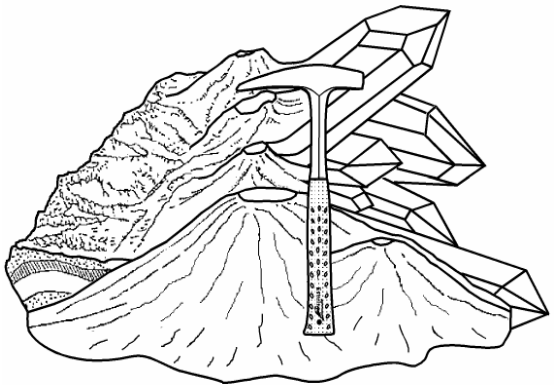


Geocene

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The Outpost - Leigh Harbour
Helen Holzer

In February 2006, GeoClub visited The Outpost, Leigh Harbour, north of Auckland. The purpose of the visit was to look at the basal Waitemata sediments and the fossils within this sediment. The trip was led by Hugh Grenfell and we were fortunate to also have along the structural and trace fossil experts, Bernhard Spörli and Murray Gregory.



Fig. 1. Fun crossing the gut. The Outpost in the background.

At the northern entrance of Leigh Harbour a wave cut platform in basal Waitematas, bisected by a number of guts, extends out to a small island (The Outpost).

The first stop was at the cliff face from which the platform extended. Here the basal Waitematas consisted of fine sandy/muddy layers interspersed with coarse pebbly layers, sometimes quite thin and not always continuous. Concretions were formed within the fine layers. One of the interesting features here, which were also seen out on the island, was the fossil ray holes in some strata in the cliffs. The rays, like today's rays, burrowed into the sand on the sea floor in shallow water. The depressions are made by the ray jetting water through its gills into the soft bottom sediments to expose invertebrates. The trace fossil produced is called *Piscichnus waitemataensis* (Gregory, 1991). A debris flow along the sea floor caused by instability, an earthquake or even a storm, came down rapidly infilling the burrows. The source of the debris would have been sand and other sediment derived from a greywacke coastline eroding at the time.

In the following photo the ray holes are seen in several horizons with numerous strata of finer and coarser layers beneath but on The Outpost, in places the ray strata are separated by a shorter interval of time with only a thin finer layer separating them suggesting more frequent debris flows into the area.



Fig 2. Ray feeding holes infilled with coarse sediment at frequent intervals in the strata.

Another feature of the finer layers was the formation of concretions. These were formed by the action of fluids percolating through the layers. In places the concretions were larger and within a single horizon.



Fig 2 Concretions within the cliff section.

However, at The Outpost they were being formed through all the finer layers.



Fig 4. Concretions in the cliffs of The Outpost

The trace fossil, *Phycodes*, is also abundant in the cliff face. These burrows radiate out and are emphasised by the colour difference which is caused by diagenesis. After the strata have been laid down, fluids within the strata change it chemically and these altered grains fill the burrows. *Phycodes* were the most abundant of the trace fossils but *Thalassinoides* and *Macaronichnus* were also found (identifications courtesy of Murray Gregory). *Thalassinoides* show as Y-shaped burrowing which are vertical shafts connecting horizontal tunnel networks. *Macaronichnus* were probably made by a worm and indicate very shallow water, immediately sub-tidal. Body fossils (e.g. brachiopods, bryozoans, echinodermata - spines) were sparse. Preservation of body fossils is perhaps affected by the high energy environment or dissolution.



Fig 5 *Thalassinoides* burrows showing the Y-shaped branching pattern. Seaward side of The Outpost.

At The Outpost itself large, fallen blocks of breccia/conglomerate immediately attracted attention as these were not present on the cliffs before the wave-cut platform.



Fig 6. Pebble/cobble sized conglomerate with a finer matrix

Some of these had pebble/cobble size rocks, while there were also some very large boulders. The fallen blocks of breccia/conglomerate around the foot of The Outpost have come from the top stratum of the island. The finer grained strata of sand/ mud with interspersed coarser layers are here completely capped by the breccia/conglomerate.



Fig 7 Larger boulders within a finer matrix

All of the blocks within this are greywacke, as in the photo above. Some show the original folding.



Fig 8 Original folding within a large greywacke boulder

While most of the breccia clasts were indurated sandstone/mudstone, there were also clasts of



Fig 9 Sea floor basalt, greenish in colour and veined contrasts with the sedimentary clasts.

sea-floor basalt from the greywackes (identified by Bernhard Spörli).

The basal Waitematas were deposited in the early Miocene (about 22 million years ago) into a rapidly forming submarine basin. The Auckland area then was low lying and at the beginning of the subsidence has been described as not unlike Auckland today with an embayed coastline and cliffs and islands of greywacke, all of which had begun to subside and the sea had begun to cover the valleys and low-lying areas. The ancient greywacke stacks around which the Miocene sediments were deposited, are still visible on the coast north of The Outpost.



Fig 9. Miocene sea stack surrounded by clasts from the breccia/conglomerate



Fig 10. Breccia/conglomerate strata with erosional contact.

A catastrophic event, e.g. an earthquake, is likely to have caused the debris flow. The large boulders indicate that it was not just beach deposits as large boulders included would have fallen from the eroding cliffs behind. In the coastal cliffs to the north, the breccia / conglomerate formed the rocky shore but it was mainly absent in the cliffs except a smaller channel a little further round. The cliffs here also had later Waitemata Group sediments with the Pakiri Formation forming the higher strata.

The Outpost was another interesting and successful GeoClub field trip. It was an excellent site to look at and discuss the basal Waitematas and their structure and setting .The added fascination was the prevalence of trace fossils and the explanations on their formation. The fun of the dinghy haul across the gut was an added amusement! Thank you to all who contributed their knowledge and interest.

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How did the cobbles get on a sandy beach?
Bruce W. Hayward



Fig. 1. Well-rounded andesite pebble on Foxton Beach.

During a GSNZ Conference field trip in November 2006, we visited Foxton Beach near the mouth of the Manawatu River. We had just been told by trip leader Craig Sloss that the Manawatu drops all its gravel load at the head of its estuary many kms inland and only finer sediment is transported out to the coast. Here at Foxton Beach we stood on a wind-swept sandy beach, backed by active and fixed sand dunes, but above high tide on the back of the beach there were occasional well-rounded cobbles and pebbles of greywacke and andesite (Figs. 1-2).

What were these doing here? Where did they come from? How did they get here?

The nearest rocky shore is more than 50 km to the south at Paekakariki or over 100 km to the north near Hawera. Somewhat closer some of the other major rivers that flow into the sea along this stretch do disgorge pebbles from their river mouths, but these are locally confined to within a few km of the entry points. There seems no evidence of a subtidal source of gravel offshore from Foxton, with no pebbles or cobbles rolling around in the intertidal, particularly low tidal zone.



Fig. 2. Cobbles, pebbles, driftwood and stumps above high tide at the top of Foxton Beach.

The answer to these questions was fortunately close at hand. Above high tide level the occasional cobbles and pebbles were accompanied by driftwood and numerous tree stumps with root boles intact, presumably washed down by the swollen Manawatu and adjacent rivers during several large flood events in recent years. Still caught up among the roots of two tree stumps were a number of rounded cobbles and pebbles. As the soil around them dried out and frittered away some of the cobbles had been released onto the beach. The greywacke cobbles were probably sourced from the Ruahine Range and could have come down one of a number of the rivers, including the Manawatu. The andesite was sourced from either Mt Taranaki lahars or the central North Island volcanoes and could have come down any of the major rivers from Rangitikei northwards.

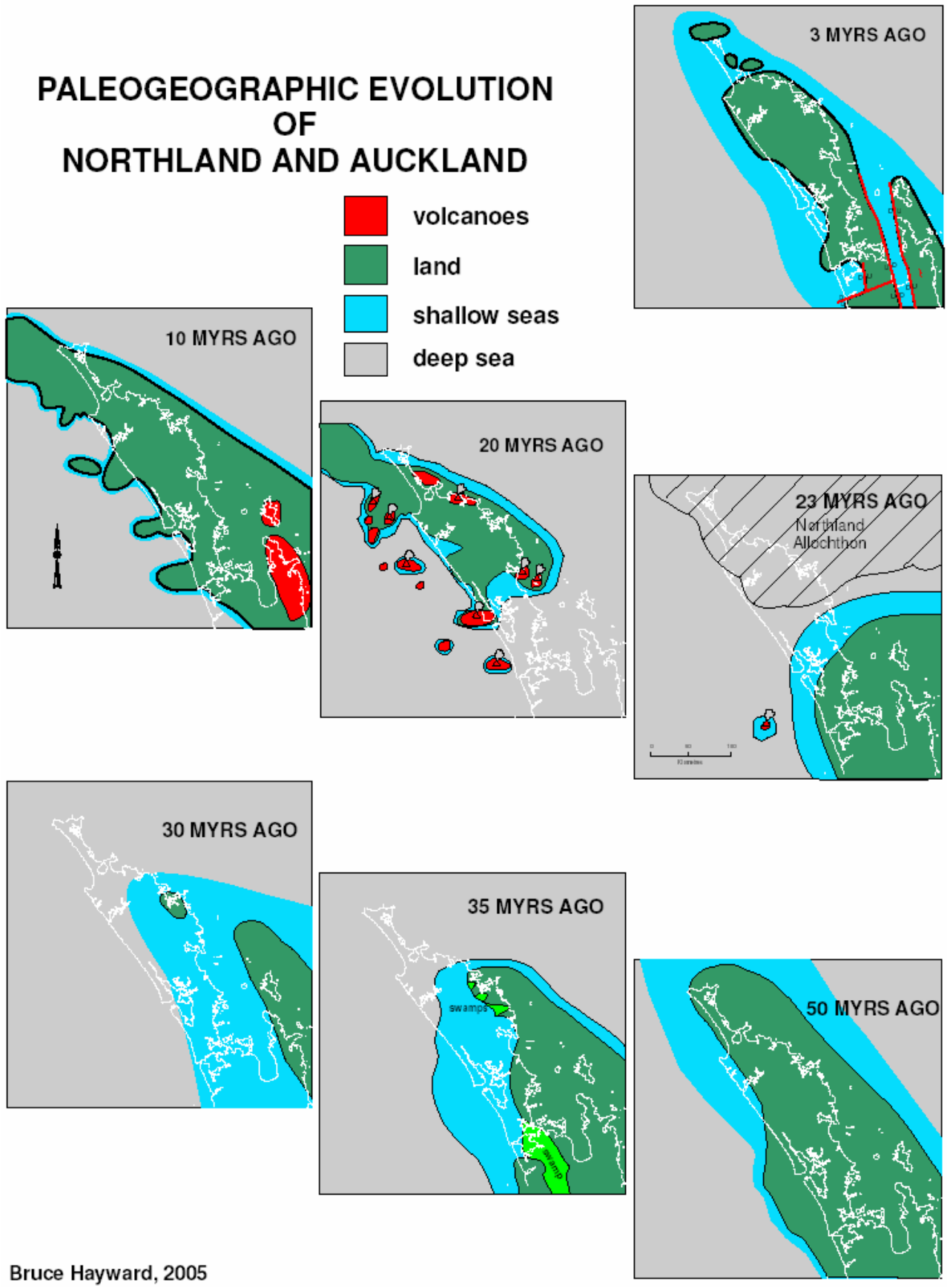


Fig. 3. A rounded cobble of andesite caught among the roots of a tree stump washed up on the back of Foxton Beach.

The trees had obviously been growing in flood plain gravels and river erosion had undermined the bank and carried away the tree and its root bole in a flood event. Some of the cobbles and pebbles would have been lost during the journey down the river, others were clearly being dropped some time later as the soil dried out on the beach, and clearly still others could have been dropped while the stump floated around in the sea.

Periodically we see isolated pebbles or even cobbles “floating” in fine-grained sandstone or mudstone beds from the ancient past, and usually these are glibly dismissed as drop stones. Here was concrete evidence of the drop stone theory in action – conceivably a stump like this could float out even into the middle of the Tasman or Pacific and drop large pebbles into the deepest and finest-grained oceanic sediment. Other transporting agents that could do the same include floating seaweed, seals that swallow pebbles, and in higher latitudes ice-bergs.

Comment: A possible explanation for some so-called tsunami deposits? Hugh Grenfell.

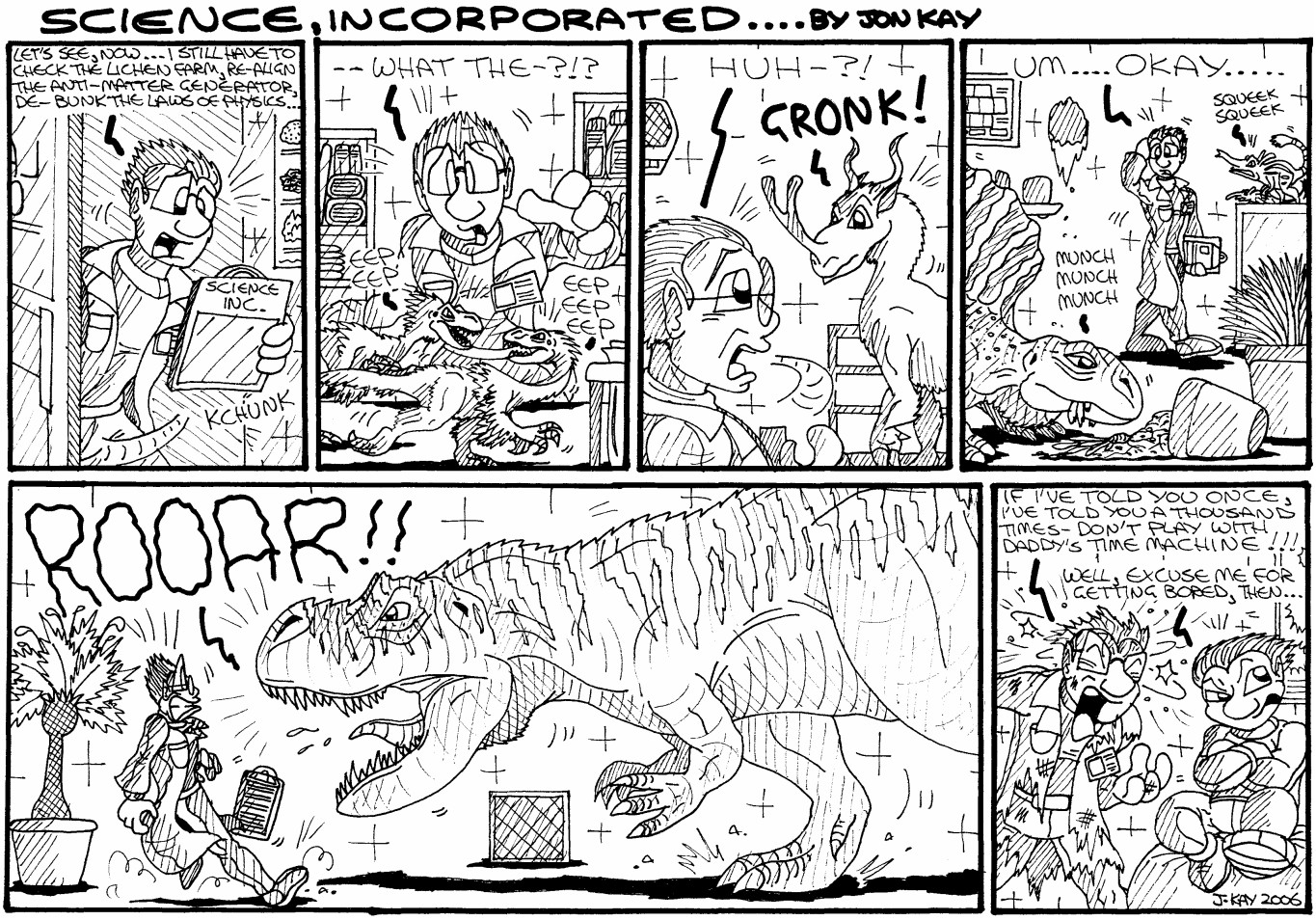


From a talk on Northland geology given by Bruce Hayward in 2005.

Muddy Delight

Upper reaches of the Manukau
Below Southdown
Tide low
Through the mangroves
The mud
On to the tidal shell bank
Countless cockles bedded together
Tight strong forming a shelf
A fossil forest - widespread
Stretches across the tidal plain
A few thousand years ago
A forested valley
With a stream running
to the sea
a few miles away.
Further out, an island
the last remnant of a drowned land
With a spit building up on its lee
Accessible now,
But how deep the mud between?
Body forward, taut,
Moving quickly
Through the sucking mud
Ankle deep, calf deep,
Knee deep, caught
A step or two from a firm creek bed
A strong hand reaches out.
Plop, free, on to the spit
and the island
A tephra remnant, eroding slowly
A reminder of the closeness of
The Volcanic Plateau and its force.
Back through the mud, evading capture.
A look at the tephra cliffs
iron filling the fractures,
A peat dike! Interesting
Exhilarating geological fun!

Helen Holzer


SCIENCE, INCORPORATED.... BY JON KAY
LET'S SEE, NOW... I STILL HAVE TO CHECK THE LICHEN FARM, RE-ALIGN THE ANTI-MATTER GENERATOR, DE-BUNK THE LAWS OF PHYSICS...
SCIENCE INC.
KCHUNK
--WHAT THE-?!?
EEP EEP EEP
EEP EEP EEP
HUH-?!
GRONK!
UM.... OKAY....
SQUEEK SQUEEK
MUNCH MUNCH MUNCH
ROOAR!!
IF I'VE TOLD YOU ONCE, I'VE TOLD YOU A THOUSAND TIMES- DON'T PLAY WITH DADDY'S TIME MACHINE!!!
WELL, EXCUSE ME FOR GETTING BORED, THEN...
J-KAY 2006

The Kidds Beach trip – June 2006
Kel Anglesey

It had been raining for some days before 20 members of the GeoClub and Auckland Branch of the Geological Society headed down to Kidds Beach. The newsletter assured us good footwear was needed and, no, there would be no more than ankle-deep mud. Reality was that puddles lay here and there and the soft ground would let you sink in much deeper than an ankle! We were greeted by strong southwesterlies and the threat of driving rain. Luckily, the latter did not eventuate and the former eased away. The day became fine and sunny.

The walk along the beach revealed a mystery. There was a deposit of rounded pebbles which had been eroded out of a conglomerate on the shore platform and which stretched for a distance of some two kilometres. They had been rounded in their journey to the conglomerate deposit but there was no obvious sign of a present-day stream that could have shifted them. Besides, the pebbles were of several types of rock, none of which outcropped nearby. The most common pebbles were red chert and greywacke with smaller numbers of quartz-grained pebbles and andesites.

Bruce Hayward, our leader, was convinced that he knew where they had come from. He directed our attention to the East where we could see the Clevedon Valley between the Hunuas to the south and the Whitford hills to the north and which disappeared in the direction of Waiheke Island and the Coromandel Peninsula. That was the valley of a river, the Clevedon River, which carried the pebbles to their present locale from outcrops much further east. It flowed when the Firth of the Thames graben did not exist. At that time, maybe 10-5 Ma ago, there was a slope down to the west from the east that extended from northern Coromandel and Waiheke. The river carried chert from the Hunuas and Waiheke, greywacke from the same places and from further east in the Coromandel andesites and quartz-veined stones.

No-one disagreed and all seemed impressed with the explanation especially when it was supported by the finding of one solitary beech tree leaf ('brassi' group) that was within the conglomerate and which comes from a tree that was largely extinct by 1.5 Ma BP.

Underneath the conglomerate was a hard rust-coloured layer of iron-rich limonite which looked like it had been freshly poured there as its surface was rounded. Many samples of this material were retrieved and taken away.

Lunch, as always, was very pleasant with the party settling down on the downwind side of a cliff to avoid the still very strong winds.

We wandered on to a small creek which emptied which emptied into the Manukau harbour and then turned to retrace our steps back.



Fig.1 Reworked cobbles accumulating on the beach.

On the way back Jeff Mauk and Phil Moore continued to discuss the origins of silicified wood and pebbles with Bruce, eventually lending their opinions in support of his thoughts about the pre-historic Clevedon River. By now, there was not a cloud in the sky and the wind had died completely - a beautiful afternoon. We walked once again past the landowner's vain attempts to stop erosion of his land where his concrete block and rubbish seawall had been overtopped, undermined or just knocked aside by the waves that must crash against it in stormy weather.

For those who had not got mud over their ankles while walking across the wet farmland on the way in, the opportunity was taken to, in places, walk over the mud flats. The wise avoided these shortcuts opting for a longer path amongst the cutty grass and sudden drops into water-filled channels.

Thank you, Bruce. Another brilliant outing for the Club and much appreciated by the members who took part.

The west-flowing "Clevedon River", Auckland

Bruce W. Hayward[1], Hugh R. Grenfell[1], Jeff L. Mauk[2], Phil R. Moore[3], and Dallas Mildenhall[4]
[1]Geomarine Research, Auckland
[2]Geology Dept, University of Auckland
[3]Peninsula Research, Waihi
[4]GNS Science, Lower Hutt

In June 2006, members of the Auckland GeoClub visited Kidds Beach (R12/720560) on the southern shores of the Manukau Harbour (Fig. 1). We were attracted to the area as a result of reports from Jeff Rankin, South Auckland Rock and Mineral Club, that the gravel beach contained quartzose pebbles not seen anywhere else locally and most similar to what they collect in the Coromandel Ranges. In recent years David Kear (e.g. Kear, 2000, 2004) had made us well aware of Hugh Battey's report of Coromandel-derived cobbles in a Pliocene conglomerate (Puketoka Formation) in the Maramarua area, 30 km south-east of Kidds (Battey, 1949) and the implications for the age of formation of the Hauraki Graben that now lies between the Coromandel and Hunua Ranges (Hochstein and Ballance, 1993).

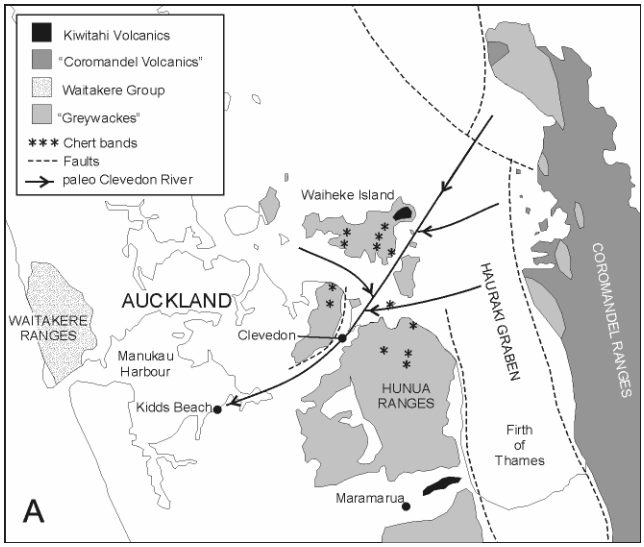


Fig.1. Simplified geological map of the Auckland region, showing location of the conglomerate at Kidds Beach and possible source of its different pebble lithologies. The inferred N Hunuas-Coromandel provenance of the conglomerate points to the existence of a west-flowing "Clevedon River" prior to the major subsidence of the Hauraki Graben.

Stratigraphy and age:

We found that the normally shelly shoreline of the Manukau was replaced by a gravel beach of red, grey and white pebbles for at least a 2 km stretch. It didn't take long to determine that these pebbles were being eroded out of the adjacent intertidal shore platform formed of weakly-bedded conglomerate (Fig. 2) with some west and north-facing cross- bedding. The conglomerate overlies limonitic sandstone and includes some lenses of log-bearing, carbonaceous sandstone and mudstone and probably belongs to Battey's Puketoka Formation



Fig. 2. View looking west along Kidds Beach. Exposure of northwest-dipping Puketoka Formation conglomerate and sandstone. Derived cobble beach in the background.

The geology of this area was mapped by MSc student Keith Berry (1986), whose maps show that this is the largest outcrop of a "red chert conglomerate" unit that has a number of other smaller exposures along the harbour coast between Karaka and Clarks Beach (Fig. 1). Berry also studied a number of local drillhole sequences and inferred that this conglomerate is underlain by early Pliocene shallow marine Kaawa Shellbed (Opoitian-Waipipian age; Berry, 1986) and is overlain by widespread rhyolitic pumiceous sands. These latter sediments presumably were transported down the Waikato River to this area from the TVZ following the start of volcanism in that region sometime after 2 myrs ago (Briggs et al., 2005). Thus Berry's (1986) observations indicate that the age of the conglomerate must be somewhere within the mid to late Pliocene (c. 3-2 myrs ago). That they are no younger than Pliocene was confirmed by us by the discovery of the leaf of a "brassi" group (large-leaved) beech (Fig. 3) in one of the carbonaceous lenses (R12/f80), a group that had largely disappeared from NZ by 1.5-2 myrs ago (Cooper, 2004).

Examination of the pollen flora from a sample of the associated carbonaceous mudstone (R12/f80) by one of us (DCM) indicates that it contains a mix of early Miocene and late Miocene pollen, with a predominance of "brassi" group beech pollen (*Nothofagidites cranwellae*) and other pollen of Tt-Tk age (c. 10.5-5 Ma). Thus this result does not support the reported stratigraphy of Berry (1986) and suggests that further field investigation is required to check the reported relationship of the conglomerate to the Kaawa Shellbeds.

Puketoka Formation conglomerate composition and provenance:

The conglomerate (and modern beach gravels) is dominated by subangular pebbles of red-brown cherts and grey argillite/greywacke clearly derived from the Waipapa Group (Table 1). The nearest source is the uplifted Hunua Ranges, but red cherts are rare in the southern and western parts closest to Kidds Beach (Schofield, 1976, 1979). The greatest concentration of chert units outcrop in the north-east Hunuas to Waiheke Island area (also the source of McCallum's red chip used widely on

Auckland footpaths). The next most common clasts are more rounded pebbles and even cobbles of cream-white crystalline "vein" quartz. Some of this has inclusions of chert that link its source to the Waipapa rocks, but other more massive and more coarsely crystalline quartz is more reminiscent of vein quartz typically encountered on Coromandel Peninsula. Other rarer pebble lithologies that are most strongly linked to a probable Coromandel source are of silicified wood, chert, sinter?, and silicified flow-banded rhyolite. Rounded andesite pebbles also could be sourced from the Coromandel volcanics, but an equally possible source is the Kiwitahi andesites that outcrop along the eastern side of the Hunuas (Black et al., 1992). As the crow flies the nearest andesite source is the Waitakere Ranges to the north-west, but this seems improbable as it is contrary to the direction indicated by all the other lithologies.

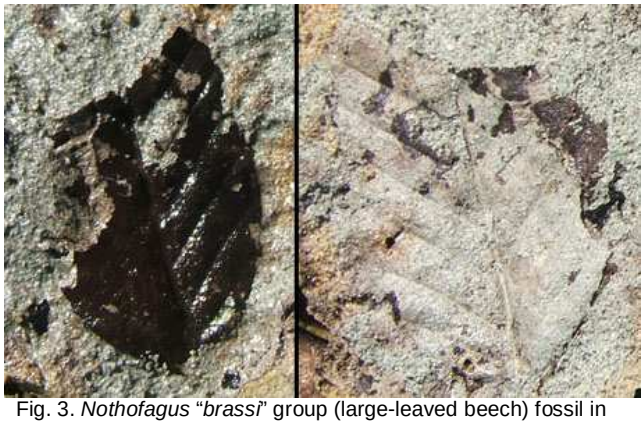


Fig. 3. *Nothofagus* "*brassi*" group (large-leaved beech) fossil in one of the carbonaceous lenses (R12/f80).

The shape of the pebbles reflects a combination of their hardness, jointing, and distance transported. The softest and largest clasts are well-rounded but were locally derived Waitemata Sandstone. The smallest and most angular pebbles are the red cherts - sourced from the hardest and most closely-jointed rocks but transported c. 30 km. Clasts transported the furthest (c. 50 km) are those inferred to be derived from the Coromandel volcanic region. These are all the hardest lithologies in the Coromandel Range (fresh andesite, quartz, silicified rhyolite and wood) but even so most have been rounded during their long journey. None of the more common softer lithologies found on Coromandel Peninsula (e.g. rhyolites, ignimbrites, altered andesites) are present in the conglomerate and presumably were not hard enough to survive the journey. The most convincing Coromandel-sourced pebble has vein quartz and andesite together – a combination not seen in the Waitakere Ranges nor Kiwitahi andesites.

A west-flowing "Clevedon River":

The probable provenance of the pebbles in the Kidds Beach conglomerate requires a transport route from the N Hunuas-Waiheke area. Geological maps (e.g. Edbrooke, 2001) show the existence of a narrow elongate "half graben" directly linking the two areas and now occupied by the Clevedon Valley and Ardmore-Papakura lowlands.

Table 1. Character of the cobbles and pebbles in the Puketoka Formation conglomerate.

Lithology	%	Size	Shape	Provenance
Sandstone	30	<50 cm	r-wr	Waitemata Sandstone (local)
Red-brown chert/argillite	30	<8 cm	sa-sr	Waipapa Gp, N Hunuas -Waiheke
Grey argillite/greywacke	25	<10 cm	sa-r	Waipapa Gp, Hunuas-Waiheke
White "vein" quartz	10	<20 cm	sr-r	Coromandel Hunuas (Waipapa Gp)
Grey andesite	5	<10 cm	r	Coromandel, ?Waiheke, ?Waitakeres
Flow-banded rhyolite	<1	<10 cm	r	Coromandel
Silicified wood	<1	<10 cm	sr-r	Coromandel
Chert/sinter	<1	<6 cm	sa-sr	Coromandel

This valley lies between two uplifted NW-tilted blocks of Waipapa "greywacke" with the Hunua Ranges to the south and the Whitford –Maraetai block to the north uplifted along the NW-trending Papakura Fault. Coal exploration drillhole 8427 in this "half-graben" intersected Eocene and Miocene sedimentary rocks sitting atop greywacke basement (Edbrooke et al., 1994) and indicate that it is clearly down faulted and not purely erosional through the greywackes. Thus it would seem that a west-flowing river passed through this valley in the late Miocene or Pliocene. The present arrangement of islands and flooded valleys at the eastern end of the Tamaki Strait (between Waiheke and the Hunuas) suggests that several west-flowing tributaries fed this ancient "Clevedon River", and one or more of these could have originated from the vicinity of

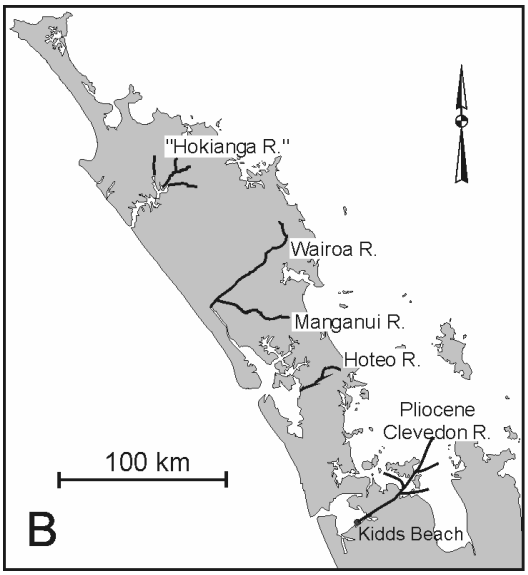


Fig. 4. Present day west-flowing Northland rivers due to regional tilting

Coromandel township, prior to the subsidence of the Hauraki Graben.

A substantial west-flowing river through the Auckland region may seem counter-intuitive given the present geography, but further north much of northern Auckland and Northland is predominantly

drained by west-flowing rivers (e.g. Hoteo, Manganui, Wairoa, Hokianga) and reflect the general western tilt of the geology of the Northland-Auckland peninsula. Prior to the foundering of the Hauraki Graben this western tilt seems to have extended south-eastwards to the Hunua-Coromandel region. Much of the central Coromandel Range is tilted eastwards today and suggests that maybe the Hauraki Graben may have been an area of thermal up-doming prior to the graben's formation.

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This is a slightly updated version (additional palynological dating) of an article that previously appeared in the GSNZ Newsletter:

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Addendum 2011

Another important outcrop of Puketoka Formation can still be seen near the Pokeno at the intersection of Pioneer Road and SH1 (NZMG Grid S12/904369). This and nearby railway cuttings were probably seen by Battey (1949). The railway cuttings are now overgrown. The geology of the Pokeno area, including the Puketoka Formation, is described and mapped in detail by Kear (1961) who interestingly considered the early phases of the Franklin Volcanic Field to be contemporaneous with the Puketoka Formation.

Pliocene conglomerates - a spanner in the works for archaeology

Kath Prickett,
Auckland War Memorial Museum

As a result of the Auckland Branch of the Geological Society and GeoClub's June 2006 visit to Kidds Beach, it became apparent that assumptions regarding chert resources used by Maori in the Auckland region required revision. The discovery of large quantities of high quality cherts in situ on the southern shore of the Manukau, was the first surprise. The existence of a solid gravel beach in what is usually regarded as a soft shoreline area is not widely known. The second surprise was that the lithologies represented in the beach gravels were of Waipapa Group and Coromandel origin. This means it can no longer be assumed that there is a direct link between the stone resources of the Gulf Islands, the Hunuas and the Coromandel and objects made from them recovered from archaeological sites in the Auckland area. Instead, a significant proportion could have a direct link to the Manukau beach gravels sources.



Fig.1 A cobble of chalcedonic chert from Kidds Beach

The early Matatuahu site on Manukau South Head (Prickett, 1987) for example, had numerous chert artefacts manufactured from a variety of chert types which occur in the Coromandel. The site also had tools made from stone materials "imported" from long distances away, such as the distinctive, fine grained basalt from Tahanga, eastern Coromandel. Given this connection, it seemed a reasonable proposal that much of the chert had come from there. Well, it may have of course, but the larger part of the journey was not by human conveyance, and was of considerably greater antiquity. For Maori, the source was actually very close by.

To further confuse sourcing, we can add the Puketoka Formation to the mix. The recent GeoClub visit (February 2007) to the Puketoka Formation type locality near Maramarua, in the northern Waikato, confirmed there has been an accessible source of abundant high quality cherts of Coromandel origin at the locality, as well as other lithologies suitable for tool making. A pa site has been constructed over one exposure of the Pliocene conglomerate, having the resource literally on the back doorstep.



Fig.2 Chert cobble from the Puketoka Formation, Maramarua (type locality)

The upshot of renewed awareness of these Pliocene deposits, the Manukau as mapped by Berry (1986) and the Puketoka Formation reported by Battey (1949), is to provide a cautionary tale. It should not be assumed in the first instance, a simple relationship exists between Maori acquisition of geological materials and their present primary occurrences. It is wise to know one's conglomerates very, very, well and never forget alluvium.

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Fossil Cow Shark tooth
Hugh Grenfell
(modified from Poirieria 18, p.49. 1996)

On a 1996 GeoClub field trip to Kaitarakihi and Huia, members may remember Murray Baker's unique find at Kaitarakihi, Manukau Harbour. It was in a Parnell Grit unit (Waitemata Group) we were exploring.

The late Ian Keyes (IGNS, Wellington) kindly identified the tooth and wrote the following:

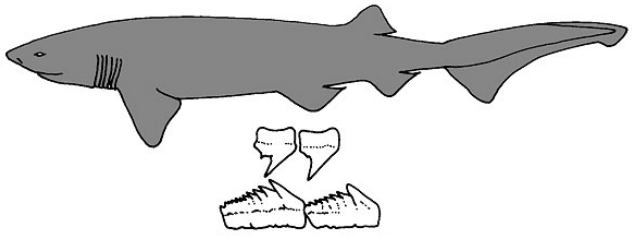
"The tooth that was collected from the Parnell Grit can be identified as *Notorynchus primigenius* (Agassiz). It is a member of the Family Hexanchidae which in living forms have 6 to 7 gill slits, and the nearest living relative of the fossil would be *Notorynchus cepedianus*, known as the "broadnosed 7-gill shark". The tooth illustrated is a thin, blade-like lateral, with 5 of the crownlets showing. If you were to excavate it you would find the large principal crown to the right, bearing fine denticles at the base. It looks a good specimen so is probably worth excavating carefully. This species is a Miocene form in most countries, but I have only seen a few good ones from New Zealand. Being fairly thin they frequently are broken in fossil deposits."

Subsequent excavation by me revealed exactly what Ian described!



Kaitarakihi *Notorynchus primigenius* tooth.

Cow sharks are found worldwide in cold to tropical seas at depths to 1800m. They are widespread in the New Zealand region. Average size 4m. One species (*Notorynchus cepedianus*) is regarded as potentially dangerous to humans. They are described as cylindrical sharks with six or seven gill slits; subterminal mouth with large, blade-like, comb-shaped teeth in lower jaw and one dorsal fin (Paulin *et al.* 1989). In the old Fish Hall of the Auckland War Memorial Museum there used to be a nice cast of *N. cepedianus* with a mouth full of these very characteristic teeth. Murray generously donated his fine specimen to Auckland War Memorial Museum (AK102038).


Living cow shark teeth

Reference:

Paulin, C.; Stewart, A.; Roberts, C. & McMillan, P. 1989: New Zealand fish - a complete guide. *National Museum of New Zealand Miscellaneous Series* No. 19.