be visited if possible. Hence, in reading Battey's paper and visiting his localities, it was clear that his stratigraphy was subsequently being applied incorrectly and in strange ways in the Auckand region (see Hayward & Grenfell, 2010).

Battey named the Puketoka Formation from the section at Puketoka trig (-37.221720° 175.190390°), southwest of Mangatangi, near Maramarua, and stated the sediments "are here named the Puketoka formation, since they attain their greatest thickness at Puketoka Hill" (Battey, 1949, p.438). I consider this the type locality. The current outcrop is in good condition but needs detailed logging and documentation. It shows best the mixture of lithologies and importantly the provenance of the material from the Coromandel Group volcanics (andesitic and rhyolitic material including sinters and petrified wood), the Waipapa Group and the Kiwitahi Volcanic Group (Battey, 1949; Hayward & Grenfell, 2010).

Battey did a great job describing the geology of a wider area from Kohanga / Onewhero in the west to Puketoka trig in the east. Much of what he described as Puketoka Formation is probably correct, although I would disagree, for example, that outcrops such as those near and east of the then proposed Koheroa Road railway crossing (-37.243357° 175.097697°) are necessarily part of the Puketoka Formation (Battey 1949, Pl.46, Fig.4, p.440 and Pl.48, Fig.1). They are more likely to be younger Taupo Volcanic Zone-sourced Tauranga Group sediments. Interestingly, Battey goes to some length to discuss the chalazoidites (accretionary lapilli) in these sediments. These are also a feature of other Tauranga Group material in the Auckland area (e.g. Point England, Tamaki Estuary).

More recently, GNS has been undertaking a review of the Puketoka Formation and the Tauranga Group generally in the Auckland region. Having been to other kosher outcrops of the Puketoka Formation, I thought it would be worth taking another look at the extensive mapping of the formation around Pokeno by both Battey (1949) and Kear (1961).

Locality 1 (Fig. 1)

I was interested in this problematic locality since Battey (1949, p.439) recorded Puketoka Formation here in railway cuttings 70 chains (1.4 km) southeast of the former Pokeno Station (see the NZMS1 1959 map or the 1942 airphoto for station location). The locality sounded promising and is plotted here at -37.251021° 175.031010° (Fig. 1, Locality 1).

The outcrop is clearly visible in 1942 and 1952 airphotos but unfortunately, I could see from recent satellite imagery and from State Highway 1 itself that the outcrop was in bad shape. Initially I discounted it as not being worth close inspection and anyway access seemed tricky. It has turned out to be a very problematic outcrop not just because of its current condition.

Battey (1949, p.439) described the following here - locally crumpled Tertiary beds dipping 20°N to 32°W, which were unconformably overlaid by 2' of dark sand and mud rich in "decomposed vegetal matter". Above this was 8' (2.44 m) of greywacke conglomerate (clasts 1.3–10.2 cm) thought to represent the Puketoka Formation. The conglomerate was said to be overlain by 12' of blocky basalt. I couldn't find any trace of the conglomerate or the basalt. Has it all been quarried away at some time? I doubt it. Today there are very large boulders of fresh basalt rip rap at the base of the outcrop placed there by KiwiRail in recent years to presumably stabilise the slope.

This railway cutting was also studied by Kear (1961, pp.156-157), but he describes it quite differently as "white carbonaceous siltstone overlying 35' of soft purple siltstone



Figure 1. Area just south of Pokeno. Localities 1–5.
A) Main trunk railway line, B) State highway 1, C) Pioneer Road, D) Bluff Road, E) "Bald Hill", F) Synlait Milk Factory.

and quartz sandstone", which were given a Waipipian and Mangapanian (Late Pliocene to Early Pleistocene) age. But strangely he makes no mention of 8' of conglomerate, nor is any mention made of the 12' of blocky basalt above this, as seen by Battey (1949). The outcrop is mapped as Puketoka Formation by Kear (1961, Fig. 3).

What is going on? The discrepancy between Battey's and Kear's descriptions of Locality 1 is puzzling.

Kear (1961, Fig. 5 and p.159), however, does discuss highly weathered conglomerate, 10 feet thick, pebbles up to 2 inches (which he calls Puketoka Formation) in another railway cutting c. 600m to the southeast. This is part of his "Pokeno South Cutting" section and stratigraphic column. He also describes 20' of "pillow-like basalt blocks thrust into clay". There is more similarity between Battey's description of Locality 1 and Kear's description of the "Pokeno South Cutting". It seems likely that Battey got his railway cuttings muddled and his locality "railway cuttings 70 chains (1.4 km) southeast of the Pokeno Railway Station" is not accurate. Other Battey localities have been difficult to locate using his descriptions.

Unfortunately, some 70 years on from Battey's paper, the outcrop at Locality 1 is very weathered and covered in gorse and scrub. Digging with a trenching tool, I could only find very weathered lithologies such as greenish grey siltstone, a carbonaceous chocolate siltstone with plant fragments, a very water-saturated, cream-coloured, gritty, quartz rich siltstone (? rhyolitic tephra) and an orange brown, highly weathered sandstone / siltstone that closely resembled weathered Pokeno West Volcano tuff seen just west of here and just to the north of Locality 2 (see Fig. 1). While there are no contacts to be seen, I would suggest the greenish grey siltstone is Tertiary, the chocolate siltstone some kind of lacustrine deposit possibly associated with the cream coloured rhyolitic tephra (? Tauranga Group) and the orange brown sandstone highly weathered Pokeno West Volcano tuff. Apart from Battey's "carbonaceous siltstone" and Kear's "quartz sandstone", little of these observations seem to match what Battey or Kear saw. Thus, I cannot confirm the presence of the Puketoka Formation at Locality 1.

I have not visited Kear's "Pokeno South Cutting" (-37.253293° 175.037311°) but will speculate about the interpretation of one of the lithologies found there - the Pokeno Clay (Kear, 1961, p.159). At the northern end of the "Pokeno South Cutting", the following sequence is described by Kear.

- Pink and white pumiceous clays, during the deposition of which basalt pillow-like blocks have been thrust into the clay that was squeezed between pillows and baked (20' thick).
- Very soft white clay (5' thick).
- Carbonaceous mudstone with leaves (sample N47/f514) (5' thick).

The plant fossils from N47/f514 were assigned a Castlecliffian age (Couper & McQueen 1954, p.403). I think the Pokeno Clay is part of the Tauranga Group and is either a rhyolitic tephra or re-worked tephra. The soft, water-saturated

tephra was some time later penetrated and loaded by a basalt lava flow (described as pillow-like - see Kear 1961, Fig. 6) from a South Auckland Volcanic Field volcano probably to the north or the west (see Briggs *et al*. 1994, Fig. 2, Taylor, 2012), but not necessarily from Pokeno West Volcano. The carbonaceous mudstone may be correlative with the chocolate siltstone seen at Locality 1. Puketoka Formation conglomerate is described as being found below the basal carbonaceous mudstone 100 m to the east (Kear 1961, pp.157 and 159).

Locality 2 (Figs 1, 2a–c, 6e)
Much later, my interest in the geology was again piqued when travelling north on State Highway 1 near Pokeno I noticed an outcrop / bluff (-37.252787° 175.029827°) just southwest of Locality 1 described above. Given its proximity, I wondered if this too could be Puketoka Formation. A very quick visit at the time suggested as much, since it appeared to be fluvial in character with well bedded "sandstones and siltstones" with a few rounded cobbles and pebbles. Also on this short visit I saw Locality 3 (Fig.3) from a distance and discounted it based on previous mapping as probably highly weathered Tertiary sediments, but it turned out to be much more interesting (see latter).

My second visit to the bluff at Locality 2, and armed with a hammer and a camera this time, was more leisurely. Looking from a distance and taking photographs, my first thought was "That looks like tuff!" (Fig. 2a–b). As you will see later, it sometimes pays to go with your gut. But after examining as much of the outcrop as possible, I again concluded it was probably Puketoka Formation with occasional well-rounded greywacke pebbles and cobbles in well-bedded gritty sandstone. But the presence of what looked like angular ?basalt/?andesite fragments bothered me. For example, were they fragments of Kiwitahi volcanics? Rereading Kear (1961, p.157) slightly reassured me because he had a sample petrologically analysed. Kear (1961, p.157) stated that Dr J.J. Reed [NZGS mineralogist and petrologist] had examined a sample of the "sandstones" petrographically (N47/p505, P20274, Kear 1961, Fig. 3. [-37.252755° 175.029431°]). Reed reported (pers. comm. to Kear) "Thus the common occurrence of pumiceous glass, quartz, orthoclase and altered biotite indicate clearly a rhyolitic origin, and the less plentiful hornblende, hypersthene, augite, and brown glass an andesitic source". Kear stated further that "Two very different sources of these sediments are therefore indicated. Petrography shows that the bulk of the sandstones were derived from a rhyolitic-andesitic source such as Rotorua-Taupo or Coromandel, while field evidence shows that a fair amount of locally-derived basalt was added during deposition." So to Kear, since the sediments were derived from both rhyolitic and andesitic sources (i.e. Coromandel or Taupo Volcanic Zone), it fitted with them being Puketoka Formation and he mapped them as such. Kear also noted basaltic fragments and even volcanic bomb sag craters (I did not see any here but see my later description of Localities 4a&b). These he explained as being due to contemporaneous volcanism ("Bombay Basalts") at the time the Puketoka Formation was being deposited.



Figure 2a. Locality 2, bluff of West Pokeno Volcano tuff.



Figure 2b. Locality 2, West Pokeno Volcano tuff with occasional rounded clasts of recycled Puketoka Formation. Hammer for scale.



Figure 2c. Just northwest of Locality 2, highly weathered West Pokeno Volcano tuff.

When I visited Localtiy 2, there were also fresh earthworks about 150 m northwest of the edge of the bluff showing both highly weathered and fresh outcrops of these lithologies (Fig. 2c). Now, if you look very closely at Battey's map

(1949, Text-figure 1), you will see he maps the bluff itself as “Pleistocene, Basalt lava flows and ash deposits” and the surrounding land as Puketoka Formation. So who was right, Battey or Kear? I consider the bluff and most of the immediate area (some of which was exposed by earthworks at the time) to be part of the Pokeno West Volcano tuff ring which contains a significant amount of material recycled from the Puketoka Formation.

Fortunately I could see other outcrops that needed to be explored about 1 km to the west where there were more prominent bluffs like the one I was standing on (Localities 4a&b). Because they are near-vertical, these bluffs are almost invisible on airphotos or satellite images. To the southwest was Locality 3, which also required closer scrutiny.

Locality 3 (Figs 3, 6c)
As mentioned earlier, I first dismissed this outcrop as highly weathered Tertiary, since Battey (1949) mapped it as Puketoka Formation and Kear (1961) as Waikawau Sandstone. To be fair to them, there was no outcrop at the time of their mapping and the current outcrop is due to a large slip that apparently occurred in 2008 (Taylor, 2012). Close up, the outcrop is clearly a massive bed (or ?beds) of rhyolitic material or ignimbrite at least 8 m thick. I later discovered Waikato University Masters student Simon Taylor had studied the outcrop as part of his work on the South Auckland Volcanic Field around Pokeno (Taylor, 2012). He described and imaged an outcrop at the southeastern end of the slip that shows an important irregular unconformity between the ignimbrite, which is overlain by West Pokeno Volcano tuff (Taylor, 2012, p.31 & 35, Fig. 3.9). When I visited, this particular part of the outcrop was obscured by heavy gorse but I think it is just visible from Pioneer Road. Taylor names the ignimbrite as Kidnappers Ignimbrite (Cooper *et al*. 2016, Mangakino Volcanic Centre, aka Potaka Tephra, ~1 Ma) and this helps constrain the age of West Pokeno Volcano (i.e. <1 Ma).



Figure 3. Locality 3, Kidnappers Ignimbrite (Tauranga Group).



Figure 4a. Locality 4a, bluff of Pokeno West Volcano tuff. Bluff Road Cone lava flows visible to the right.

Localities 4a-b (Figs 1, 4a–e, 6)
At these localities there are excellent tan brown, bluff-forming outcrops of the Pokeno West Volcano tuff ring (Battey, 1949, p.445, Taylor, 2012). It was generally correctly mapped as “basaltic volcanics” by Battey (1949) but apparently incorrectly by Kear (1961, p.157) as Puketoka Formation and contemporaneous “Bombay Basalts” with outcrops of basaltic tuff marked by triangles. It is presumed Kear meant the tuffs occurred within Puketoka Formation sequence (contemporaneous) but it is clear that the tuff is much more widespread over the area Kear mapped as Puketoka Formation “sensu stricto”. As at Locality 2 these localities include occasional recycled pebbles and small cobbles derived from the Puketoka Formation (e.g. greywacke, porphyritic andesite, siliceous sinter), primary angular basaltic fragments and good examples of small bombs and sag craters in the bedded tuff (Figs 4a–b, 6a&d).

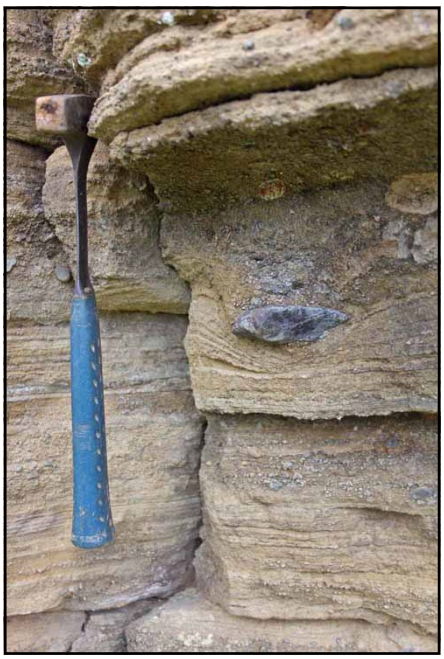


Figure 4b. Locality 4a, Pokeno West Volcano tuff with rounded clast derived from the Puketoka Formation and impact sag.



Figure 4c. Locality 4a, Pokeno West Volcano tuff with cross bedding and an irregular, scoriaceous basalt clast at the tip of the hammer.

Locality 5 (Figs 5, 6b)
Olivine rich basaltic lava flows, ~150 metres wide, outcrop here. The most likely explanation for the lava is that it came from the adjacent, younger Bluff Road Cone to the west (0.64 Ma, Briggs *et al*. 1994, Taylor, 2012, p.162). The lavas apparently overtopped and possibly partially eroded the Pokeno West Volcano tuff ring. Some of it is well exposed in the stream bed under a bush remnant (Fig. 5) and some boulders also outcrop on clear ground to the southeast of the bush (Fig. 4a).



Figure 4d. Locality 4a, Pokeno West Volcano tuff.



Figure 5. Locality 5, Lava flow from Bluff Road Cone.



Figure 4e. Locality 4b, Pokeno West Volcano tuff showing a clast of baked sediment and impact sag.

Conclusions
Although some of the sections described by Battey (1949) and Kear (1961) are obscured and highly weathered, much of the geology they saw (plus a new outcrop) is still visible. The issues discussed above regarding Locality 1 and the different observations of Battey and Kear are not resolvable without the outcrop being freshened up. Although widely mapped by Battey and Kear, the only likely outcrop of the Puketoka Formation in the area is that described by Kear (1961, p.157) at the Pokeno South Cutting. It was disappointing not to find more Puketoka Formation outcropping given how widely it was mapped. The extensive recycling of Puketoka Formation material into the Pokeno West Volcano tuff was very interesting and confirms it underlies much of the area. The unconformity between the Kidnappers Ignimbrite and Pokeno West Volcano tuff helps constrain the age of the latter.

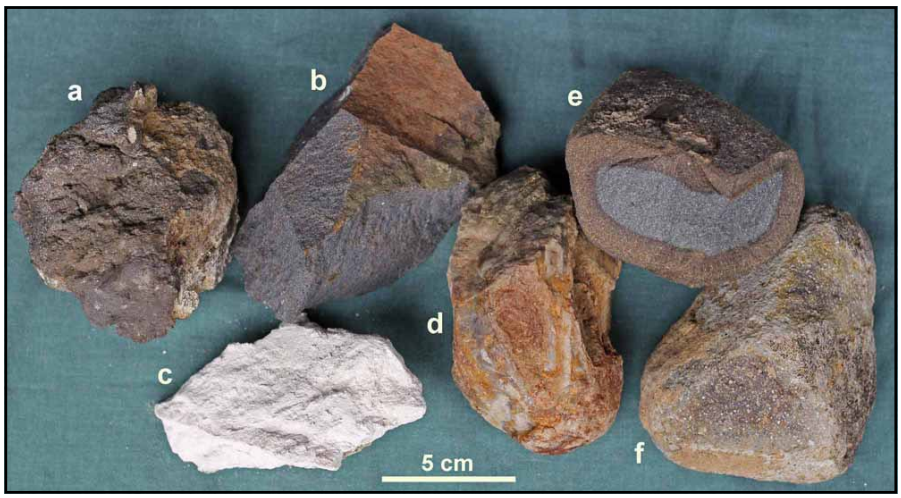


Figure 6. Pokeno lithologies.
a. Blocky basalt bomb (in tuff at Loc. 4b),
b. Olivine basalt (lava flow at Locality 5),
c. Ignimbrite (at Locality 3),
d. Red, cream and grey rhyolitic sinter cobble (in tuff at Locality 4a),
e. Weathered porphyritic andesite cobble (in tuff at Locality 4a),
f. Greywacke cobble (in tuff at Locality 2).

Localities

Locality 1: -37.251021° 175.031010°. Currently obscured. Battey records Puketoka Formation "greywacke conglomerate" (1949, p.439, "70 chains (1.4km) southeast of Pokeno Railway Station" (see NZMS1 1959 map for station location). Kear site also (1961, Fig.3 and p.157), N47/f524 Puketoka Formation carbonaceous siltstone described as having a Waitotaran (Late Pliocene) microflora). I could not confirm the presence of typical Puketoka Formation.

Locality 2: -37.252855° 175.029683°. South Auckland Volcanic Field, Pokeno West Volcano tuff. Appears to be marked on Battey map (1949, Fig.1) as "basaltic lava flows and ash deposits". Marked as an outcrop of tuff by Kear (1961, Fig.3. N47/p505) but discussed and mapped as Puketoka Formation (Kear, 1961, p.157).

Locality 3: -37.254752° 175.029451°. Tauranga Group, Taupo Volcanic Zone ignimbrite (Kidnappers Ignimbrite).

Localities 4a-b: 4a: -37.256857° 175.021187°; 4b: -37.255722° 175.017659°. South Auckland Volcanic Field, Pokeno West Volcano tuff. Discussed and mapped in Battey (1949, Fig.1, p.445) as "basaltic lava flows and ash deposits".

Locality 5: -37.256449° 175.018732°. South Auckland Volcanic Field, Bluff Road Cone olivine rich, basaltic lava.

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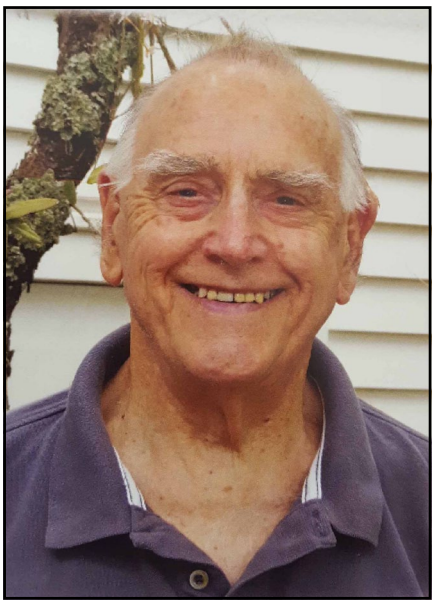
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JACK GRANT-MACKIE'S CONTRIBUTIONS TO GEOCENE

Jill Kenny

Palaeontologist Jack was always an avid supporter of the Auckland GeoClub. In his later years, he had a burst of enthusiasm to get his remaining research published, and he chose GeoClub's Geocene magazine as a simple means to do this.

Here, I have repeated first paragraphs for each of his articles published in Geocene to encourage readers to delve back to his articles in the Geocene magazine archives, now held in the National Library Archives (https://natlib-primo.hosted.exlibrisgroup.com/primo-explore/fulldisplay?docid=NLNZ_ALMA21350370940002836&vid=NLNZ&search_scope=NLNZ&tab=catalogue&lang=en_US&context=L).



A photo from Jack's funeral service sheet, 26 February, 2021.

A fossil egg case of *Alcithoe arabica* from the Whanganui Pleistocene



Geocene 7, Figure 1: Fossil Alcithoe egg case from coastal cliffs west of Castlecliff. Shakespeare Cliff Sand at locality R22/f6469 (AU989).

Back in the 1970s my Department conducted field classes in the Whanganui–Hawera area to study their strata and faunas. In May 1971, with Peter Ballance, Graham Gibson, and a bunch of 3rd-year students, I found a small white sphere embedded in the rock, hollow and empty except for two gastropod protoconchs (Fig. 1). This egg case is 11.6 mm diameter and very thin and fragile (shell material 0.2–0.3 mm thick), but it had not collapsed during compaction and lithification. It was seen because it broke in half on extraction and both halves are preserved in the collections of the Geology Programme, Auckland University's School of Environment (specimen G7161, the coastal cliffs west of Castlecliff, from the Shakespeare Cliff Sand at locality R22/f6469 (in the Geosciences Society of NZ Fossil Record Electronic Database, 'FRED'), along with a rich molluscan fauna and brachiopods, barnacles, other arthropods, and Bryozoa. This unit is dated as Castlecliffian Stage of the Wanganui Series and correlated with Oxygen Isotope Stage 13, about a half million years old. For the geologic setting, stratigraphy and faunal lists, see Fleming (1953), and for correlation with the oxygen isotope sequence and geomagnetic timescale, see, e.g., Carter & Naish (1999) slightly modified by Beu (2011).

For more, see Geocene 7, pp. 9–10.

Notorynchus primigenius (Agassiz, 1843), an extinct seven-gilled shark, from the Early Miocene of Pakurangi Point, Kaipara Harbour, Northland

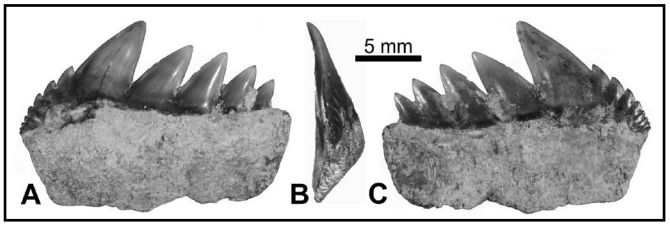
Abstract

One lower lateral tooth of *Notorynchus primigenius* (Agassiz, 1843) is reported from the Pakaurangi Miogypsina Sandstone Member of the Puketi Formation, Waitakere Group, of Altonian (Early Miocene) age at Pakaurangi Point, north Kaipara Harbour, New Zealand. It is the only shark tooth so far known from this unit.

Introduction

Six- and seven-gilled sharks are regarded as the most primitive living sharks. Sharks belong to the vertebrate Class Chondrichthyes, the cartilaginous fishes, which have a skeleton of cartilage and generally lack bone (although some ossification does occur in some of the larger species, and such vertebrae can be found fossil). Teeth are the most common fossils of sharks, and luckily isolated teeth have been found to be able to characterise individual shark species.

In modern sharks teeth are shed singly, and this can explain their general mode of occurrence in the fossil



Geocene 17, Figure. 2. *Notorynchus primigenius* (Agassiz, 1843), from locality Q08/f0585. Lower lateral tooth in (A) labial, (B) lateral, and (C) lingual views.

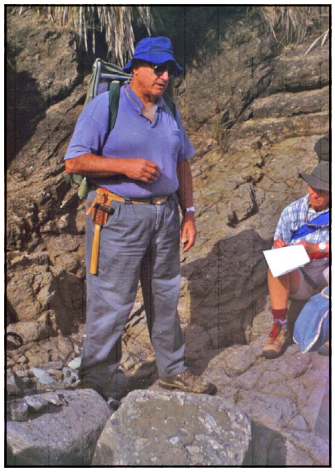
state. Sharks, which originated in fresh water, are rare in Paleozoic deposits but there was a great radiation through the Mesozoic with many modern groups evolving then and spreading worldwide in nearly all marine habitats. They are widespread but uncommon fossils in New Zealand Cretaceous and Tertiary strata (see e.g., Fordyce,1991), even though very little detailed modern work has been done on them (but see Mannering and Hiller, 2008, on a South Island Paleocene fauna, not including Notorynchus).

This report deals with a single well-preserved tooth found during a University of Auckland Geology Department student field trip. It came from the Pakaurangi Miogypsina Sandstone Member of the Puketi Formation, Hukatere Subgroup, Waitakere Group, at the tip of Pakaurangi Point, Kaipara Harbour (Jones, 1969, Ballance et al., 1977) (Fig. 1), and is the only shark tooth so far known from this unit. The collection of which it is a part is catalogued as AU19936 in the holdings of the School of Environment, University of Auckland, and the tooth itself is held as V462 in that School's Catalogue of Type and Figured Specimens.

For more, see Geocene 17, pp. 8–10.



Jack at a Geoscience Society of New Zealand Conference field trip, November 2010.



Kiritehere Triassic section, November 2001 Auckland Geoclub field trip.

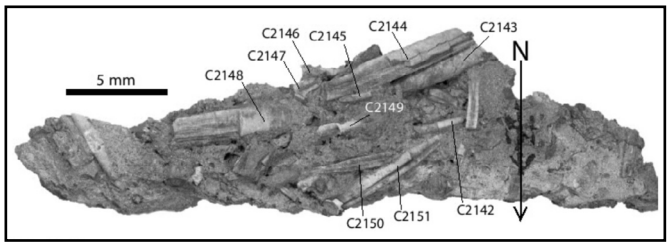
Current-aligned Middle Jurassic belemnite guards from New Caledonia

Abstract

Medium to coarse sandstones and fine conglomerates of the Testard Formation, Baie de St-Vincent Group, Téremba Terrane, on the northwest coast of île Mathieu, Baie de St-Vincent, southwest New Caledonia, contain many guards of the belemnite *Eobelemnopsis compressa* (Avias, 1953) aligned dominantly in an east–west direction. Numbers of guards, falling off almost symmetrically either side of this orientation, indicate deposition under the influence of an apparent north–south current, although the amount of post-depositional rotation of the Terrane in unknown.

Introduction

During field work in New Caledonia, I encountered on the coast of île Mathieu, southeast Baie de St-Vincent, a closely spaced set of bedding planes containing many aligned belemnite guards. The guards are preserved in sandstones and fine conglomerates. Collected samples are held by the School of Environment, University of Auckland, as collection AU7257 (NC/f426 in FRED, the database of localities of fossil collections held in New Zealand institutions and run jointly by the Geoscience Society of New Zealand and GNS Science, Lower Hutt, New Zealand); grid reference 61320.75572 on Sheet 4832, La Tontouta (Serie Orange, 1: 50,000, Institut Géographique National, Paris, 1987); collected by JAG-M, 27 October, 1975, and by JAG-M and N. Hudson, 26 October, 1983.



Geocene 18, Figure. 2. Segment of the sequence, including parallel aligned belemnite guards (C2142–C2151) lying in the bedding plane, from NC/f426, île Mathieu, New Caledonia.

Setting

The belemnites occur in medium to coarse sandstones and fine conglomerates of the Moziman Member, Testard Formation (Campbell et al. 1985), and occupy a stratigraphic thickness of 0.5 m, dipping at 17° and striking 120°. They are identified as *Eobelemnopsis compressa* (Avias, 1953), which was dated by Challinor & Grant-Mackie (1989) as Early Bajocian. More recently (Challinor & Hudson, 2017) sequences with this belemnite have been correlated with the late Middle Temaikan Stage of the New Zealand scheme, with an international age of latest Aalenian to late Early Bajocian. Although *E. compressa* is not recorded from New Zealand sequences, it occurs in New Caledonia with and just below *Retroceramus (Fractoceramus) inconditus* (Marwick, 1953), a marker bivalve for Hudson's (2003) early Middle Temaikan.

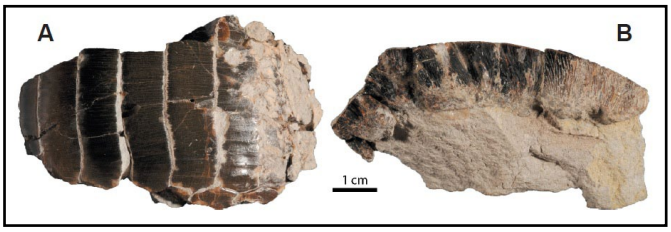
For more, see Geocene 18, pp. 2–4.

Aetomylaeus, an eagle ray genus new to the Oligocene of New Zealand

Abstract
Most of the tooth-plate of an eagle ray, judged to belong to the genus *Aetomylaeus* Garman 1908, and possibly related to *A. cubensis* Iturralde-Vinent *et al*.,1998, of the Cuban and Brazilian Miocene, is recorded from the Glen Massey Formation, possibly the Dunphail Siltstone Member, of Whaingaroan-Duntroonian age (Early-Middle Oligocene; 34.6-25.2 Ma) in the Karamu Quarry, Raglan, area. It constitutes the first report of this genus in New Zealand.

"Myliobatis" altus Davis, 1888, described from the Tertiary of Trelissick Basin, Canterbury, may have been another member of the genus Aetomylaeus, but the two known remnants are now so shattered as to be unidentifiable and Davis' name must be regarded as a *nomen dubium*.

Introduction
The modern New Zealand ray fauna (Batoidea) includes but one species of eagle ray, *Myliobatis tenuicaudatus* Hector, 1877, generally occupying shallow water sands and seagrass meadows. Fossils rays are widespread but not abundant in the New Zealand Tertiary marine record (Fordyce 1991) and virtually all have been referred to the large genus *Myliobatis* Cuvier 1817. Davis (1888) described three new species from the Oligocene and Miocene of Trelissick Basin, Canterbury, with one of the species reported also from other South Island localities. The same three species were also recorded by Chapman (1918) and many isolated teeth have been reported subsequently at generic level from many sites of Cenozoic age around New Zealand (Fordyce, 1991).



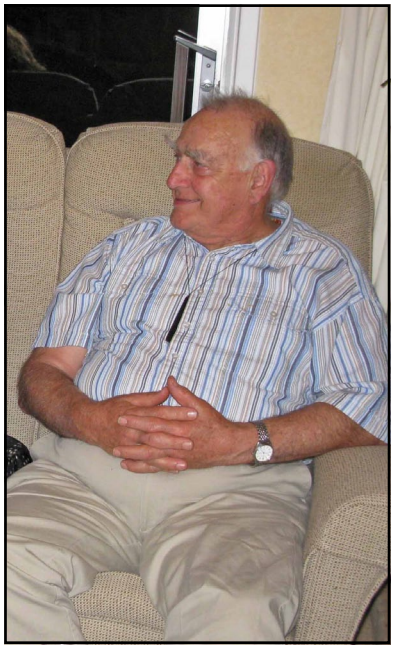
Geocene 18, Figure. 2. *Aetomylaeus* sp. cf. *A. cubensis* Iturralde-Vinent et al., 1998, V564, from S15/f13, Karamu Quarry. A, occlusal view. B. right lateral view.

The earliest-known fossil rays are from the European Early Jurassic (Long, 1995; Family Rhinobatidae), but Myliobatidae, the eagle rays, appear in the Late Cretaceous and rapidly become widespread throughout the Tertiary. They are found generally as isolated teeth or tooth-plates, in common with all Chondrichthyes, in Tertiary marine deposits worldwide.

In New Zealand deposits, they are not common enough yet to have chronostratigraphic value, nor well enough known at species level to have a clear view of evolution or species distribution and longevity. So any additional information will assist future work in this direction.

For more, see Geocene 18, pp. 18–21.


Kawhia giant ammonite site, November 2001 Auckland Geoclub field trip.

Geomarine party for the launch of the Hayward *et al*. GNS Monograph 21 - "Recent New Zealand Shallow-Water Benthic Foraminifera".


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DIVERSITY OF FOSSILS NAMED FOR JACK GRANT-MACKIE

Bruce W. Hayward

Jack's breadth of interest and study is reflected in the diversity of fossil groups in which species have been name for him:

Hydrocoral
Pliobothrus grantmackiei Squires 1965 Oligocene

Gastropoda
Monilea grantmackiei Hayward 1981 Miocene

Bivalves
Ouamouia grantmackiei Campbell, 1984 Triassic, New Caledonia

Belemnites
Hibolithes arkelli grantmackiei Challinor 1975 Jurassic

Ammonites
Xenocephalites grantmackiei Westermann and Hudson 1991 Jurassic
Paraboliceratoides grantmackiei Stevens, 1997 Jurassic

Barnacles
Graviscalpellum grantmackiei Buckeridge, 1983 Miocene
Tasmanobalanus acutus grantmackiei Buckeridge 1983 Miocene

Radiolaria
Siphocampe grantmackiei O'Connor 1997 Miocene
Glomeropyle grantmackiei Aita, 1999 Triassic
Polyfistula? grantmackiei Sashida 2000, Permian Thailand

Brachiopoda
Loboidothyris grantmackiei MacFarlan, 2016 Jurassic

Ostracoda
Oculocytheropteron grantmackiei Milhau, 1983 Miocene

Fish otoliths
Congridarum grantmackiei Grenfell 1984 Miocene

Birds
Pachyplichas jagmi Millener 1988 Quaternary

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QUIZ ON SOUTH AUCKLAND VOLCANIC FIELD

Wendy Goad

1. Which was the most recent volcanic centre identified in the South Auckland Volcanic Field?
2. Where was the last eruption in the South Auckland Volcanic Field?
3. Which is the biggest explosion crater in the South Auckland Volcanic Field?
4. Which volcanic centre has diatomite within the tuff ring?
5. Which volcanic centre is located the furthest south in the South Auckland Volcanic Field?
6. When did eruptions start and finish in the South Auckland Volcanic Field?
7. When did the Hamilton Ash first arrive in the Manukau Lowlands?
8. The basement rocks of the Manukau Lowlands are Mesozoic greywacke and argillite (western Murihiku Terrane). What formation directly underlies the products of the South Auckland Volcanic Field volcanism and the Hamilton Ash?
9. Which fault moved in the 1891 earthquake?
10. What was the primary source of the groundwater that fuelled the phreatomagmatic eruptions north of the Waikato River and west of the Drury Fault in the South Auckland Volcanic Field?

(Answers on last page)

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THE SAND IS COMING – NEW BEACH SOUTH OF PIHA

Bruce W. Hayward

In late February 2021, an enthusiastic group of Auckland Geoclubbers visited South Piha to see for themselves the reported buildup of sand on the beach this summer. We chose a spring low tide late in the day to give us the maximum chance of seeing the most sand. We were fortunate to have Peter Crossley with us, as he has recently been 3D-imaging and mapping the local sea caves.

First stop was Lion Rock/Whakaari (Fig. 1) where, even 1.5 hours before low tide, we were able to walk on dry sand around on the seaward side. The sand buildup had buried and killed all the bull kelp that used to adorn the low tide/subtidal rocks. In September 2015 there had been a similar buildup of sand and on that occasion. One could walk on dry sand on spring low tides out to the seaward side of Lion Rock, but there was still a large deep-water pool between the sand and rock and the bull kelp survived. In 2021, we were able to walk on sand into the largest gut in the rocks on the seaward side and up into a large sea cave with two entrances.

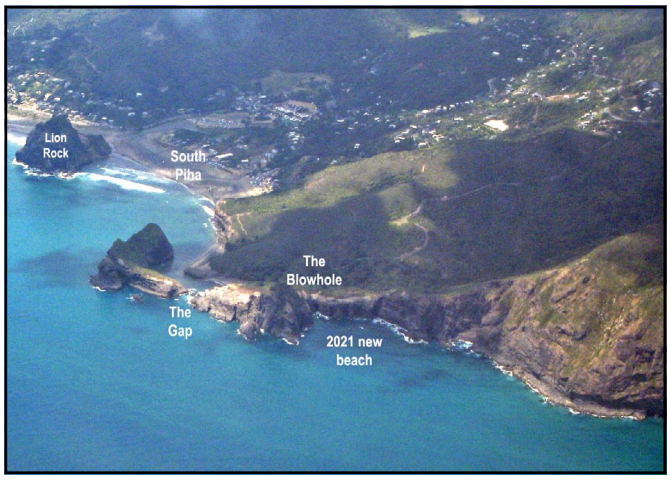


Fig. 1. Aerial view of the location of the new beach in the bay in the centre foreground in 2015. South Piha and Lion Rock are on the left.



Fig. 2. The sand dune present in the bay that leads to The Gap. South Piha, in Feb 2021.

Next, we walked south to The Gap embayment at the south end of South Piha (Fig. 1), which was completely full of sand at low tide. On its eastern side, a large 5 m sand dune had once again grown in front of the rocky cliffs (Fig. 2). In 2008 a similar but smaller dune grew here but was mostly eroded away the following winter (Fig. 3). The tunnel through Taitomo Island was still fully wet even at spring low tide, but at The Gap itself it was possible to jump down onto the sand and enter the caves eroded along the dikes on its south side.

Our main goal, however, was The Blowhole (formerly on the Byles property but now parkland), which Peter reported was full of sand and able to be negotiated (Fig. 2). This was not the first time in recent years that sand had built up inside The Blowhole. In 2002, Margaret Morley and I had been able to walk through The Blowhole tunnel to a small beach on the exposed outside on a particularly low spring tide (Fig. 3). On that occasion the narrow beach that had built up on the outside was still submerged by the surge from waves at low tide and access along the base of the cliffs was extremely limited without swimming. On our visit in 2021, there was a new beach on the outside of The Blowhole and foot of the cliffs between Kaiwhare Pt and Takatu Head. It was 200–300 m wide, parallel to the cliffs and extended 50 m or more out into the sea at low tide (Figs 4–7).

Since I started regularly visiting South Piha in the 1970s this was only the second time I have seen sufficient sand inside The Blowhole tunnel to allow an easy walk through it to the outside and the first time there has been a significant sand beach on the outside. I know of no maps that show a beach in this locality and conclude that this may be the first time in over 150 years (and possibly much longer) that a sand beach has been thrown up between Mercer Bay and Piha. The big question now is will it become semipermanent and even grow larger or will it erode away in future large storm events?



Fig. 3. The small sand dune that grew in the bay leading to The Gap, South Piha, in 2008. This dune eroded away completely but has recently grown again.

The bigger picture

It is well-established that longshore drift along the west coast of the Auckland region is from south to north and clearly this sand has been moved northwards in the nearshore coastal zone. I have previously noted that there is solid evidence that:

a. there was a large sand flat ("the lost land of Paorae") outboard of the seaward side of the northern end of Awhitu Peninsula in the pre-European 18th century and possibly earlier (Cowan, 1914);

b. this lost land off Awhitu had been eroded away by the 1840s, by which time there was a partly vegetated island in the vicinity of the Manukau Harbour bar in the middle of the entrance to Manukau Harbour;



Fig. 4. The small sand beach that accumulated in 2002, seen at spring low tide outside The Blowhole.



Fig. 5. Looking into The sand-filled Blowhole tunnel from the outside in Feb 2021.

c. the present extensive Whatipu sand flat was accreted rapidly in the 1930s-1950s (Williams, 1977);

d. since the 1970s, the seaward side of the Whatipu sand flat has fluctuated by a few hundred metres but has not significantly changed in the last 50 years (Blue & Kench, 2017);

e. since the 1970s the northern end of the Whatipu sand flat, north of Pararaha, has grown seaward enormously and vast quantities of extra sand have filled up Karekare Bay, with the low tide line approximating a straight line between Paratahi Island and the tip of Farley Pt (Fig. 8).

Now the excess sand in the inshore coastal zone has extended north towards Piha. I have previously speculated that we are seeing the onshore expression of a vast slug of excess sand slowly moving north up the west coast of Auckland and that maybe this was produced by the last big eruption from Taupo Volcano, 1800 years ago (Cameron *et al*., 1997; Hayward, 2017). In the last hundred or more years there has been no other obvious large input of sand into the west coast inshore system that might explain the northward-advancing accretion. Indeed, in more recent time, the construction of the Waikato River hydrodams and sand dredging in the lower river have greatly decreased/



Fig. 6. Walking from The Blowhole on to the new beach at spring low tide in Feb 2021.



Fig. 7. Geoclubbers examine rocks at the south end of the new beach outside The Blowhole, 2021.

stopped the natural delivery of sand to the coast at the Waikato River mouth. Possibly as a result of this, the seaward sandy cliffs of Awhitu Peninsula are eroding at the present time, contributing a small amount of extra sand into the coastal system, but nowhere sufficient to explain all the accretion we see along the Waitakere coast at present.

One test of the above hypothesis would be to see if the Whatipu sand flat starts eroding away as more sand moves north – which would assume the amount of excess sand in the system provided by the Taupo eruption is finite and no longer being added to. How long will it be before people can walk on a dry sand beach from Karekare to Piha?

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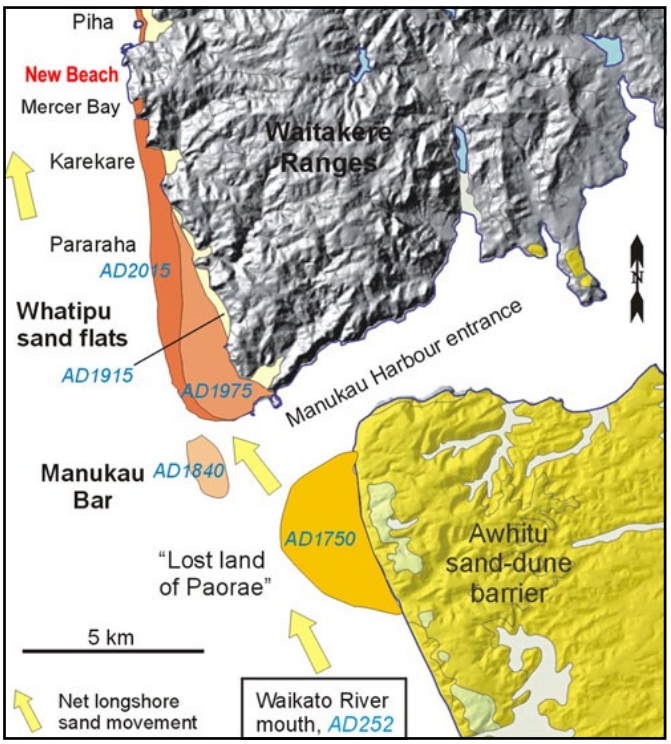


Fig. 8. Map showing the northward advance of accreted sand along the coast between AD1750 and AD2015. The 2021 new beach is labelled in red.

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COOK ISLANDS KARST

Garry Carr

At a recent Geoclub meeting (17/11/2020), Bruce Hayward gave a talk on basalt karst in New Zealand and mentioned the occurrence of karst on Rarotonga (Cook Islands). Here I present photographic evidence of karst on Rarotonga. These two photos were taken by the author at Tuoro or Black Rock on the northwest coast of Rarotonga, not too far from the airport. It is easily accessible, there being a layby off the main round the island road. The English name for the site is, of course, derived from the black basaltic lava which is exposed on the coast here.

To Cook Islanders, Tuoro is believed to be the place where spirits of the dead leave Rarotonga. Those spirits ascend a pua tree and leap from it to begin their journey back to their ancient homeland Avaiki, to the west. Compare this to the significance of Cape Reinga to Maori here in Aotearoa New Zealand.

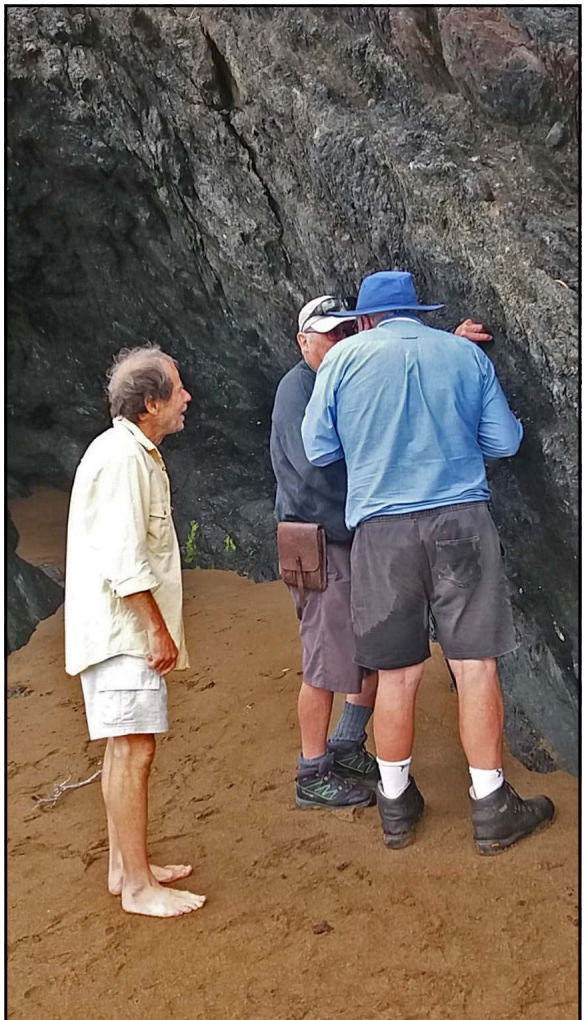
According to information on the storyboard erected at the site, Black Rock is one of the few remaining, readily accessible areas where visitors can see where stone was worked by the Maori people of Rarotonga in earlier times.





Karst at Tuoro or Black Rock, Rarotonga Cook Islands

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Oops – a wet Landing!

WHO ARE THESE PEOPLE?

Who are these three people? Two GeoClubbers and a famous Northland sculptor, no less. They are promising an article on this outcrop for the next issue of Geocene. The caption below will then make sense.

Please send the Editor your thoughts on who they are and also your suggestions for a caption.

AUCKLAND GEOLOGY CLUB FIELD TRIPS 1992–2020

Bruce W. Hayward

Auckland Geology Club (Geoclub) was formed as the Auckland Museum Geology Club at the inaugural meeting on 2nd November 1992. The meeting was called together by Bruce Hayward and Les Kermode. The lecture at that meeting was presented by Les Kermode on the potential places we could go around Auckland for field trips. The first field trip, led by Bruce Hayward, was to Whatipu on Sunday 6th December, 1992 and attracted 35 participants.

Up to the end of 2020 there have been 384 Geoclub field trips, mostly half and one day trips around Auckland (see below) but including 11 multi-day trips to the South Island and two overseas (to Norfolk Island and New Caledonia). We have also had the following North Island multi-day trips: 10 to Northland, 13 to Waikato and Coromandel Peninsula, 6 to the Bay of Plenty and 11 to the remainder of the North Island. The largest number of field trips in one year has been 18 in 2002. The most participants on one field trip was 52 to Tank Farm and Smiths Bush in July 2000 and also to Bartrum Bay in 2001. Fifty attended a boat trip around Kawau Island in 1993. The fewest was 5 to the Little Huia coast on a rainy Sunday in 2010.



Fig. 1. The first Geoclub field trip to Whatipu in December 1992.

List of Geology Club trips with date, place, leader and number of participants.

AUCKLAND CITY

JUL 93 Building stones of Auckland, led by Bruce Hayward and Les Kermode (18)
SEP 95 Building stones of Auckland, led by Les Kermode (43)
AUG 96 Granite and Marble (40)
JUL 99 Auckland Museum galleries, led by Tasha Black, Mike Eagle (18)
NOV 02 Hobson Bay to St Heliers, led by Bruce Hayward (10)
OCT 03 Building stones of Auckland, led by Hugh Grenfell (40)
AUG 07 Auckland City's foreshore (11)
JUL 09 Auckland's historic stone buildings, led by Bruce Hayward (15)
APR 10 Auckland's early water supply, led by Bruce Hayward (21)
JUN 10 Historic stone buildings of East Auckland, led by Bruce Hayward (15)
JUL 11 Tamaki coastal geology, led by Bruce Hayward (18)
MAY 13 Heather & Alison's rock collection (10)
AUG 13 Bucklands Beach beach rock, led by Bruce Hayward (12)
JUN 15 Hobson Bay and Orakei Basin, led by Bruce Hayward (40)
NOV 19 SE Manukau, led by Hugh Grenfell (10)
NOV 20 Mangere Treatment plant fossil dig, led by Bruce Hayward (23)

AUCKLAND VOLCANIC FIELD

JUN 93 Volcanoes of Central Auckland, led by Kel Anglesey (20)
SEP 93 Landscape Rd lava cave, led by Les Kermode (42)
OCT 93 Takapuna fossil forest, led by Bruce Hayward (42)
OCT 94 Mangere Mt and Ihumatao, led by Bruce Hayward and Les Kermode (43)
AUG 95 Tamaki's volcanoes, led by Les Kermode & Bruce Hayward (45)
SEP 96 North Shore volcanoes, led by Les Kermode (22)
JUL 97 Three Kings volcano, led by Les Kermode (35)
JUN 98 Hobson Bay, led by Bruce Hayward and Les Kermode (23)
AUG 99 Mt Eden, led by Les Kermode (38)
JUN 00 Ihumatao fossil forest clean up, led by Bruce Hayward (20)
JUL 00 Tank Farm & Smiths Bush, led by Bruce Hayward (52)
AUG 00 Mt Wellington volcano and flows, led by Les Kermode (31)
SEP 00 Ihumatao fossil forest clean up, led by Hugh Grenfell (20)
MAR 01 Otuataua stonefields led by Bruce Hayward & Les Kermode (35)
SEP 01 Ihumatao fossil forest & Otuataua stonefields clean up, led by Hugh Grenfell (12)
OCT 01 One Tree Hill, led by Les Kermode (30)
JUN 02 Stewarts Lava Cave, led by Hugh Grenfell (31)
JUN 02 Pigeon Mt & St Kentigerns cliffs, led by Bruce Hayward & Anna Sandiford (25)



Fig. 2. Explanation of the geology of the ceramic clay quarry in an altered rhyolite dome near Matauri Bay by Roger Evans, 1995.



Fig. 3. Lunchtime breather above the Huriwai Beach Jurassic fossil plants locality, 1997.

SEP 02 Ihumatao fossil forest & Otuataua stonefields clean up, led by Hugh Grenfell (20)
OCT 02 Mangere Mt & Ihumatao fossil forest, led by Bruce Hayward (18)
OCT 02 Lake Pupuke & Takapuna Reef fossil forest, led by Rod Martin (17)
OCT 02 Puketutu Island, led by Bruce Hayward (22)
MAR 03 Takapuna, led by Bruce Hayward (28)
JUN 03 Waiouru, led by Hugh Grenfell (17)
SEP 03 Mt Albert and lava caves, led by Hugh Grenfell, Murray Baker, Glenn Carter (27)
JUN 04 Crater Hill, led by Ian Smith (32)
AUG 04 Mangere Inlet hills, led by Bruce Hayward (12)
SEP 04 Ihumatao fossil forest and clean up, led by Hugh Grenfell (12)
JUL 05 Waitomokia & Mangere Lagoon, led by Bruce Hayward (15)
OCT 05 Takapuna fossil forest, led by Bruce Hayward (18)
JUL 06 Panmure Basin, led by Hugh Grenfell (13)
SEP 06 Ihumatao fossil forest and clean up, led by Hugh Grenfell (11)
OCT 06 Volcanoes of East Auckland Pt 1, led by Bruce Hayward, Garry Carr (21)
NOV 06 Volcanoes of East Auckland Pt 2, led by Bruce Hayward, Garry Carr (20)
JUL 07 Mapping North Head, led by Bruce Hayward (17)
SEP 07 Mt Wellington Heritage Week, led by Dan Hikuroa (15)
SEP 07 Mt Wellington stonefields cleanup, led by Hugh Grenfell (10)
JUN 08 South coast Puketutu, led by Bruce Hayward (19)



Fig. 4. Les Kermode explains the intricacies of Maungarei/Mt Wellington in 2000.

SEP 08 Three Kings Volcano, led by Bruce Hayward & Jill Kenny (16)
OCT 08 Mt Wellington stonefields clean-up, led by Hugh Grenfell (8)
NOV 08 Pupuke Volcano, led by Bruce Hayward (20)
MAY 09 McLaughlins Volcano and stonefields, led by Bruce Hayward (23)
JUN 09 Volcanoes of East Tamaki, led by Bruce Hayward (22)
OCT 09 Volcanoes of Papatoetoe to Otahuhu, led by Bruce Hayward (17)
AUG 10 Ambury Park lava flows and lava caves, led by Bruce Hayward (21)
OCT 10 One Tree Hill lower slopes, led by Bruce Hayward and Bernhard Spörli (16)
AUG 11 Hochstetter's lost volcanoes, Mangere, led by Bruce Hayward (11)
NOV 11 New volcanoes, led by Bruce Hayward (28)
JUN 12 Royal Oak Craters, led by Bruce Hayward (19)
SEP 12 Devonport Volcanoes, led by Peter Scott (20)
JUN 13, Mt Eden, led by Bruce Hayward (18)
JUL 13, Mt Wellington west side, led by Bruce Hayward (33)
SEP 13 Otuataua stonefields, led by Bruce Hayward (16)
MAR 14 Wiri lava cave, led by Peter Crossley (36)
JUN 14 Rangitoto's Wreck Bay & Emu Pt, led by Peter Crossley and Bruce Hayward (25)
AUG 15 Pupuke, led by Peter Scott (14)
APR 16 Mangere Lagoon and Mt, led by Bruce Hayward (15)
NOV 17 Mt Albert lava flows, led by Hugh Grenfell (15)
DEC 17 Cheltenham Beach and North Head Xmas BBQ, led by Bruce Hayward (25)
AUG18 Rangitoto summit and caves, led by Bruce Hayward (14)
OCT 18 Hampton Park, led by Bruce Hayward (18)
MAR 19 McLaughlins Mt led by Bruce Hayward (16)
APR 19 Mangere lava flow field led by Bruce Hayward (16)
SEP 19 Otuataua basalt karst and Maungataketake, led by Christine Major and Bruce Hayward (14)

WAITEMATA GROUP, AUCKLAND

AUG 93 Tip of Whangaparaoa Peninsula, led by Bruce Hayward (24)
FEB 94 North Head to Takapuna, led by Les Kermode and Bruce Hayward (20)
APR 95 North Manukau coast, led by Bruce Hayward (20)
OCT 95 Musick Point, led by Les Kermode (22)
JUN 97 Omana, Motukaraka, led by Bruce Hayward (20)
OCT 97 St Heliers, led by Peter Ballance (30)
AUG 98 Eastern Beach Anticline mapping, led by Hugh Grenfell and Graham Gibson (10)
DEC 98 Mahurangi Xmas BBQ, led by Bruce Hayward (35)
MAR 99 Castor Bay, led by Bernard Spörli (45)
AUG 99 Torbay, led by Bruce Hayward (38)
OCT 99 Whangaparaoa Pt, led by Peter Kivell (32)
DEC 99 Wenderholm Xmas BBQ, led by Hugh Grenfell (25)
DEC 00 Long Bay Regional Park BBQ (35)
JUL 01 Eastern Beach to Howick, led by Bruce Hayward (30)
MAY 02 Martins Bay, led by Bernhard Spörli (25)
AUG 02 Titirangi coast, led by Hugh Grenfell (28)
OCT 02 Army Bay, led by Peter Kivell (14)
MAR 03 Castor Bay to Murrays Bay, led by Bruce Hayward (27)
JUL 03 Pt Chevalier, led by Bruce Hayward (28)
SEP 03 Parnell Baths clean up, led by Hugh Grenfell (17)
OCT 03 Cheltenham Beach, Led by Rod Martin (11)
OCT 03 Eastern Beach, led by Murray Baker (8)

JUL 04 Pt England to Tahuna Torea, led by Bruce Hayward (12)
AUG 06 Kendall Bay, Birkenhead, led by Hugh Grenfell (21)
JUN 07 Laingholm, led by Hugh Grenfell (17)
SEP 07 Karaka Bay, led by Graeme Mansergh (18)
SEP 07 Cape Horn, led by Hugh Grenfell (25)
NOV 07 Scandrett Regional Park, led by Bruce Hayward (16)
JUL 08 Coalmine Bay, led by Hugh Grenfell (12)
FEB 09 West Mahurangi Regional Park, led by Bruce Hayward (15)
AUG 09 Lynfield coast, led by Bruce Hayward (13)
DEC 09 Mahurangi Regional Park, led by Bruce Hayward (20)
FEB 10 Pakiri Beach and Regional Park, led by Bruce Hayward (6)
DEC 10 Shakespear Regional Park BBQ, led by Bruce Hayward (21)
MAR 12 Musick Pt, led by Bruce Hayward (12)
DEC 12 Armour Bay, led by Bruce Hayward (15)
AUG 12 Kennedy Park to Castor Bay, led by Lorna Strachan (26)
FEB 13 Arkles Bay to Little Manly, led by Bruce Hayward (21)
DEC 14 Omana Regional Park BBQ, led by Bruce Hayward (18)
AUG 14 Takapuna Head, led by Bruce Hayward (20)
AUG 15 Long Bay to Okura, led by Bruce Hayward (19)
FEB 16 Narrow Neck to Takapuna Beach, led by Peter Scott (13)
MAY 16 Fossil Bay, Waiheke, led by Bruce Hayward (16)
AUG 16 Campbells Bay to Murrays Bay, led by Bruce Hayward (21)
DEC 16 Brick Bay, led by Bruce Hayward (20)
JUN 17 Stillwater, led by Peter Scott (10)
JUN 17 Karaka Bay to Achilles Pt, led by Bruce Hayward (19)
AUG 17 Army Bay to Whangaparaoa Head, led by Bruce Hayward (17)
SEP 17 Eastern Beach, led by Bruce Hayward (17)
MAY 18 Martins Bay, led by Bruce Hayward (12)
JUL 18 Mellons Bay to Howick Beach, led by Bruce Hayward (22)
May 19 Kauri Pt, led by Bruce Hayward (21)
JUL 19 Stanmore Bay led by Bruce Hayward (18)
DEC 19 Pt Chevalier Xmas BBQ led by Hugh Grenfell (14)
MAR 20 Mahurangi Regional Park, Cudlip Pt, led by Bruce Hayward (16)
JUN 20 Campbells Bay, led by Bruce Hayward (37)
NOV 20 Browns to Murrays Bay, led by Bruce Hayward (15)



Fig. 5. Ready to explore the underground workings at broken Hill gold mine, Coromandel, 2000.



Fig. 6. Negotiating the gloopy mud to get to the small scoria cone inside Mangere Lagoon explosion crater, 2005.

WEST AUCKLAND AND WAITAKERE RANGES

DEC 92 Whatipu, led by Bruce Hayward. (35)
DEC 93 North Piha BBQ, led by Bruce Hayward (30)
DEC 94 Karekare BBQ, led by Bruce Hayward (33)
DEC 95 Te Henga BBQ, led by Bruce Hayward (36)
DEC 96 Muriwai BBQ, led by Bruce Hayward (40)
FEB 96 Kaitarakihi to Huia Dam, led by Bruce Hayward (40)
SEP 96 Nihotupu Dam, led by Bruce Hayward (22)
APR 94 Pollen Island, jointly with Museum Conchology Section (30)
JUL 95 Pollen Island, led by Hugh Grenfell and Bruce Hayward (18)
AUG 97 Waitakere Dam, led by Bruce Hayward (30)
OCT 97 Whatipu, led by Bruce Hayward (16)
DEC 97 South Piha BBQ, led by Bruce Hayward (40)
MAR 98 Piha Gorge, led by Bruce Hayward (12)
MAY 98 Anawhata Beach, led by Bruce Hayward (30)
NOV 99 Fairy Falls, led by Bruce Hayward (17)
SEP 00 Lake Wainamu, led by Bruce Hayward (30)
FEB 01 Cornwallis, led by Bruce Hayward (30)
APR 01 Bartrum & Powell Bay, led by Bruce Hayward (52)
JAN 02 Mokoroa Stm, led by Bruce Hayward (24)
APR 02 Karekare mapping, led by Bruce Hayward (15)
JUL 02 Crystal Mt & Waitakere Valley, led by Bruce Hayward (32)
FEB 03 Te Waharoa, led by Bruce Hayward (26)
JUN 03 Footsteps of Hochstetter, led by Bruce Hayward (18)
AUG 03 Kitekite Falls, led by Bruce Hayward (24)
DEC 04 Karekare BBQ, led by Bruce Hayward (27)
JAN 05 Mercer Bay, led by Bruce Hayward (15)
JUN 05 Huia Pt, led by Bruce Hayward (17)
DEC 06 Kaitarakihi BBQ, led by Bruce Hayward (25)
DEC 07 Muriwai BBQ, led by Bruce Hayward (38)
DEC 08 Kakamatua to Cornwallis, led by Bruce Hayward (24)
SEP 09 Whites Beach, led by Bruce Hayward (6)
SEP 10 Little Huia coast, led by Bruce Hayward (5)
MAR 11 Te Henga, led by Bruce Hayward (21)
DEC 11 Piha BBQ, led by Bruce Hayward (10)
Feb 12 Omanawanui Track, led by Bruce Hayward (8)
MAR 13 Titirangi and Landsendt, led by Hugh Grenfell (19)
JUL 14 Kaitarakihi, Kakamatua, led by Hugh Grenfell (7)



Fig. 7. Using the special bridge to view the ignimbrite and peat section in St Kentigerns cliffs, 2007.

OCT 14 North Piha, Whites Beach, led by Bruce Hayward (21)
DEC 14 Muriwai, Xmas BBQ, led by Bruce Hayward (25)
MAR 16 Bartrum Bay submarine canyon, led by Hayward (23)
AUG 16 Wainamu and O'Neills Bay, led by Bruce Hayward (11)
OCT 16 Waikumete Cemetery, led by Hugh Grenfell (22)
Aug 17, Pollen Island, led by Michael Coote and Bruce Hayward (19)
May 18 Anawhata, led by Bruce Hayward (17)
DEC 18 Xmas BBQ rainy. Whatipu led by Bruce Hayward (10)
JUN 19 Te Henga old quarry, led by Hugh Grenfell (16)
JUL 20 Swanson potholes, led by Michael Coote and Kent Xie (24)
AUG 20 Karekare to Pararaha, led by Bruce Hayward (28)

GULF ISLANDS

MAR 93 Motuihe Island, led by Les Kermode and Bruce Hayward (38)
NOV 93 Kawau Island, led by Bruce Hayward and Rob Brassey (50)
JUN 94 Motutapu, led by Bruce Hayward and Hugh Grenfell (20)
MAR 95 Browns Is to Waiheke, led by Bruce Hayward, Mike Eagle, Glenn Carter (45)
DEC 96 Rangitoto, led by Les Kermode (32)
APR 98 Stony Batter, Waiheke, led by Bruce Hayward (25)
MAY 99 Motuora Island (45)
MAR 00 Motuihe Island, led by Hugh Grenfell & Bruce Hayward (36)
NOV 00 Double-U Bay, Waiheke, led by Hugh Grenfell (20)
SEP 02 Rangitoto west coast, led by Jack Grant-Mackie (22)
NOV 04 4 days Great Barrier Island, led by Bruce Hayward (21)
MAR 05 Rangitoto and caves, led by Bruce Hayward (12)
OCT 07 Rotoroa Island, led by Bruce Hayward (33)
MAY 08 Tiritiri Matangi, led by Helen Holzer (28)
FEB 09 Rakino Island, led by Bernhard Spörli and Bruce Hayward (38)
FEB 10 Motutapu and Rangitoto, led by Bruce Hayward (11)
SEP 11 Motukorea, led by Lucy McGee (29)
OCT 13 Ponui Island, led by Bernhard Spörli & Hugh Grenfell (40)
MAR 15 Waiheke Island by van, led by Bruce Hayward (30)
FEB 17 Motuihe Is, led by Bruce Hayward (23)
APR 18 Great Barrier Is 6-day trip, led by Bruce Hayward (18)

RODNEY DISTRICT

OCT 94 Leigh area, led by Bruce Hayward (31)
JUN 96 Waiwera to Whangaparaoa, led by Bruce Hayward (28)
OCT 96 Toe of the Allochthon, led by Bruce Hayward (25)
NOV 97 Toe of Allochthon, led by Bruce Hayward (20)
FEB 98 Okahukura Peninsula, led by Bruce Hayward and Hugh Grenfell (12)
MAR 98 Mathesons Bay, led by Bruce Hayward and Hugh Grenfell (30)
NOV 98 Okura, led by Hugh Grenfell (28)
APR 99 Hoteo, led by Bruce Hayward (25)
FEB 00 Tawharanui, led by Bruce Hayward (25)
JUN 00 Algies Beach, led by Bruce Hayward (23)
JUN 01 Okahukura, led by Bruce Hayward (25)
AUG 01 Kaipara South Head, led by Hugh Grenfell (20)
OCT 02 Mt Auckland, led by Bruce Hayward (18)
DEC 02 Shakespear BBQ, led by Bruce Hayward (30)
NOV 03 Upper Waitemata Harbour, led by Bruce Hayward (20)
DEC 03 Stanmore Bay BBQ, led by Hugh Grenfell (21)
MAY 04 Ti Pt & Goat Island Bay, led by Bruce Hayward (25)
NOV 04 Waiwera to Hadfields, led by Bruce Hayward (22)
OCT 05 Omaha, led by Bruce Hayward (20)
FEB 06 The Outpost, Leigh, led by Hugh Grenfell (20)
APR 06 Kaipara Regional Park, led by Bruce Hayward (11)
MAY 06 Mangawhai Heads, led by Garry Carr (15)
MAR 07 ALPURT, led by Steve Crawford (24)
FEB 08 Gittos Pt, led by Glenn Carter (26)
APR 08 Atiu Regional Park, led by Bruce Hayward (11)
JAN 12 Ti Pt karst and Sugarloaf, led by Bruce Hayward (15)
MAY 13 Glorit and Tapora sand mines, led by Bruce Hayward (5)
OCT 13 Mahurangi South shore, led by Bruce Hayward (4)
FEB 14 Mangawhai Spit, led by Garry Carr (14)
APR 14 Oruawharo Hyaloclastite, led by Bruce Hayward (16)
JUN 14 Silverdale stratigraphy, led by Hugh Grenfell (23)
Jun 15 Christian Bay & Tawharanui, led by Bruce Hayward (12)
JUL 16 Warkworth radio telescope, led by Christine Major (24)
NOV 16 Warren Judd's collection and Wainui road cuts, led by Bruce Hayward (18)
APR 17 South Kaipara Peninsula, led by Bruce Hayward (11)



Fig. 8. A wet trip around the former shoreline of Auckland City, 2007.

SOUTH AUCKLAND AND FRANKLIN DISTRICT

FEB 93 Kaawa, leader Mike Eagle (22)
MAR 94 Waiuku area geology, led by Hugh Grenfell (28)
AUG 94 Inland Port Waikato, led by Mike Eagle (38)
NOV 94 Kawakawa Bay to Miranda Coast, led by Hugh Grenfell (30)
JUN 95 Palmers Beach, led by Glenn Carter (25)
APR 96 Waiwiri Beach, led by Bruce Hayward (30)
MAR 97 Inland Port Waikato, led by Kel Anglesey (24)
APR 97 Huriwai Beach, led by Mike Eagle with Auckland Botannical Society (60)
SEPT 97 Franklin volcanoes, led by Les Kermode (25)
NOV 97 2-days Kawhia led by Waikato Branch (25)
JUN 99 Bombay Milburn Quarry, led by Craig Cook (32)
JUN 01 Waikato North Head mine, led by Dion Pastars (24)
NOV 01 Tapapakanga Regional Park BBQ, led by Bruce Hayward (20)
OCT 03 Ohuka Beach, led by Murray Baker (15)
FEB 04 Hamiltons Gap, led by Bruce Hayward (17)
OCT 04 Central Awhitu west coast, led by Hugh Grenfell (15)
AUG 05 Mangere Inlet mud romp, led by Hugh Grenfell, Bruce Hayward (18)
DEC 05 Orere Pt BBQ, led by Bruce Hayward (23)
MAR 06 Kawakawa Bay, led by Bruce Hayward (9)
JUN 06 Kidds Beach, led by Bruce Hayward (20)
FEB 07 St Kentigern cliffs, led by Bruce Hayward (25)
FEB 07 Mercer to Puketoka, led by Hugh Grenfell (20)
May 07 Clarks Beach, led by Bruce Hayward, Colin Wilson (16)
MAR 10 Awhitu Regional Park, led by Bruce Hayward (16)
MAR 09 Hamiltons Gap to Cochranes Gap, led by Bruce Hayward (25)
JUL 10 Whitford coast, led by Bruce Hayward (18)
Feb 11 South Auckland Volcanic Field, led by Wendy Goad (18)
JUN 11 Beachlands, led by Bruce Hayward (10)
OCT 11 Daff Rd quarry Jurassic fossils, led by Hugh Grenfell (11)
APR 14 Waitawa Regional Park, led by Bruce Hayward (13)
APR 15 Wattle and Big bays, Awhitu, led by Bruce Hayward (15)
JUN 15 Drury coal field & Pukekohe volcanoes, led by Bruce Hayward (19)
OCT 15 Kellyville and Onewhero volcanoes, led by Wendy Goad (14)
DEC 15 Hunua Falls, led by Bruce Hayward (22)
FEB 16 Weymouth, led by Hugh Grenfell (21)
JUL 16 Kariotahi, led by Bruce Hayward (19)
FEB 17 Karaka Pt Pliocene, led by Bruce Hayward (15)
DEC 18 Hamiltons Gap to Cochranes Gap, led by Bruce Hayward (6)
FEB 20 Clarks Beach to Waiuku Pleistocene, led by Hugh Grenfell (15)
OCT 20 Northern Franklin Field, led by Wendy Goad (12)

NORTHLAND

JAN 94 3 days Whangarei geology, led by Bruce Hayward (35)
JAN 95 3 days Whangaroa to Doubtless Bay, led by Bruce Hayward (31)
NOV 95 Puketotara, led by Bruce Hayward and Glenn Carter (32)
FEB 97 Mangawhai Heads, led by Bruce Hayward (35)
MAY 97 3 days South Hokianga, led by Bruce Hayward (22)
OCT 00 3 days North Kaipara, led by Hugh Grenfell (for BWH) (28)
MAR 02 Laings Beach, led by Bruce Hayward (25)
OCT 03 5 days Far North, led by Murray Gregory, Bruce Hayward (25)
MAR 04 Waipu Caves, Hewletts Pt, led by Bruce Hayward (28)
MAR 04 Bull Pt, led by Glenn Carter (21)
FEB 05 Takahiwai and One Tree Pt, led by Bruce Hayward (17)
APR 07 Orongo Pt, led by Rhiannon Daymond-King (19)
MAY 07 4 days North Cape, led by Bruce Hayward, Hugh Grenfell (28)
FEB 08 Gittos Pt, led by Glenn Carter (26)
DEC 10 4 days Whangarei geology, led by Bruce Hayward. (41)
MAY 11 2 days Hukatere Peninsula, led by Glenn Carter, Bruce Hayward (29)
MAR 12 Whakapirau, led by Glen Carter (12)
APR 12 Waipu Cove, led by Bruce Hayward (18)
OCT 12 Mangawhai Heads, led by Garry Carr (17)
DEC 15 Pahi, led by Bruce Hayward (19)
NOV 16 8 days Kerikeri and Opononi, led by Bruce Hayward (36)
OCT 17 Waipu Estuary and One Tree Pt, led by Bruce Hayward (10+ 40 public)
MAR 18 Baylys Beach, led by Bruce Hayward (10)
MAR 19 Pakaurangi Pt and Puketi, leader Bruce Hayward (15)
MAY 19 4 days NE Northland, Whangarei & Paihia, leader Bruce Hayward (30)



Fig. 9. Four Peters seek the shade of a large schist boulder at Butchers Dam, Central Otago, 2009.

WAIKATO

MAY 93 2 days Waitomo and Kiritehere, leader Les Kermode (20)
APR 95 Huntly coalfield, led by Richard Ruddick (28)
SEP 98 Karioi, led by Waikato Branch (25)
MAR 99 Gibsons Beach, led by Hugh Grenfell (25)
MAY 99 Hamilton Basin, led by Les Kermode (24)
NOV 01 3 days Kiritehere, led by Jack Grant-Mackie (26)
MAY 03 Huriwai, led by Hugh Grenfell, Glenn Carter (23)
DEC 08 Port Waikato karst, led by Marlene Lynam & Hugh Grenfell (13)
APR 09 2 days Taupo, led by Gill Jolly, Murray Baker, Garry Carr & Bruce Hayward (25)
MAY 10 2 days Waitomo, led by Peter Crossley (20)
MAY 10 Ngaruawahia Cenozoic strata, led by Hugh Grenfell (12)
APR 11 Port Waikato dinosaur hunt, led by Hugh Grenfell (12)
MAY 12 Miranda chenier plain, led by Bruce Hayward (40)
MAY 12 Kaawa, led by Wendy Goad (24)
MAY 13 2 days Kawhia area, led by Mark Robbins (11)

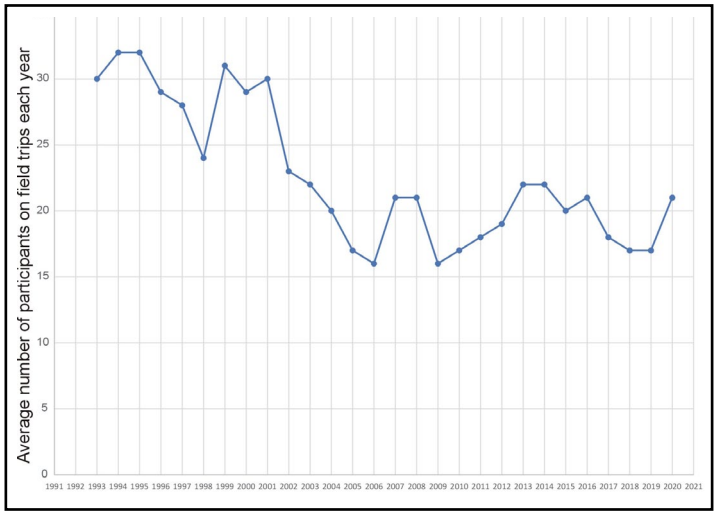


Fig. 10. Lunch on the beach with trip leader Hamish Campbell (right), in New Caledonia, 2017.

FEB 14 2 days Kawhia to Te Maika, led by Mark Robbins (17)
OCT 14 Carters Beach, led by Hugh Grenfell (14)
SEP 16 Hamilton Basin, led by Adrian Pittari and David Lowe (28)
Mar 17 Otorohanga fossil forest, led by Christine Major (17)
FEB 18 Sunset Beach, Port Waikato, led by Bruce Hayward (28)
FEB 19 Nikau Cave and limestone waterfall organised by Wendy Goad (15)

COROMANDEL

APR 94 Waihi, led by Phil Moore (46)
NOV 96 2 days Coromandel, led by Phil Moore (26)
MAY 98 2 days Whitianga area, led by Phil Moore (26)
APR 00 2 days Kauaeranga Valley, led by Bruce Hayward (31)
APR 01 2 days Broken Hills & Whangamata, led by Stuart Rabone & Phil Moore (35)
NOV 01 Kauaeranga lake beds, led by Bruce Hayward (7)
APR 05 Waiarongomai gold field, led by Phil Moore (21)
MAY 03 Golden Cross mine site, led by Jeff Mauk (24)
APR 13 2 days East Coromandel coast, led by Roger Briggs (25)
MAY 14 2 days north Coromandel Pen, led by Alastair Brickell, Bruce Hayward, Liz Hoskin, Johnny Irons (22)
FEB 15 Kauaeranga Valley, led by Bruce Hayward (24)
APR 17 Waihi and Karangahake, led by Bruce Hayward (26)
JUN 18 Thames School of Mines, led by Hugh Grenfell (12)



BAY OF PLENTY - TARANAKI

MAY 94 2 days Tongariro, led by Les Kermode.(16)
APR 96 2 days Rotorua geothermal, led by Stuart Simmons (20)
FEB 99 3 days north Taranaki, led by Graham Gibson, Bruce Hayward (31)
NOV 99 5 days Mayor Island, led by Bruce Hayward and Hugh Grenfell (40)
APR 02 3 days eastern Bay of Plenty, led by David Kear, Bill Wingate, Bruce Hayward (24)
APR 04 2 days Mt Taranaki, led by Vince Neall (24)
APR 05 3 days Rotorua, led by Will Esler, Ashley Cody, Bruce Hayward, Murray Baker (28)
NOV 05 2 days Kaimais to Tauranga Harbour, led by Bruce Hayward, Phil Moore (15)
APR 08 2 days White Is, Tarawera, Matata, led by Garry Carr & Kel Anglesey (18)
APR 12 3 days southern Ruapehu, led by Garry Carr (17)
MAY 16 3 days Taumaranui to Whanganui, led by Julie Palmer (27)

EAST COAST

JAN 96 4 days East Cape, led by Jill Kenny (23)
MAR 03 4 days Napier, led by Arne Palletin, Vincent Caron, Kyle Bland (32)
MAR 06 4 days Mahia, led by Bruce Hayward, Murray Baker (18)
MAY 15 6 days Gisborne & East Cape, led by Bruce Hayward, Mike Marden, Phil Moore (21)

CENTRAL NEW ZEALAND

NOV 06 4 days Wairarapa, led by Bruce Hayward, Martin Crundwell (22)
NOV 07 6 days NW Nelson, led by Bruce Hayward (28)
NOV 11 5 days Marlborough, led by Bruce Hayward (24)
MAY 17 3 days Wellington, led by Bruce Hayward and Hamish Campbell (19)
NOV 19 8 days NW Nelson, led by Bruce Hayward (28)
NOV 20 8 days Tasman district, led by Bruce Hayward (24)

SOUTHERN NEW ZEALAND

NOV 08 6 days north West Coast, led by Bruce Hayward (25)
NOV 09 6 days Central and North Otago, led by Bruce Hayward & Hugh Grenfell (25)
NOV 12 6 days South Otago to Southland, led by Bruce Hayward and Ross Ramsay (25)
NOV 13 6 days Canterbury, led by Bruce Hayward, Margaret and John Bradshaw, Zane Bruce (30)
NOV 14 7 days West Coast to Mt Cook, led by Bruce Hayward, Margaret and John Bradshaw (29)
NOV 17 7 days Eastern Fiordland, led by Bruce Hayward and Ross Ramsay (23)
NOV 18 7 days Kaikoura Earthquake to Christchurch, led by Jesse Kerse, Kate Pedley, Bruce Hayward (29)

OVERSEAS

NOV 16 8 days Norfolk Island, led by Bruce Hayward (18)
JUL 17 7 days New Caledonia, led by Hamish Campbell and Chris Adams (18)

Fig. 11. Average number of participants on Geoclub field trips each year.

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HYPERLINK INSTRUCTIONS

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QUIZ ANSWERS

1. Karaka Cone.
   (Hayward, B.W. 2018. Karaka Volcano - a previously unrecognised 'castle and moat' basalt volcano located between the Auckland and South Auckland volcanic fields. Geoscience Society of New Zealand Newsletter 24: 15–18.)
2. The c. 560,000 eruption of Pukekohe Hill.
   (Briggs, R.M., Okada, T., Itaya, T., Shibuya, H., Smith, I.E.M., 1994. K-Ar ages, paleomagnetism, and geochemistry of the South Auckland volcanic field, North Island, New Zealand. *New Zealand Journal of Geology and Geophysics* 37: 143–153.)
3. Onewhero tuff ring, formed c. 0.88 Ma, is the largest tuff ring in the South Auckland Volcanic Field, with a diameter of 2.6 km at its widest point. The tuff deposit is approximately 750 m wide around the entire tuff ring. The highest point of elevation on the tuff ring rim is 182 m above sea level.
4. Kellyville maar near Mercer.
5. Kauri Road Scoria Cone beyond Onewhero village.
6. The youngest was 0.56 ± 0.05 Ma at Pukekohe Cone and the oldest 1.6Ma ± 0.51 at the Te Kohanga tuff ring; an outlier is the Drury Hills Cone at 2.24 ± 0.37 Ma.
   (Briggs *et al.* 1994, see whole reference in answer 2)
7. Hamilton Ash derives from several ashfalls from the CVZ. They have an age span of c. 350,000 to c. 100,000 years and in turn are overlain with a patchy composite cover bed veneer of intermixed tephra's that have accumulated incrementally millimetre-by-millimetre over the past c. 60,000 years. A likely source of these ashes is the Whakamaru Group ignimbrite possibly produced from the Whakamaru caldera volcano.
   (Lowe, D.J., Neall, V.E., Hedley, M., Clothier, B., Mackay, A. 2010. Guidebook for pre-conference North Island, New Zealand "Volcanoes to Oceans" field tour (27–30 July). 19th World Soils Congress, International Union of Soil Sciences, Brisbane. Soil and Earth Sciences Occasional Publication No. 3, Massey University, Palmerston North, pp. 7–29.)
8. The Taurnga Group of fluvial and lacustrine gravels, sands, silts and muds.
9. The Waikato Fault offshore of Port Waikato.
10. The Kaawa Formation - a highly porous and permeable, slightly indurated, thick sandstone (up to 250 m thick around Pukekohe and Tuakau), which forms an important aquifer system in South Auckland. The Kaawa Formation consists of coarse to medium sandstone with interbedded shell beds including small rounded volcanic and Waitemata Group sandstone fragments.
    (Schofield, J.C. 1958. Notes on volcanism and structure in Franklin County. *New Zealand Journal of Geology and Geophysics* 1 (3): 541–599.)

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