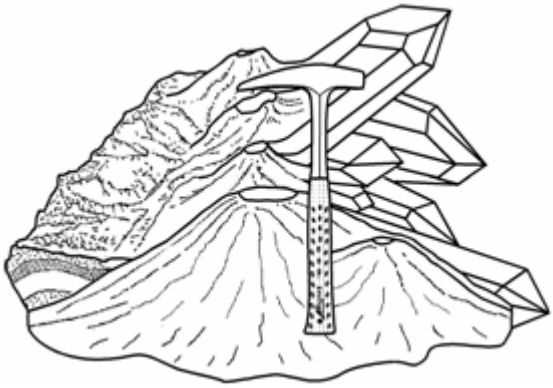


Geocene

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Geocene is a periodic publication of GeoClub, 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 not refereed.

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OTAGO HERRINGBONE HUSHINGS

Hugh Grenfell

Mining of placer deposits where streams of water are used to break down, move and process deposits (e.g. for gold, tin or lead), is an ancient form of mining which has various names such as “streaming”, “hushing”, “ground sluicing” and “booming”. Hushing was used during the formation and expansion of the Roman Empire from the 1st century BC until the end of the empire (Wikipedia 2012). The method is well described by Pliny the Elder in his *Naturalis Historia* from the 1st century AD. He distinguishes the use of the method for prospecting for ore and use during mining itself. The Romans used hushing for alluvial gold deposits, and in opencast vein mining, for removal of rock debris, created by mechanical attack and fire-setting. Pliny describes how tanks and reservoirs are built near the suspected veins, filled with water from an aqueduct, and the water suddenly released from a sluice-gate onto the hillside below, scouring the soil away to reveal the bedrock and any veins occurring there. A famous, and very large scale, Roman example is at Las Médulas in northern Spain (Wikipedia 2012).



Figure 1: Roman alluvial gold mining, Las Médulas, northern Spain UNESCO World Heritage Site.

An example in the UK of similar Roman mining techniques can be found at Dolaucothi Gold Mines, also known as the Ogofau Gold Mine, near Pumsaint, Carmarthenshire, Wales. There are many other examples of Roman and later workings in Yorkshire, Cornwall (Cornwall County Council 2012, Figs 2&3) and Wales (e.g. Timberlake 2004). Sluicing was commonly used in North America (Lindström et al. 2000) and New Zealand in the 19thC (Figs 4&5). The technique apparently continues to be used in Papua New Guinea. Eventually these techniques were superseded by large scale operations such as hydraulic sluicing using monitors (Fig. 6) or huge bucket line gold dredges (Fig. 13).



Figure 2: The remains of medieval tin streaming at West Moor, Altarnum, Cornwall (Cornwall County Council 2012).



Figure 3: Streamworks at Enniswor gey, Restormel, Cornwall ?1940’s (Cornwall County Council 2012). This area viewed today with Google Earth is very overgrown with large trees (Have a go finding it – good luck!).

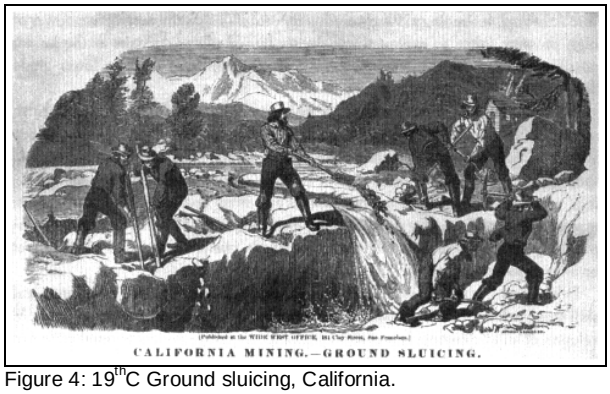
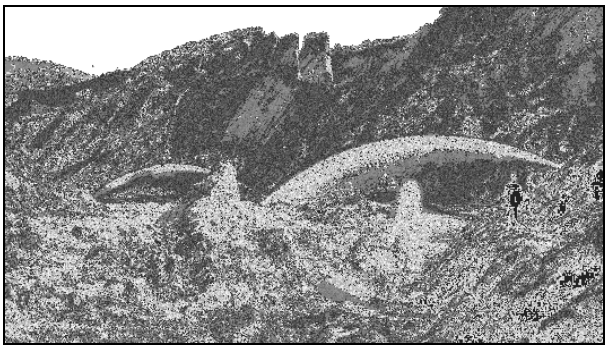


Figure 4: 19thC Ground sluicing, California.


Figure 5: Ground sluicing in Otago, late 19th C.


Figure 6: Hydraulic sluicing. Three monitors being used at St Bathans, Otago, late 19th C.

In November 2009 GeoClub had a trip to the Otago region. One of the highlights of the trip was to an interesting 19th C alluvial gold mining locality on river terraces north of Cromwell and adjacent to Lake Dunstan. The Quartz Reef Point Historic Reserve is accessed from a small parking area on SH8, just south of John Bull Creek. A kilometre walk uphill takes you to the DoC lookout over the herringbone tailings of the mining area (NZMS260 G41/395722). From here the herringbone walls, intermediate walls and sluice channels can be clearly seen in a pristine condition although they were made 140 years ago (Figs 7-11). Curiously the workings don't seem to have been visited by McKay (1894) when reporting on more than 70 gold bearing deposits in the South Island, although he clearly travelled up the Clutha Valley.

How were the herringbone structures formed? The information display at the DoC lookout did not seem to make much sense to us at the time. Similarly the descriptions by Ritchie (1981) are not entirely clear. Were they constructed from the bottom up or the top down, how were the ribs exploited etc? Much of what I write below is conjecture.

- Water was channelled to the site from a storage dam, where and when required, by ditches and wooden races or flumes and probably on site by large diameter canvas hoses. It is tempting to speculate that the earth dam visible today on Goggle Earth (topographically higher to the southeast of the workings) was the original water storage source (or at least the same site).
- The water saturated sediments are loosened by pick and shovel. Lindström (2000, p.61) describes the process best I think. Exploiting existing topography, the central backbone of the "herring" is dug first, probably with water assistance, and boulders and cobbles moved to each side and stacked up neatly by hand to create the channel walls (Fig. 12). This excavation also serves to prospect the gravels.
- Immediately more, and more sediment is exposed for extraction. The smaller size fractions (mud, sand and gravel) are sluiced away and processed at the base of the main drain where any gold is captured. In this way the land surface is deflated to as great a depth as possible and as much sand and gravel removed as possible.


Figure 7: Google Earth image of the Quartz Reef workings. Scale bar = 50m. SH8 is off to the left.


Figure 8: Google Earth image of the Quartz Reef workings in more detail. You can just make out the intermediate walls.

The exposed banks in Figures 10-11 give some idea of the amount of material processed / removed. Of course enormous amounts of fine sediment ultimately also ended up “polluting” the Clutha River (now under Lake Dunstan).

- The main drain is then intersected progressively by symmetrical auxiliary branch drains extending off at an angle (ribs). Serious mining begins at the base of main drain as sediment laden water is channelled progressively down each auxiliary drain (rib), possibly simultaneously from each side. Again in the branches the larger rock material is moved aside to access the fines and wall constructed. Once the fines are removed, and the channel established, the large rocks are moved back into the drain and used to trap the auriferous sediment as the sediment on either side of the rib channel is worked. Periodically the water flow is slowed to a trickle and the large rocks in the floor of the channel washed and removed. The trapped sediment is then worked with sluice-boxes to extract any gold (Ewing 1898). Then once again large rocks are added to line the rib channel floor and the process repeated if required. Intermediate walls (which buttress the ribs) of the main and auxiliary drains are also constructed (Fig. 8). And so on it goes, working systematically up the main backbone.



Figure 9: Quartz Reef Point workings looking towards Cromwell.

On the same trip we also visited the enormous tailings left behind by gold dredging at Earnscleugh Flats, near Alexandra. Here the earlier hushings have been overprinted by later very large scale gold dredging operations which lasted from the 1890’s until 1963 (Fig. 13).



Figure 10: Quartz Reef Point workings



Figure 11: Quartz Reef Point workings

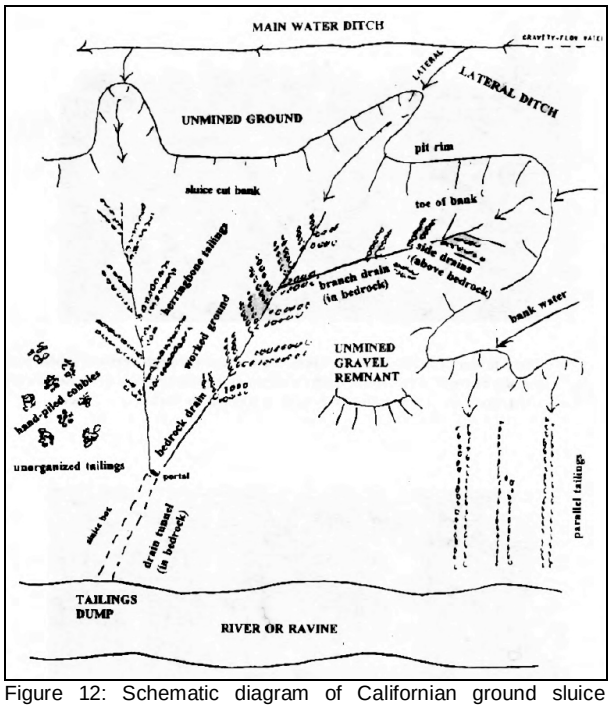


Figure 12: Schematic diagram of Californian ground sluice workings (Lindström 2000). For a better version of this diagram download the .pdf referenced below).



Figure 13: Earnscleugh Flats tailings near Alexandra. Seen also on the same GeoClub trip were these remnants of herringbone hushings which have been overprinted by later large scale gold dredging seen in the background (Image from Petchy 2006).

Another New Zealand example of the use of hushings comes from the tin workings at Pegasus Bay, Stewart Island which are described in great detail by Petchy (2006). Tin ore (cassiterite) was discovered here in 1888 by gold prospectors when it interfered with gold recovery. By 1890 144 mining claims were registered but the alluvial deposits, derived from the erosion and weathering of granites, were nowhere near as rich as anticipated and the rush was over by the end of 1890. A rise in tin prices in the early 20thC (WWI?) saw renewed interest with over £9000 being spent between 1912 and 1917, but again it was ultimately a failure. The hushings here were nowhere near as elaborate as those at Quartz Reef Point but nonetheless the same techniques were being applied (Fig. 14). They could be termed "blow down" or "parallel" tailings using the terminology of Ritchie (1981).

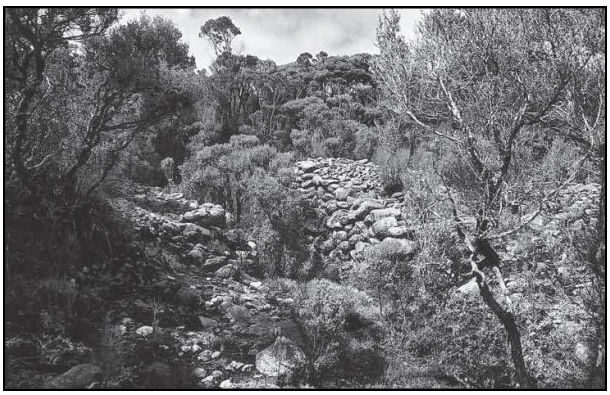


Figure 14: Tin mining hushings Port Pegasus area, Stewart Island (Petchy 2006).

Petchy (2006) states that "the mining technology employed at the Pegasus tin field was a direct transplant from the goldfields of southern New Zealand (and had been introduced to New Zealand from the Australian and Californian goldfields). There is no direct link to the Cornish tin fields, as although Cornish miners were present in the Otago goldfields (Paterson 1980), Cornish alluvial tin mining had effectively finished several hundred years earlier. The fact that archaeological sites in the Pegasus tin field bear striking similarities to much older Cornish sites suggests that the basic technology was developed to an effective form at an early date, and had subsequently changed little over time."

While I would like to think some of my Cornish ancestors were involved with the Quartz Reef Point hushings there seems to be little historical documentation of who operated these particular workings. Chinese miners also used the technique (e.g. Ah Wees Pt, Clutha River, ?NE of Wanaka Airport (Ritchie 1982)). Whatever was the case, the miners were incredibly versatile and obviously knowledge of ancient mining techniques was passed from one generation to another to be used in lands where no such mining had been done before. The Quartz Reef Point tailings are an outstanding example of the "art" of hushing and are preserved mostly because of the arid Central Otago climate which prevents vegetation growing over them (unlike the tin workings at Port Pegasus). Today, of course, such 19thC environmental vandalism would not be tolerated (we hope).

Acknowledgements: Thanks to Lloyd Carpenter for the J. Ewing (1898) paper.

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MARY ANNING – FIRST WOMAN PALAEONTOLOGIST

Margaret Morley

The tongue twister "She sells sea shells on the sea shore" is familiar to most of us, but few realise that its author Terry Sullivan (1908) was referring to Mary Anning (Wikipedia; Fig. 1). A recent television programme on Mary Anning caught my interest and reminded me of a fossil brachiopod in my collection related to the story. The specimen was given to me by a nephew during a visit I made to Poole, Dorset, England in 1981.

Mary Anning, the oldest of 10 children, was born in March 1799 in Lyme Regis, Dorset. Her father was a cabinet maker. She was named for an older sister who died in infancy. Since the family were poor they supplemented their income by selling fossils collected from the local cliffs. The house was built on the town's bridge where they used to set up an outside table to catch the wealthy tourists visiting the seaside resort. Mary learnt to read and write while attending Sunday school.



Figure 1: Mary Anning

The 55 km stretch from Dorset to Devon is known as the Jurassic coast and is one of the richest fossil locations in Britain (Fig. 2). Fossils are common in the Blue Lias Formation which consists of alternate layers of limestone and shale laid down in a shallow sea 210-195 mya.

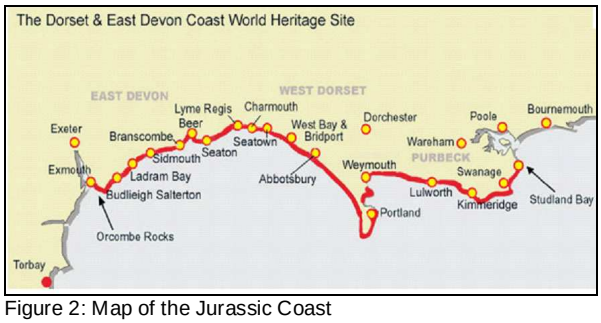


Figure 2: Map of the Jurassic Coast

The warm seas, being nearer the equator, were full of life. The commonest fossils were ammonites, known then as snake stones (Fig. 3). Belemnites were called devil's fingers, while vertebrae were verteberries. The fossils sold well, not only as curiosities, but also because they were believed to have powerful medical and mystical properties.



Figure 3: Ammonites in rock, Lyme Regis Beach. Photo: Bruce Hayward.

When Mary was ten years old, her father died of tuberculosis, so the money earned by selling fossils became vitally important. Two years later, she and her brother Joseph, uncovered a complete skeleton of an ichthyosaur. It sold for 23 pounds. Collecting was most productive in the winter months when storms lashed the coast and landslides exposed more fossils. These had to be collected between tides before the in-coming tide smashed them to pieces against the rocks and steep cliffs (Fig. 4). Mary nearly lost her life in 1833 in a landslide which killed her terrier dog Tray. The same storms that swept along the coast also flooded the house, on one occasion the family had to rush upstairs and crawl out of a bedroom window to avoid being drowned.



Figure 4: Lyme Regis Beach. Photo: Bruce Hayward.

Mary found species unknown to science e.g. the first plesiosaur skeletons, the first pterosaur outside of Germany and fish fossils. She was the first to provide information on fossil ages. She dissected modern animals in order to understand the anatomy of fossils. She cemented fossil bones on frames, made drawings, then had them engraved. These sold well.

At the time the Victorian mind set was that the world was only 6000 years old, Mary's ammonite species showed that this could not be true. The evolution of ammonites was not understood. Her work contributed to fundamental changes in scientific thinking in the early 19th century about prehistoric life and the history of the earth. Mary was battling against heavy odds because scientists at the time were mostly wealthy Anglicans while the Anning family were poor, and religious dissenters, probably Methodists. In addition, as a woman, she was not eligible to join the Geological Society of London. However some influential people did befriend her, the geologist De LaBeche used her fossils to paint prehistoric life. His paintings were made into prints and sold for Mary. Lieutenant Colonel Birch was Mary's best customer; he arranged an auction of fossils that made 400 pounds, a large sum at that time. In 1840 Lewis Agassiz named a fossil shark after Mary, Acrodus anningae. An African bird anninga *was also named in her honour (Jack Grant-Mackie pers. comm.).

Her observations played a key role in the discoveries that belemnites contained fossil ink sacs and that coprolites (called bezaar) were fossil faeces. Shortly before she died of breast cancer in 1847, Mary was made an Honorary Member of the Geological Society. More recently, in 2010, her work was acknowledged by the Royal Society when Mary Anning was included in a list of the ten British women who have had the most influence on the history of science.

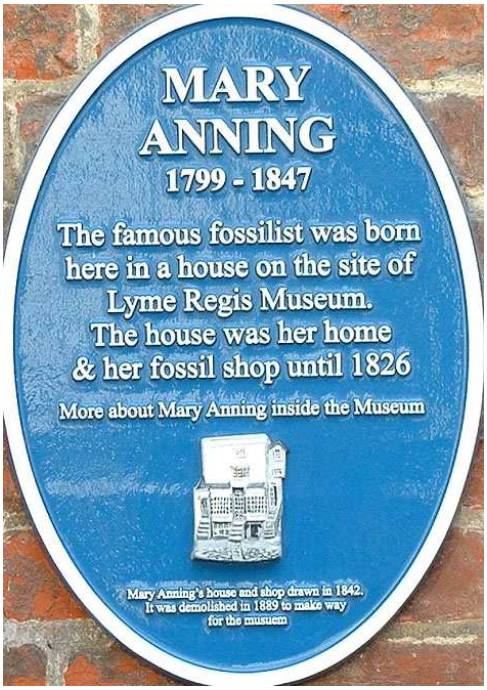


Figure 5: Anning Plaque

This recognition came too late for Mary who said, "The world has used me so unkindly I fear it has made me suspicious of everyone". This resentment appears to have been caused by unscrupulous people who bought Mary's fossils, then passed them off as their own.

Today Lyme Regis holds an annual fossil festival with guided tours to find fossils along the coast. A plaque, recognising Mary Anning as the first woman palaeontologist, has been erected on the site of the Anning house (Fig. 5).

My fossil brachiopod has connections to a fascinating story.

Acknowledgments
Thank you to Bruce Hayward who helped format this article and its illustrations.

AMBURY PARK LAVA FLOW TREE MOULD
Bruce Hayward

In August 2010 a group of GeoClubbers visited Ambury Regional Park on the lava flow field of Mt Mangere. After being guided through Ambury Park and Ambury Road lava caves by Peter Crossley we decided to explore the coastal exposures of basalt lava flows. We headed southwest from the Ambury Park visitor centre and proceded clockwise around the coast. After inspecting a low lava cave, some of us ventured onto the soft shelly intertidal sand and came across an unusual smoothed section of lava within the otherwise rubbly angular face of basalt lava (Fig. 1).



Figure 1. Location of tree mould (x) in lava flows on the coast of Ambury Regional Park.

Closer examination showed that this was a 4-5 m long, near-horizontal partial mould of a 0.6-0.8 m diameter tree trunk. There was little obvious tapering and it is probably the mould of part of a podocarp, possibly kauri, trunk that may have collapsed into the molten lava flow and was rafted along by it.


Fig. 2. Tree mould in basalt lava flow on the foreshore of Ambury Regional Park (umbrella for scale).

As the lava cooled and solidified, it made a smooth mould of one side of the presumably burning trunk, which is now exposed on the Ambury Park foreshore (Fig. 2).

There seems to be no previous written record of this lava flow tree mould and the late Les Kermode never showed it to GeoClub nor talked about it. As it is in part of Ambury Regional Park it is protected from damage by human activities and adds an extra feature of interest for visitors, particularly those with a geological bent.

A FOSSIL EGG CASE OF ALCITHOE ARABICA FROM THE WHANGANUI PLEISTOCENE

Jack Grant-Mackie

Back in the 1970s my Department conducted field classes in the Whanganui – Hawera area to study their strata and faunas. In May 1971, together 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).

The two unemerged and undamaged 'foetal' juveniles lying within the egg are about 6.5 mm long and may be the remnant of a larger 'litter', some of which could have been lost, unnoticed, when the egg case was broken open. The remaining two are thin-shelled juveniles of about 2½ whorls consisting of bulbous protoconchs with an eccentric paucispiral nucleus, a pyriform aperture and a straight columella showing 3 apparent plaits. The initial whorl-and-a-bit on each is smooth but there is a hint of very faint spiral lirae over the last whorl and base and the beginnings of rounded axial sculpture on the body whorl of one shell, fading out onto the base. The spiral ornament does not show up well in the figure, especially with the interior of the egg case containing also fine debris which may be organic (egg remnants) or inorganic (sand and silt), or both, and not able to be gently brushed away, but with careful focussing one can see very faint spiral threads over the body whorl. The whorl profile is smoothly rounded and the suture obvious.

Powell (1979: 211) stated that the egg case in *Alcithoe arabica* and *A. swainsoni* "is a white calcareous dome, half an inch in diameter. Up to three embryos may develop from the egg, but if less than that number survive, then a larger protoconch results". Since then, these two 'species' have been synonymised (Bail & Limpus 2005) and recognised as ecologic variants, with the more nodulose arabica form found in harbours and the smoother swainsoni form in shallow open ocean conditions.

Penion is another gastropod genus that has direct development from the egg without a veliger stage, but Beu & Maxwell (1990: 362) record it as having "a large heavy embryonic shell (several in each large, horny egg capsule" (my emphasis). Morley (2004) states that the egg case in *A. arabica* is about 15 mm in diameter. From these points. clearly the egg case belongs to *Alcithoe*, but the presence of very faint spirals is not mentioned in any description I have seen of the species in that genus.

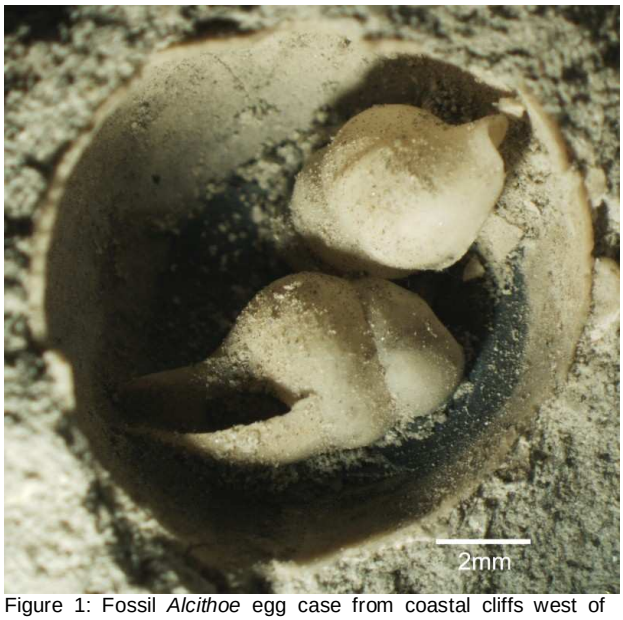


Figure 1: Fossil *Alcithoe* egg case from coastal cliffs west of Castlecliff. Shakespeare Cliff Sand at locality R22/f6469 (AU989).

Examination of specimens in the reference collection of the University of Auckland Geology Programme shows that some specimens do in fact posses weak spirals. Most, however, are too worn or corroded for them to be preserved, even if previously present. Two specimens from the Castlecliff Castlecliffian, both labelled G6718, prove to have 4-5 weak spiral threads on the first post-neanic whorl which then fade away and the whorls assume the 'swainsoni'-type form. A specimen (G2040) of *A. (Leporemax) brevis* from the Nukumaruan strata (2.4 – 1.7 million years old) of Kereru, Hawkes Bay, has a large smooth globose protoconch of two whorls followed by a half-whorl with four weak spirals, after which the axials begin. A second specimen of this species, from AU5727, Ruataniwha, also Nukumaruan, shows this same sculptural development. No specimens of *A. (L.) fusus* examined by me show spirals other than a

faint angulation on the third post-neanic whorl; this on later whorls becomes the shoulder of the shell. Spirals of the type described above do not seem to be present in unworn specimens of this species.

Fleming (1953) included *Alcithoe swainsoni* and *A. (Leporemax) fusus* in the fauna he recorded from the Shakespeare Cliff Sand. Beu & Maxwell (1990) stated that the protoconch of *A. arabica* and *A. fusus* are very similar, except that in arabica the protoconch is large and 4-5 mm wide, and in *fusus* it is small and 2-3 mm wide. The fossil specimens are ~ 3.5 and 4.0 mm wide and thus conform more closely to *Alcithoe arabica*, and this is the identification accepted here. Perhaps the incipient axial sculpture on the protoconchs suggests the *swainsoni* form and an open ocean site.

Eggs are very rare objects in the fossil record, and I am aware of few other reported occurrences in the New Zealand fauna, none of which is of molluscan origin and most of which are merely eggshell: Worthy & Grant-Mackie (2003) recorded the presence of two partial eggs of the Little Blue Penguin, *Eudyptula minor*, from Pleistocene deposits at Oamaru; eggs and eggshell of Moa (Dinornithiformes) are well-known from Late Quaternary dune and other sequences in various parts of New Zealand (e.g. Gill. 2006), and eggshell is reported with moa bone fragments in the Miocene Manuherikia Formation, Central Otago (Tennyson et al. 2010). Overseas, fossil eggs are occasionally reported, most notably those of dinosaurs (for those interested, for instance, Google 'fossil eggs'), but fossil molluscan egg cases do not figure in either Google or Wikipedia entries, so may be unknown. I have found no record in any of the world literature I have consulted and Cox (1960), a prominent molluscan specialist who contributed to the relevant volume of the Treatise on Invertebrate Paleontology, stated therein that he also knew of none.

It would seem that this record of a fossil gastropod egg case may be the first for both New Zealand and globally!

Acknowledgements:
Alan Beu, GNS Science, Lower Hutt, has been most helpful in bringing me up to date on the state of knowledge of *Alcithoe* taxonomy. The photography was largely done by Neville Hudson and Ritchie Sims, Auckland University Geology Programme. Neville also curated this specimen and provided helpful discussion of its identity.

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RANGITOTO BRANCHING LAVA LOBES
Bruce Hayward

Pillow lava flows are composed over overlapping and branching lobes or fingers of lava that have glassy selvedge of rapidly cooled lava enclosing coarser-grained solid lava with radiating cooling joints on the inside. They are characteristic of lava squeezed out into water on the floor of the sea or a lake. They were given the name pillow because of their appearance as a pile of pillows in cross-section in a cliff.

Most of the lava flows on Rangitoto Island in the middle of Auckland's Waitemata Harbour are a heap of blocky rubble – typical of the surface of viscous aa lava flows. In a few places the lava flow surface is ropey and festooned typical of more liquid pahoehoe lava flows.



Figure1. The Rangitoto lava lobes flow across the intertidal zone as seen here from Rangitoto Wharf at low tide.

Less than 50 m from Rangitoto wharf where everyone lands on the island and just over the low seawall (Fig. 1) adjacent to the information shelter the lava flow has another form – branching lobes. Here the lobes are entirely within the intertidal zone (3.5 m range), best seen at low tide and not visible at all at full tide. This feature was examined at close quarters by members of GeoClub in March 2005.



Figure 2. Small, curved lava lobe branching off the main lobe on right.

On the same trip the group traversed the coastline for a further 1 km to the east and found nothing with similar form.

Here near Rangitoto wharf, a single flow lobe appears from beneath the sea wall near high tide level and as it flows down through the sloping intertidal zone it buds off three more elongate flow lobes (Fig. 2). Each lobe is 0.5-1 m across (?diameter) and 3-10 m long, usually curved as it flowed down the steepest gradient. Each lobe has a 0.1-0.2 m wide zone of laminated to flow-banded, more glassy basalt on either side (Fig. 3). Inside, each lobe consists of ropey festoons of lava typical of the surface of pahoehoe flows.



Figure 3. Typical view down on one of the lava lobes crossing the intertidal zone near Rangitoto wharf. Note the flow-banded zone on either side with pahoehoe ropey festoons inside.

How did these branching lava lobes form? Was the tide in? How long did it take for them to branch and flow across the intertidal zone before coming to a halt and solidifying? Is their form a result of flowing into cold water? I do not have answers to these questions but suspect that the lobes did indeed flow into cold water which may have prevented the lobes spreading out and confined them to narrow conduits. The cold seawater may have quenched the terminal end of the main lobe causing the still molten lava inside to burst out through splits in the walls to create the additional narrow lobe branches.

These lobes are similar to pillow lava lobes in their size, in their branching and in having an inside structure quite different from the more glassy flow-

banded outer structure. They appear to differ from typical pillow lava lobes in that the upper part does not seem to have had a convex glassy skin over it and has relatively flat pahoehoe festoons instead. These differences may equate to eruption in the intertidal zone rather than being completed immersed under water.

These pillow-lava-like lobes are like a miniature version of larger lava lobes that flowed into the sea in several other places around the fringes of Rangitoto Island, such as around the southwest corner (Fig. 4). Again, their branching lobate bird's foot-like form possibly was caused by their flowing into water. The cold water possibly cooled and halted the flow at the terminus of each lobe causing the molten lava still inside the lobe to break out as another branch further back up the lobe.



Figure 4. Large-scale branching lava flow lobes on the southwest corner of Rangitoto Island.

FOSSIL OLIGOCENE COCONUT FROM NORTHLAND

Bruce Hayward

In December 2010 a group of GeoClubbers called in at Waikiekie Quarry, west of the Brynderwyns, on our way home from the Whangarei long weekend geology trip. The quarry extracted Oligocene sandy muddy limestone from a block within the displaced Northland Allochthon. A small block of Waitemata Group sandstone and siltstone sits atop the limestone in the upper part of the quarry face. A few rare fossil coconuts were known to have been found in the limestone here on a previous visit in 1982 (Q07/f9; Hayward et al., 1990). Reportedly specimens were first found in 1977 by Mr and Mrs R.H. Rogers who sent them to the University of Auckland for identification, but a photo of them has never been seen.



Figure 1. Fossil coconut from Oligocene limestone, Waikiekie Quarry, Northland.

Having obtained permission to enter the quarry, some of us sat down to eat lunch while others made a quick inspection of nearby boulders and faces. Within minutes Jean Hawken (Whangarei member) returned with a well-preserved, ~5 cm long coconut with three distinctive eyes at one end (Fig. 1). She had seen the surface of something unusual and a quick tap on the rock with her hammer and it split (Fig. 2) revealing the fossil. It was the only specimen found that day.

The small size of the “coconut” suggest that it does not come from a palm tree of the modern tropical coconut genus Cocos, but probably comes from the more temperate genus *Parajubaea* that today grows in at high altitude in South America, somewhat akin to the temperature of northern New Zealand today (Endt and Hayward, 1997).



Figure 2. Split rock showing the mould the fossil coconut fell out of.

Similar small fossil coconuts have been found in scattered occurrences of Eocene, Oligocene and Miocene sedimentary strata in Northland, Hawkes Bay, North Otago and South Canterbury (Berry, 1926; Ballance et al., 1981; Campbell et al., 1991; Black, 1996).

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WAITAKERE RIVER PILLOW LAVA FLOW
Bruce Hayward

One day while mapping the geology of the Waitakere Ranges in the 1970s, I did a traverse of a section of the Waitakere River below the high Waitakere Falls. I recorded a significant pillow lava flow forming a 19 m high waterfall about 250 m downstream from the Waitakere Dam atop the 95 m-high Waitakere Falls. The location is in rather rugged country away from tramping tracks and thus it is seldom visited. To my knowledge the only record of this flow appears on the 1:50,000 geological map of Q11, Waitakere (Hayward, 1983) where it is shown as a minute sliver marked "pillow lava; mw" (Waiatarua Formation) (Fig. 1). There is no recorded description or photograph of it.

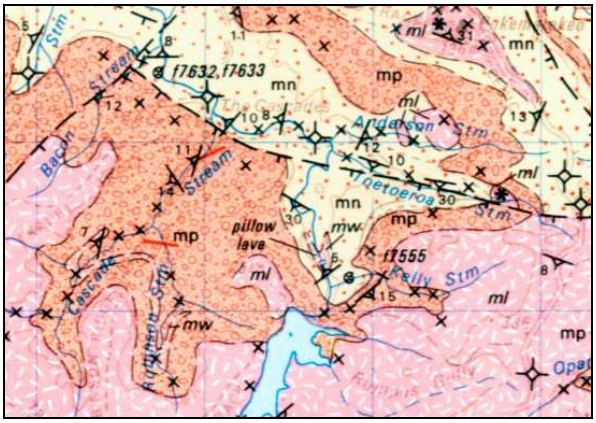


Figure 1. Portion of the 1:50,000 geological map of Q11 Waitakere (Hayward, 1983) showing the location of the pillow lava flow downstream from the Waitakere Dam and Falls.

In 2007 I made a specific trip back up the Waitakere River with my daughter Kathryn especially to photograph and look at this flow. The flow at Q11/467773 is about 10 m thick, nearly flat-lying and overlies bedded volcanic sandstone and mudstone. Its upper parts form the top of the falls. The flow is best exposed on the true right bank (east side) in the amphitheatre (Fig. 2) that surrounds the falls. Much of the exposed flow is composed of a large internal feeding tube with radiating columnar cooling joints (Fig. 2) with 0.3-1 m diameter pillows (less well-exposed) around and above it.

This flow is a second example in northern New Zealand of a pillow lava flow with the exceptional internal structure seen in the internationally-reknowned Maori Bay flow (Hayward, 1979).


Figure 2. Exposure of the Waitakere River pillow lava flow in the amphitheatre on the downstream side of the waterfall they create. Note the large fan of cooling joints formed by the solidified internal feeder tube.

The large fan of cooling joints is inferred to be the solidified, 8-10 m diameter internal feeder tube that flowed with molten lava supplying the advancing front of the flow with its narrower diameter elongate pillow fingers, which also form the carapace around the feeder tube.

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THE WHITFORD BOULDER – TAINUI CANOE MOORING STONE

Bruce Hayward and Jeff Mauk

A group of GeoClubbers visited the foreshore around Whitford in August 2010. While exploring the Waitemata Sandstone tidal platforms we came across a large boulder that was clearly out of place. We speculated on its possible source and how it could have got to its present location, but no firm conclusions were reached. In March 2011 the authors revisited the boulder to make a more detailed examination of its composition and to undertake a more extensive survey of the surrounding area.

Setting

The location of the boulder is approximately 800 m east of the end of Broomfields Rd, on the west side of tidal Turanga Creek, 3 km downstream from Whitford (36º 54.86'S, 174º 57.59'E). The boulder sits at mid-high tide level on a sandstone shore platform, where it has eroded itself into a depression about 10 cm deep. The boulder's location is approx. 40 m from the main navigable channel of Turanga Creek (Fig. 1). The boulder sits out in the open, about 5 m from the edge of the overhanging pohutukawa that grow in the ~10 m high cliff behind. There is no obvious human modification or earthworks in the cliff, base of the cliff or top of the cliff within 50 m of the boulder.



Figure 1. The Whitford Boulder sits on the shore platform adjacent to the tidal Turanga Creek channel.

Under the pohutukawa at high tide level there is a small concentration of rounded cobbles and pebbles, mostly of local Waitemata lithologies. Careful searching in 2011 located about 30 cobbles and pebbles (5-30 cm diam) of other out-of-place rock types within 20 m that probably had the same explanation of origin and transport to the boulder. Beyond this distance we found only two pebbles of possibly similar origin.



Figure 2. The Whitford Boulder engendered much debate over its origin when visited by GeoClubbers.

Description

The Whitford Boulder has a diameter of approximately 1.5 m and a height of 1 m. It is mottled orange and grey-white in colour and extremely hard (Fig. 2). The surface is irregular, slightly rounded but not polished. It is a pervasively and extensively silicified breccia with angular to rounded clasts, 0.5 to 8 cm in diameter (Fig. 3). Both the clasts and matrix are strongly silicified. Most clasts are massive with no obvious flow-banding or fabric; many have minute rectangular holes, which appear to be leached out crystals of feldspar or pyroxene. If so, then the original clasts were probably andesite or dacite. Small rust-coloured patches on the boulder suggest that there is minor sulphide mineralization associated with the quartz, and up to 0.5% pyrite was observed in some places as disseminated grains up to 1 mm across in the clasts and matrix.



Figure 3. A close-up view of the surface of the Whitford Boulder shows it to be a silicified breccia. Note hammer head (bottom right) for scale.

The ~30 cobbles and pebbles found at high tide level within 20 m of the boulder are a mix of rock types (Fig. 4). Some are identical to the boulder and

were probably derived from it. Four are different kinds of silicified wood, one is an orange chert, several red and white jasper, and another is a 20 cm-diam, rounded cobble of silicified fine-grained andesite that has a 2 cm cream-coloured outer rind, suggesting long exposure as a cobble (Fig. 5).



Figure 4. Some of the partly rounded siliceous cobbles and pebbles collected from the high tide beach within 20 m of the Whitford Boulder. Lithologies include siliceous breccia, red jasper and silicified wood.



Figure 5. Broken piece of rounded cobble composed of silicified fine-grained andesite (grey) on the inside and a 2 cm wide leached cream-orange weathering rind parallel to the rounded outside of the cobble.

Source

The Whitford Boulder's composition is consistent with its derivation from an area of strong hydrothermal alteration with an original country rock of andesite or dacite. Rocks of almost identical composition occur along the west coast of Coromandel Peninsula around Coromandel Harbour and on the coast north of Thames. The associated silicified cobbles clearly do not come from the Auckland region either and probably have come from the coast of the Coromandel Peninsula as well, potentially from the same area as the Whitford Boulder.

Possible explanations of how the boulder got to Whitford

1. Dumped on foreshore in early European times

This explanation was the most favoured at the time of the Geoclub trip when it was first brought to our attention. In the 19th and early 20th centuries, flat-bottomed scows were a major vehicle for transport of goods around the Hauraki Gulf. When they had no load, the scows sometimes were stacked with locally collected rocks for ballast, which were then dumped when cargo was next being loaded. Many of the rocks found around the foreshore of the Hauraki Gulf today that are out of place were undoubtedly part of the discarded ballast from early European times. Of necessity these ballast rocks were usually of a size that could be lifted by one person and rocks smaller than 20 cm in diameter would not have been worth loading either. The Whitford Boulder is far too large and heavy for even 6 men to have lifted and thus we consider discarded ballast as an unlikely explanation and similarly many of the associated quartzose rocks are too small to have been considered for ballast. Scows would have come up Turanga Creek to the flax mill and the charcoal burners at Whitford, but it seems unlikely that they would have dumped extra ballast at this locality.

A scow may have had these rocks on board and for some reason it beached at this locality at high tide and they were dumped off, possibly to assist refloating or possibly just to get rid of them. We speculate that someone on a scow noticed these rocks on the Coromandel coast and decided to load the Whitford Boulder with considerable mechanical assistance and other small rock specimens to take and show to someone, maybe to try to get them interested in taking out a mining claim or to get an opinion on whether it was likely to be gold-bearing. If this was the situation then presumably the opinion was not encouraging and they were dumped here.

2. Meteorite origin

Local historian Alan La Roche (pers. comm.) recalls the theory of local farmers that this rock was a meteorite that landed in the 20th century and upset the local cows milking. Attractive as this explanation is, the boulder's rock type is quite unlike any meteorite and this origin is not supported.

3. Tainui Canoe mooring stone

After our two visits to the Whitford Boulder, we contacted Alan La Roche to enquire whether he knew of how the boulder got where it is – thinking that he might confirm our early European dumping by a scow hypothesis. Instead he said he knew the boulder well and so did pre-European Maori. He believes it is the one mentioned in Maori traditional

histories as the stone to which the Tainui Canoe was moored during its epic journey from East Cape across the Bay of Plenty and Hauraki Gulf and eventually portaged from the Tamaki Estuary into the Manukau Harbour. On this journey tradition states that it came up the Turanga and moored in the estuary at this locality. The Whitford Boudler is the only likely candidate to tie the Tainui Canoe to and there is no reason not to believe that it was indeed used. Clearly, this large boulder was present here on the foreshore in pre-European times and on this basis it would seem that the hypothesised early European dumping origin can be discarded.

4. Remnants of an outcrop of Pliocene Puketoka Formation

A similar assemblage of quartzose cobbles to that found at Whitford occurs on the hills near Maramarua and is derived from erosion and weathering of the Pliocene Puketoka Formation s.s. (Battey, 1949; Hayward and Grenfell, 2010). These rocks at Puketoka, which include a 2 m diameter boulder of quartzose breccia, are inferred to have been derived by erosion from the west Coromandel Range and to have been transported westwards in a west-flowing valley system prior to the foundering of the Firth of Thames (Battey, 1949; Kear, 2000). This Pliocene river is inferred to have flowed through the small Maramarua graben between greywacke blocks south of the Hunua Ranges.

Another deposit of Pliocene Puketoka Formation s.s. containing abundant quartz lithologies occurs at Kidds Beach on the south shore of the Manukau Harbour, and has also been inferred to have been transported there by another west-flowing river from Coromandel via the narrow Clevedon graben at the north end of the Hunua Ranges (Hayward et al., 2006, 2007).

Could the Whitford Boulder and associated rocks also be derived from another Pliocene Puketoka Formation s.s. outcrop? No such outcrop has been mapped in this area, but these could be the most resistant remnant cobbles and boulder from an outcrop that has been eroded away. The similarity of the rock types to those at Puketoka is compelling support for this explanation. The Whitford locality is not so clearly in a former pathway that a river flowing from the Coromandel would have taken, but it is in a depression at the north west edge of the uplifted Whitford greywacke hills, rather similar to the Maramarua and Clevedon settings.

At the present time we believe that the most likely explanation for the origin of the Whitford Boulder is that it was derived from the western Coromandel Ranges, was transported across by fluvial flood and debris flow processes in the Pliocene, before the Hauraki Graben formed, and deposited here in a Puketoka Formation s.s. conglomerate.

Subsequently, uplift, weathering and erosion may have removed all trace of the conglomerate unit and only the relict most erosion-resistant boulder and cobbles remain here at Turanga Creek. It was subsequently used as the mooring stone for the famous Tainui Canoe during its visit to the location in early Maori times. Maybe a search might reveal more quartzose cobbles or pebbles on the surrounding hills that would support the Puketoka Formation explanation.

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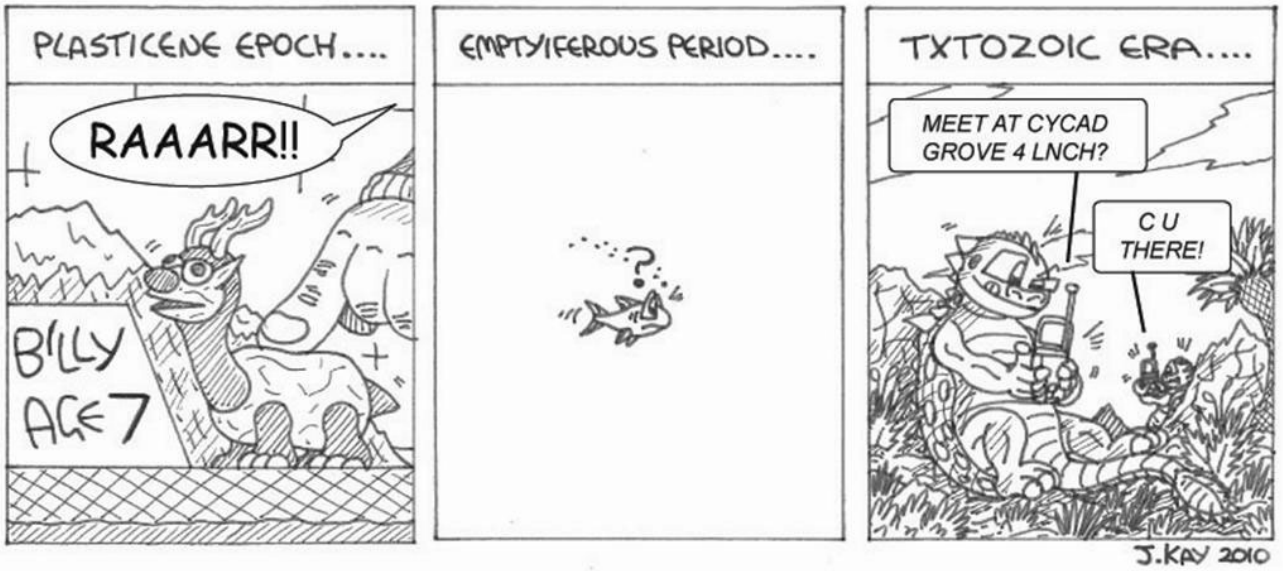
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GEOTOONS..... BY JON KAY



LITTLE-KNOWN REGIONS OF THE GEOLOGICAL TIME SCALE

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THE PERIODIC TABLE OF ELEMENTS: THE EARLY YEARS....