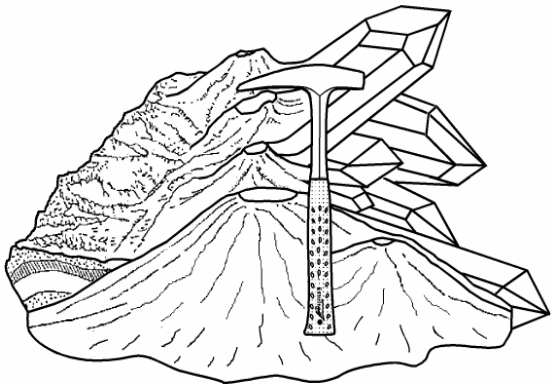


Geocene

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HALF-BAKED BOMBS AT PUKETUTU
Bruce Hayward

On the Geoclub's June 2008 field trip to Puketutu Island in the Manukau Harbour, we walked over a foreshore platform (R11/656686) eroded into layers of scoriaceous tuff. These almost horizontal bedding planes were sporadically pock-marked by depressions 0.3-1 m across, that on closer inspection were often found to contain blocks of Waitemata Sandstone, or more rarely basalt or Te Kuiti limestone.

These were clearly volcanic bombs that had been ripped from the wall of the volcanic neck and blasted out during the early explosive-style eruptions from Puketutu volcano.
The depressions were the small impact craters where the bombs had landed in the soft scoriaceous ash layers. Several of the sandstone bombs had a 1-2 cm thick outer layer of harder sandstone surrounding softer sandstone inside (Figs 1, 2).

These harder layers completely encircled the bomb and would appear to be a zone that was baked by the heat in the eruption column. We have seen similar, less spectacular baked rims to sandstone bombs in tuff at North Head.





Figs. 1-2. Sandstone bombs with baked outer layers, sitting in the depressions created by their impact with the soft scoriaceous tuff.

SEDIMENT BAKED BY PUKETUTU ISLAND LAVA FLOWS

Helen Holzer

In June, 2008 GeoClub visited the south-west shore of Puketutu Island volcano in the Manukau Harbour. Puketutu Island is privately owned and is joined by a causeway to the shore. On a previous trip to the volcano interesting baked rock strata were seen by a few members who made a brief diversion to the shore platform. The aim of this second trip was to look more closely at these rocks.

Puketutu, one of 48 small basalt volcanoes in the Auckland Volcanic Field, has an extensive tuff apron and originally had five small scoria cones, three have been quarried away since the 1950's. Unfortunately quarrying of lava flows continues today. Recent research (Cassidy, 2006) gives Puketutu's eruption date at about 29,000 calendar years BP - interestingly one of five Auckland volcanoes dated close to this time.

Baked sediment:

The rocks visited were on a small point jutting out beyond a muddy embayment (Grid reference R11/650884). Clearly seen first was sediment interspersed with basalt lava which it abutted (Fig.1) The sediment was a hard, fine-grained milky white rock (porcellanite) which had clearly been baked by the lava and was tilted in various directions. The composition of the porcellanite led to discussion about it's original origins.

At the time of Puketutu's eruption the Manukau Harbour was forested. The Manukau Lowlands are underlaid by Quaternary sediments consisting mainly of weathered rhyolitic tuffaceous sediments. The colour and cherty nature of the porcellanite seems to indicate a high proportion of quartz or being derived from quartz rich sediment.



Figure 1: Baked sediment (porcellanite) overlying and intruded by basalt lava, south-west shore Puketutu Island.

Another baked sediment type seen was an orange-red natural brick (Figure 2). In the photo below it looks as if sediment has been incorporated into the flow, but the brick was seen directly abutting the lava. The contact metamorphism resulted in the sediment being altered, and perhaps depending on the intensity of heating, to porcellanite or to natural brick.



Figure 2: An inclusion of natural brick within basalt lava, south-west shore of Puketutu Island.

Tuff:

Puketutu Island volcano has an extensive tuff apron. The relationship of the tuff to the lava flows and baked fine-grained sediment was at first puzzling.

In the area of baked sediment the tuff remained unaltered by the lava. Here the tuff beds had a north-south strike and outcropped on either side of a central, north-striking zone of basalt lava and baked sediment. To the east of this zone the tuff dipped east at about 20-25^{o} away from the baked sediment and lava (Figure 3). To the west, the tuff dipped west with the slope gradually easing back to 10-15^{o}. Clearly the tuff had completely



Figure.3. Tuff dipping east.

eroded away over the crest of a north-south-striking anticlinal structure exposing basalt and baked sediments

The observations were that the unaltered basaltic tuff appeared to directly overlie the baked fine-grained sediment which seemed to directly underlie and abut the basaltic lava. This led us to infer that the fine-grained sediment had been baked from above by the lava, which must have intruded into it and the tuff.

It appears that a narrow tongue of basalt lava flow from Puketutu Island pushed its way into the upper layers of fine-grained sediment beneath the basaltic tuff and flowed south within the sediment pile for 50 or more metres. As it intruded it pushed the overlying sediment and tuff up into an anticline above it. In places we could further see where the upper surface of the intruding lava had managed to intrude upwards through the overlying sediment and tuff along fractures and cooled to form small basalt dikes (Figure 4)



Figure 4. Basalt dyke intruding tuff.

Other basalt flows:
One feature of interest higher in the sequence was the "piles" of basalt rock overlying the tuff (Figure 5). These were not derived from the same flows that intruded and baked the sediments. A closer look showed these were not piles but "fitted together", being the eroded remnants of lava flows fractured and broken by weather, ?frost, air, water,and climate / sea level changes over 29,000 years.

The rock pile abutting the land could be seen to extend further inland. this perhaps being part of the toe of the flow as it was piled up.

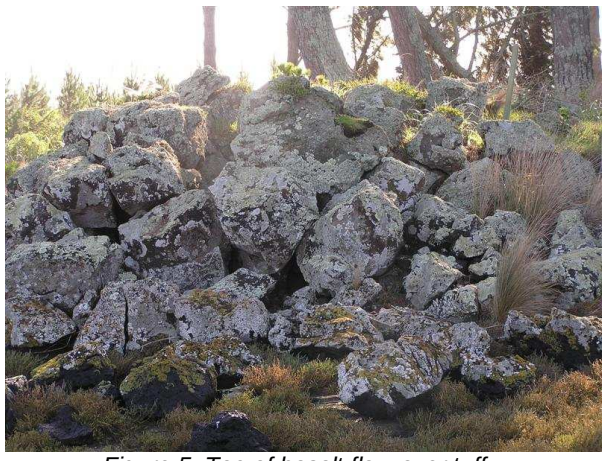


Figure 5. Toe of basalt flow over tuff.

Another pile did not have any obvious connection to the former but the conclusion was that it was of similar origin and its source had been eroded away (Figure 6). It lay on the edge of a small muddy embayment which seemed to have been formed by a natural drainage system which had eroded away part of the flows and buried what was left under the mud.



Figure 6. Tuff covered by basalt flow.

Reference:
Cassidy, J. (2006) Geomagnetic excursion captured by multiple volcanoes in a monogenetic field Geophysical Research Letters 33, L21310, doi:10.1029/2006GL027284

STALACTITES OR SPELEOTHEMS AT MANGAPOHUE NATURAL BRIDGE

Rhiannon and Peter Daymond-King

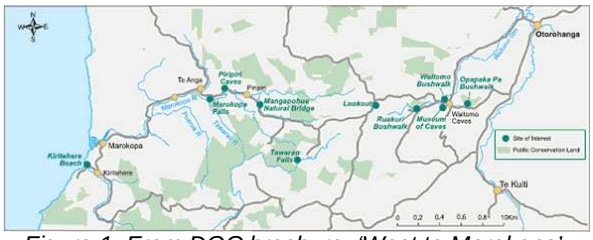


Figure 1, From DOC brochure, 'West to Marokopa', available at the Waitomo Museum.

The DOC-signposted walk to the Natural Bridge (25 km from Waitomo Village) was a delight; through bush and along a river, on a sturdy elevated pathway along the side of the cliff. (The DOC-built facilities also boast one of the cleanest long drops I've seen.) Along the walkway one can see typical limestone features of karst topography, such as depressions, caves, weathered outcrops and rain-sculptured features called 'karren'. Apparently you can see plenty of glow-worms at night – a good place to go if you don't feel like endorsing the tourist industry at Waitomo Caves (Irvine, 2008). Maps and guide books for this and surrounding attractions are available from Waitomo Museum (WMa).

The Natural Bridge itself probably formed when the present-time river gorge was a cave. There are technically two bridges, right on top of each other. The top level of the bridge is 17 m from the river . below. As the river cut down and widened the cave, most of the roof became unstable. The second bridge is at about 10m height from the river, with an observation platform above.



Figure 2: Mangapohue Natural Bridge Scale = Peter Daymond-King.

The sign by the stairs claims "Not a stalactite to be seen" – they are all 'epitrophic speleothems', also called 'biokarst' (DOCa). Rainwater drips through fractures visible in the roof of the bridge, dissolving limestone on the way. This water is absorbed and used by mosses and algae growing on the roof. As these plant colonies grow towards the light they leave behind the calcium carbonate in oddly shaped stacks (DOCa). The term 'speleothem' includes nearly all precipitates found in caves, from stalactites and stalagmites to cave coral, cave pearls, curtains, flowstone, and helictites (Kearey, 2001). 'Normal' stalactites, however, form by the passive deposition of the dissolved limestone as the water drips from the roof; biological action is not involved, as it is in the Mangapohue case (DOCa).



Figure 3: 'Epitrophic Speleothems' or 'Biokarst stalactites', hanging from the ceiling of the higher Natural Bridge. Scale of the photo c. 1 x 0.6 metres.

Speleothems are used for dating via several different techniques, including ESR dating, uranium-thorium dating, and mass spectrometry. They allow the construction of high-resolution age models and ties to tree-ring and ice-core records throughout the world (Hellstrom, 2004; Williams, 2007).

ESR dating offers a useful addition to more established techniques for dating speleothems, and a Geiger Muller instrument (developed specifically for cave dosimetry) may be used measure gamma dose rates (Lyons, 1990). Speleothems are dateable by mass spectrometry to c. 600 ka B.P. with age uncertainty often <1% and an accuracy better than that normally achieved for radiocarbon (Williams, 1996). Uranium-thorium dating is a well-established, and steadily improved, method of dating late Quaternary carbonates (Hellstrom, 2004). Using multi-collector ICP-MS technology it is now possible to minimise sample consumption and get high-quality age determinations from samples containing only one nanogram of uranium,

corresponding to ten milligrams of a typical speleothem or a few hundred micrograms of coral (Hellstrom, 2004).

Speleothems are very useful for determining various aspects of Quaternary geomorphology, including glacifluvial and glacial/interglacial cycles (Williams, 1996) and palaeomagnetic and palaeoclimatic data from oxygen isotope records (Lyons, 1990; Williams, 1996, 2007). Sequences of glacifluvial sediments interbedded with speleothems are evidence of the number and timing of glacial advances and the status of intervals between them (Williams, 1996; Hellstrom, 2004).



Figure 4: Natural limestone formation, with bed of thick oysters. Scale c.1.5 x 1 metres



Figure 5: Oyster on ridge having been broken, showing good condition of shell. Pocket-knife is 90mm long.



Figure 6: Close-up cross-section of oysters.

Episodes of speleothem deposition are interpreted as requiring tranquil underground conditions without physically damaging events, when at the same time there was sufficient vegetation on the surface to provide a partial pressure of soil CO_2 in excess of that found in the open atmosphere (Williams, 1996).

Also at the Natural Bridge, one can continue on the Loop Track across some farmland, and view occasionally cross-bedded limestone formations with beds a couple of centimetres thick. This limestone is tightly cemented (probably by calcite), indurated and subsequently very hard. This limestone contains several horizons, of around a metre thickness, of fairly tightly packed giant oysters. The oysters are on average 20cm across and 3-10cm thick. Yes, that's centimetres, not millimetres – an order of magnitude higher than the size of normal oysters today. The giant oysters are likely to be *Flemingostrea wollastoni* (Beu & Maxwell 1990, Grant-Mackie 2008); Jack Grant-Mackie notes that Kerry Rodgers has also used this name for similar giant oysters beneath the limestones at Port Waikato.

The accompanying DOC sign says that the giant oysters formed on a tidal shelf 35 million years ago (DOCb). Layers of sediment and shell fragments smothered the oyster bed and gradually compacted to form an extensive layer of limestone. About 10 million years ago, this area was uplifted to become land, and has subsequently eroded to expose the limestone in places (DOCb). The limestone also contains chips of barnacles, bryozoans, other bivalves and red algal grains (DOCb).

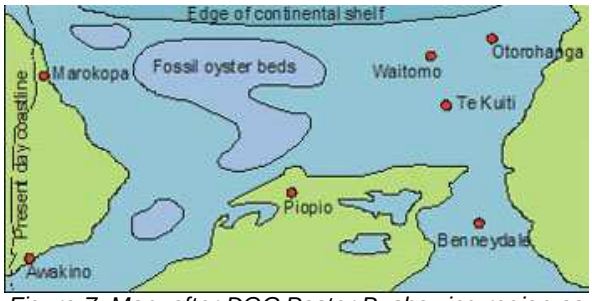


Figure 7: Map, after DOC Poster B, showing region as it may have looked 35 million years ago and the location of the oyster beds in relation to present day coastline and towns.

These oysters can also be viewed in Piripiri Caves (WMa), which are 4km further on from the Natural Bridge. These caves are not guided so you will need a torch, good boots, and mud-proof clothes. The 25-m Marokopa Falls are a further 2km along the road, with a 20 minute walk (WMa).

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DOCb: Department of Conservation, Fossilised Oysters sign

DOCc: Department of Conservation, West to Marokopa; brochure (http://www.doc.govt.nz/upload/documents/parks-and-recreation/tracks-and-walks/waikato/west-to-marokopa.pdf)

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WMa: Waikato Museum of Caves and iSITE Visitor Information Service, 2008 (http://www.waitomo-museum.co.nz/newwebpages/Edwalk.htm)

STRANDED SEA-CAVE STALACTITES IN ANDESITE ROCKS AT NORTH PIHA

Bruce Hayward

We all know that stalactites form in caves and beneath overhangs in limestone country, and most Auckland geologists are also familiar with lava stalactites formed on the ceilings of lava caves or blisters in Auckland's basalt flows. Several years ago I was somewhat surprised therefore to see stalactites hanging from the ceiling of the largest sea cave at North Piha, Waitakere Ranges. The most obvious stalactites are 30 cm long and 10 cm across and occur close to the entrance on the southern side (Fig. 1). There are numerous other, more dirty stalactites further inside the cave. A fallen piece of stalactite fizzed profusely with a drop of dilute hydrochloric acid, confirming that it was made of carbonate.



Fig. 1. Two calcite stalactites hanging from the ceiling of a stranded sea cave in non-calcareous, andesitic, Piha Formation, North Piha.

The cave occurs at the foot of the cliffs (Q11/405729), 200 m north of the carpark at the end of North Piha Rd. It was eroded by the sea earlier in the Holocene but is now separated from the beach by 50 m of sand dunes (Fig. 2). The cave is c. 15 m wide and 5 m high and appears to have been eroded along a set of four parallel fractures through gritty andesite sandstone. The roof of the cave is composed of more resistant andesite boulder and cobble conglomerate (Fig. 2). The entire 50 m high cliff is composed of andesitic conglomerate and gritty sandstone of the Piha Formation (Hayward, 1983).

The stalactites appear to have formed in the same way as they do in limestones, with calcium carbonate crystallising out around drips of water that percolate down along fractures through the overlying rock.



Fig. 2. The largest sea-cave at North Piha, stranded behind sand dunes, and containing stalactites on its ceiling.

Piha Formation is generally non-calcareous however, with no known shelly fossil beds and no obviously calcareous rocks in the vicinity of North Piha, so the source of the carbonate is unknown. I have also been informed of another stranded sea-cave with stalactites in the andesitic conglomerate cliffs north of Pararaha, 8 km south of North Piha.

These appear to be the first records of carbonate stalactites in the Waitakere Ranges and possibly in volcanic rocks anywhere in New Zealand.

Reference

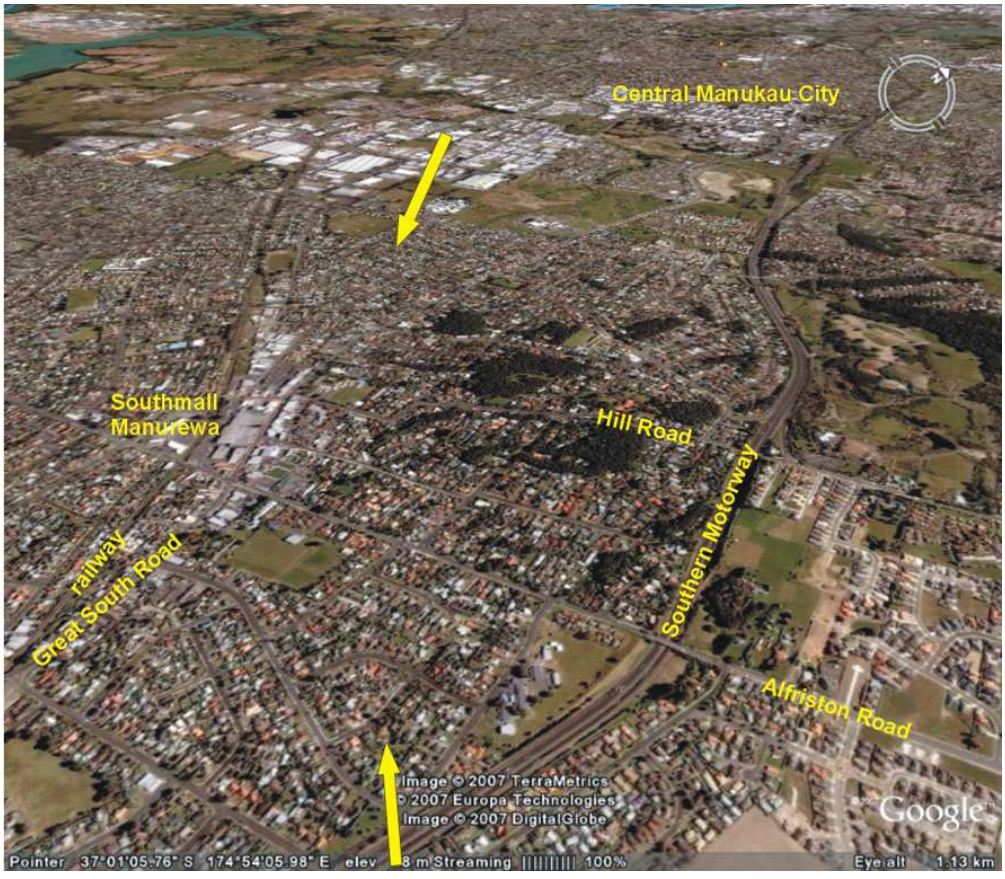
Hayward, B.W., 1983. Sheet Q11 Waitakere. Geological Map of New Zealand, 1:50,000. DSIR, Wellington.

WHAT IS THIS?
Jill Kenny

This image below is of Manurewa in 2006, copied from Google Earth last year (so it is not quite the latest version). I have manipulated the image on Google, so that it appears as an inclined view towards the northwest. At this angle and alignment it is possible to make out a faint line (arrowed).

What is this line?
Those of you who know Manurewa and Alfriston may be able to help me. I have visited the area and have determined that it is not a row of power pylons or a local stream. It is not visible on aerial photos, nor on Google Earth, except at that precise orientation. The hilly area around Hill Road is to the east of the line, the flat country in the vicinity of Weymouth Road is to the west of the line. That may give you a clue as to what I think it is, but you locals may have a much more obvious explanation.

Please put your thinking caps on!!!



THREE KINGS LAVA LAKE, AUCKLAND
Bruce Hayward and Jill Kenny

Three Kings volcanic centre in Auckland City has been mapped and described with increasing detail by Heaphy (1860), Hochstetter (1864, see Fleming 1959), Searle (1962, 1964), Kermode and Searle (1966) and Kermode (1992). Notwithstanding these descriptions, there still seemed some lack of clarity surrounding the precise geometry of the basalt lava lake that Searle and Kermode had both mapped as partly filling the south-east part of the Three Kings explosion crater. With this as background, an Auckland GeoClub field trip of 16 members explored the remaining rock exposures and landforms of the area previously mapped as basalt lava, on Sunday September 14 2008.

Previous work:
Neither Heaphy (1860) nor Hochstetter (1864) mapped the existence of basalt lava inside the Three Kings tuff ring (e.g. Fig. 1), but as both

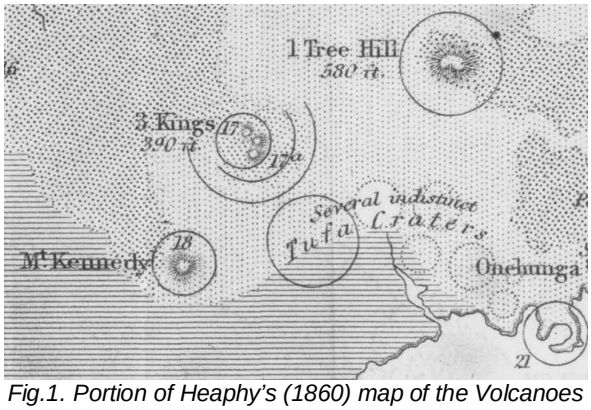


Fig.1. Portion of Heaphy's (1860) map of the Volcanoes of Auckland showing his interpretation of the volcanic landforms in the vicinity of Three Kings centre.

maps were rather small scale this is not surprising and does not necessarily indicate that they had not seen it there. In his 1962 mapping, Searle (Fig. 2) showed a lunar arc of lava inside the large Three Kings crater between the scoria cones and the tuff ring along the southern and south-western sectors. This outcrop pattern was repeated by Kermode and Searle (1966) and extended northwards for 500 m up the inside eastern side of the crater along St Andrews Rd (Fig. 3). In the southwest and southeast, however, they separated this lava from the scoria cones by wedges of tuff (Fig. 3). Kermode (1992) removed these inferred wedges of tuff (Fig. 4), presumably because by then he had seen the direct contact of the lava with the scoria cones in the southern wall of Three Kings Quarry.

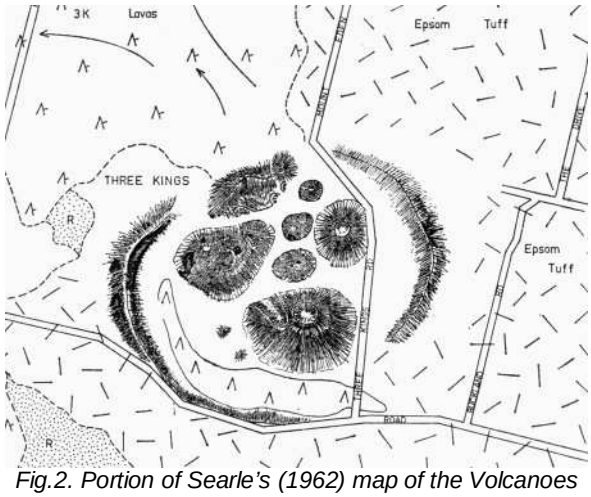


Fig.2. Portion of Searle's (1962) map of the Volcanoes of Epsom showing his interpretation of the volcanic landforms in the vicinity of Three Kings centre.

In this latest map, however, Kermode does not extend the lava outcrop anywhere near as far south or east as was done in the earlier Searle and Kermode (1966) map. Presumably the mapping of this lava across St Andrews Rd was based on observation by Searle that Kermode had not verified in the field. None of these more general works provide a particularly detailed explanation of how they interpreted the existence of the arc of lava in the southern parts of the Three Kings crater, although BWH recalls the late Les Kermode, on an earlier Geoclub trip in the late 1990s, describing it as "a lava flow filling part of the crater between the scoria cones and tuff ring".



Fig.3. Portion of Kermode and Searle's (1966) industrial series geological map of Eden showing their understanding of the distribution of basalt lava (v), scoria (b) and tuff (t) in the vicinity of Three Kings volcanic centre.

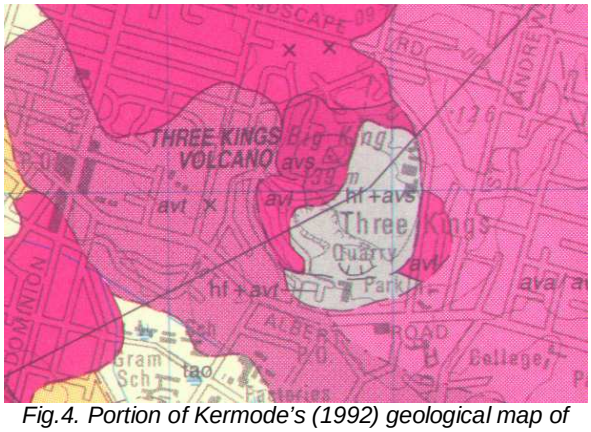


Fig.4. Portion of Kermode's (1992) geological map of urban Auckland showing his revised understanding of the distribution of basalt lava (avl), scoria (avs), tuff (avt) and human reclamation (hf) in the vicinity of Three Kings volcanic centre.

Our observations:
1. In the southeast corner of Three Kings crater there is a linear outcrop of vertically-columnar-jointed basalt running from the grounds of Three Kings School diagonally across St Andrews Rd and through the front gardens of a number of properties on the east side of the road. From here the outcrop is patchy through properties through to Rowan Reserve between Rowan Rd and Gorrie Ave. This linear basalt outcrop is flat-lying and forms the crest of the tuff ring in this part of its arc. Despite searching we could find no evidence of any lava that had spilled over this crest and down towards Mt Albert or Buckley roads to the east. A 30-50 m wide terrace extends from the corner of St Andrews Rd and Gorrie Ave eastwards along Gorrie Ave at the same height as the top of the linear basalt outcrop. From the terrace and basalt outcrop the land level slopes quite steeply down by 5-10 m to the natural floor of the crater, now covered in houses.

We infer that this horizontal line of basalt around the southeast crest of the tuff ring is the cooled and solidified rim of a lava lake that was left after some of the lava lake drained away and the main central portion of crust on the lake surface collapsed to create the lower crater floor level.

2. In the southern wall of the deep Three Kings quarry, close to Mt Eden Rd, the thirty degree lower slope of a scoria cone is abutted and overlain by solid basalt with an upper level approximating the same level as the lava lake rim, 500 m away on St Andrews Rd.

We infer that this is on the northwest side of the moat-like depression where the lava lake abutted the slopes of one of the central scoria cones, cooled and solidified before the central portion of the lake drained away and the crust collapsed.

3. In the southwest corner of Three Kings crater, we found that McCulloch Ave runs along an arcuate, 10 m-deep trench, with weathered tuff forming the steep slope on the southwest outside and less-weathered jointed basalt forming the steep slope on the northeast inside of the arc. This basalt underlies the flat to undulating surface of Smallfield Ave that lies between McCullough Ave and the former Three Kings quarry depression that worked some of the central scoria cones. The height of this basalt land surface is approximately the same as the basalt lava lake rim to the east.

We infer that this is the western end of the same basalt lava lake identified in the south-east (Figs 5-6). In this vicinity the lava was more viscous and its advancing westward front solidified and prevented the lava from reaching the inner tuff wall of the crater. When the more liquid portions of the lake drained away, this western portion was cooler and more solidified and did not subside.

Conclusions:
Early eruptions of Three Kings volcano were phreatomagmatic style that produced the largest explosion crater (1 km across) and surrounding tuff ring in the Auckland volcanic field. As ground water was used up the style of eruption switched to dry fire-fountaining that built five or more scoria cones from several vents inside the crater.

Towards the end of this phase molten lava burst forth from the base of these scoria cones and filled much of the moat between the scoria cones and arcuate southern half of the tuff ring. The lava was cooler and more viscous in the southwest where its front solidified before reaching the inner wall of the crater. In the southeast, the edge of the lava lake reached the crest of the tuff ring but did not flow over it. Quite possibly the lava lake rose no higher because it broke through the northern crest of the tuff ring at Duke St and a large stream of lava flowed off down the valley to the north-west. This break through could have lowered the lip of the tuff ring and may have resulted in the partial draining of the lava lake and the collapse of its surface crust in the southeast.
The recognition of this partially drained lava lake and its solidified southeastern rim along the tuff ring crest is the second example of such a feature in the Auckland volcanic field – the other is in Crater Hill, Papatoetoe.

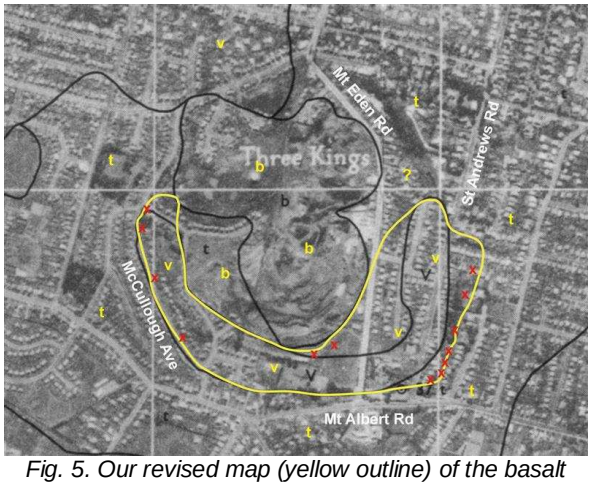


Fig. 5. Our revised map (yellow outline) of the basalt lava lake outcrop (v) within the southern portion of Three Kings Volcano. Red crosses are exposures of in-situ basalt lava. The modified base grey and black map is that of Kermode and Searle (1966). b = scoria, v = basalt lava, t = tuff.

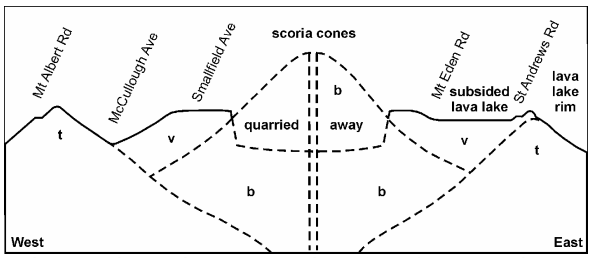


Fig. 6. Schematic cross-section of our interpretation of the subsurface geology of Three Kings volcano (symbols as for Fig.5).

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HARD GEMSTONES: GEM QUALITY MINERALS OF MOHS HARDNESS >8

Rhiannon Daymond-King

Mohs Scale	Mohs mineral	Absolute hardness
1	Talc	1
2	Gypsum	3
3	Calcite	9
4	Fluorite	21
5	Apatite	48
6	Orthoclase	72
7	Quartz	100
8	Topaz	200
9	Corundum	400
10	Diamond	1500

Here's a quick revision of the Mohs scale of hardness, developed by German mineralogist Friedrich Mohs in 1812. It is not a linear scale, as the absolute hardness scale beside it (3rd column) shows.

The "Hard Gemstones" are stones that occur in the Mohs hardness scale 8 and above, including topaz.



Painite, once believed to be the rarest mineral on earth, is today still considered very rare. It was first found in Myanmar by British mineralogist and gem dealer Arthur C.D. Pain in the 1950s. When it was confirmed as a new mineral species, the mineral was named after him. For many years, only three small painite crystals were known to exist. Before 2005 there were fewer than 25 known crystals found, though more material has been unearthed recently in Myanmar.

Painite contains trace amounts of chromium and vanadium, with iron giving it an orange-red to brownish-red colour similar to topaz. It exhibits dichroism in ruby red and pale brownish orange.

The crystals are naturally hexagonal in shape, and, until late 2004, only two had been cut into faceted gemstones.



Rhodizite is a rare potassium caesium beryllium aluminium borate mineral. Just its chemistry gives away its rarity! Specimens come from only a few areas: the Ural Mountains, and a few sites in Madagascar.

Rhodizite should not be confused with several similar sounding minerals such as the silicates rhodonite and rhodesite, or the carbonate rhodochrosite.

Rhodizite is remarkable for not only its chemistry but its bright adamantine lustre and high degree of hardness. Both these properties lend themselves well to the fashioning of a gemstone.

The name comes from the Greek "rhodizein" = "to be rose-coloured" in allusion to its property of turning a flame red.



Spinel occurs in shades of red, pink and purple. Red spinels may be used to imitate rubies. The colour comes from inclusions of Cr (chromium) and Fe (iron). They may also fluoresce red.

Spinel often forms octahedral crystals. It is infusible.

Ferrous iron, zinc and less commonly manganese substitute for the magnesium in spinel in all proportions, and ferric iron and chromium may substitute in part for aluminium. The end

members of these substitutions form the other members of the spinel group. Clear red crystals contain near pure magnesium, known as ruby spinel. Iron spinel, also known as pleonaste, is dark green to black. Chrome spinel, or picotite, is yellowish brown.

Other Spinel Group Members:
Formula AB_2O_4

A	B=Al	B=Fe^{3+}	B=Cr
Mg	***Spinel*** $MgAl_2O_4$	Magnesio-ferrite $MgFe_2O_4$	Magnesio-chromite $MgCr_2O_4$
Fe^{2+}	Hercynite $FeAl_2O_4$	Magnetite $Fe^{2+}Fe^{3+}{}_2O_4$	Chromite $FeCr_2O_4$
Zn	Gahnite $ZnAl_2O_4$	Franklinite $ZnFe_2O_4$	— $ZnCr_2O_4$
Mn	Galaxite $MnAl_2O_4$	Jacobsite $MnFe_2O_4$	— $MnCr_2O_4$



Taaffeite was first discovered from misidentified gemstone specimens, thought to be mauve spinels. Count Taaffe, a Dublin gemmologist and the discoverer, realized that a pale mauve "spinel" in a jeweller's junk box was doubly refractive. Spinel, as an isometric gemstone, is unable to display such a phenomenon.

It is also weakly pleochroic (different colour shades can be seen from different viewing angles), with a refractive index of around 1.72, and may occasionally display weak green fluorescence under ultraviolet light.

Taaffeite has hardness, density and index of refraction properties that are very similar to spinel, and is therefore difficult to distinguish from the much more common gemstone. The double refraction is the key to identification, and often the only way that most of the gem quality taaffeite has been found, in Sri Lanka alluvial deposits, and in lower grade associated with fluorite in China.



Topaz appears in colours from colourless to orange and yellow-brown. The colouring agents are iron and chromium. Clear topaz can appear very like diamond, and in fact has a very similar specific gravity. A pink colouration is usually artificial, produced by gently heating the dark yellow stones. Blue topaz is created by gamma-ray irradiation.

Topaz occurs typically in granite and rhyolite and associated with quartz. It is formed by fluorine-bearing vapours in the last stages of solidification of igneous rocks. It is infusible and insoluble.

The name is from Topazion, an island in the Red Sea. It is believed that the topaz of modern mineralogists was unknown to the ancients and that the stone then called *topazos* was actually the mineral chrysolite or peridot. The "topaz" in the Old Testament also may have been chrysolite.

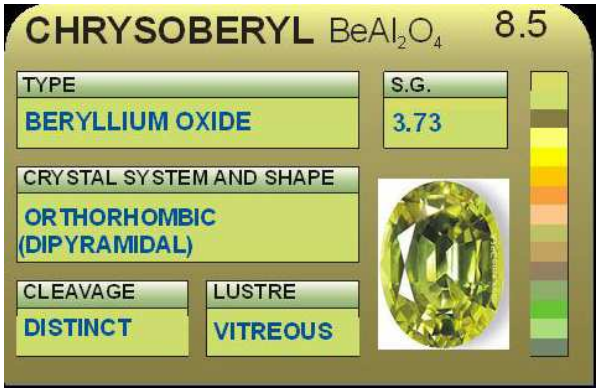


Alexandrite is the emerald green variety of chrysoberyl – but it differs from chrysoberyl in that alexandrite always displays a colour change between natural and artificial light. The colour change phenomenon is a result of the presence of chromium ions and the way they are absorbed and reflected. In rubies the chromium absorption band is around 550 nanometres and in emeralds, the band is around 600nm. In alexandrite, where

the band is at 580nm and right between ruby red and emerald green, the stone is balanced between them. When the light is balanced (daylight), the stone will be green but when the light source is reddish (incandescent), the stone appears red

Alexandrite is found in older rocks than other types of chrysoberyl. It was discovered in the Ural Mountains, 1830 – and originally thought to be emerald, which it is used as a gem substitute for.

Alexandrite is now synthetically manufactured at great cost for use in the windows of space craft, because it can filter out harmful cosmic rays.



Chrysoberyls range from light green to brownish yellow in colour. Crystal faces often have striations on, and are commonly twinned. Chrysoberyl is infusible, insoluble and in fact so resilient, specimens can be cleaned in acid. It forms in pegmatite and metamorphic rocks.

Cat's eye chrysoberyl, also called cymophane, is a variety displaying chatoyancy, or an opalescent lustre whose surface plays a long narrow beam of light which comes from aligned impurities, fibrous or needle-shaped crystals, especially of rutile.

The name chrysoberyl is derived from the Greek words *chrysos* and *berullos*, meaning "golden" and "gem crystal."

Corundum has a hardness of 9 – the two main varieties are ruby and sapphire. Corundum is an aluminium oxide. It is the presence of trace elements like chromium, iron, vanadium and titanium which are responsible for the wide range of colours in which the mineral occurs. The red colour in rubies is primarily a result of the presence of chromium. Red corundum is known as ruby and any other colour is called sapphire.



Ruby's colours may vary from different angles. Fibrous rutile inclusions within the ruby may form a geometric shape, creating asterism, prized highly when cut *en cabochon* to emphasize the star-like light patterns. Rubies may fluoresce red.

Fine rubies, especially Burmese stones over 3cts, are among the rarest and most expensive gemstones in the world. Prized for their beauty, durability, and rarity, it is the quality of the colour which most determines the value of the stones. The ideal colour is that of a traffic light – a highly fluorescent red of high intensity. Demand for gem quality rubies has always been strong and some mining records from Burma date back almost 500 years.



Sapphires are corundum crystals, the blue versions of which contain impurities of iron and titanium. Colourless or yellow varieties of corundum may become blue when heated, increasing their value.

While many sapphires may exhibit faint colour changes upon exposure to incandescent or fluorescent lights occasional stones may display dramatic changes.

Asterism is also a feature of sapphires, as a result of the light reflecting from the silky crystallizations of rutile inside some stones.



Diamond may be many colours, from white to pale yellows, browns, greens, blues and pinks, but the most valuable diamonds are completely colourless. Diamonds may be artificially green coloured by irradiation with high energy particles, then this into deep yellow by heat treatment, or blue coloured by exposing the stone to fast-moving electrons. Diamonds often fluoresce various colours under ultra-violet light.

Diamonds are very hard, in fact the hardest naturally occurring substance, making them an excellent gemstone, but they have perfect 3-way cleavage, thus are brittle and difficult to cut. The name diamond is a corruption of the Greek word *adamas*, meaning invincible. They are insoluble in acids and alkalis. At very high temperature in oxygen diamonds will burn to CO_2 gas, leaving no ash.

The carbon atoms within the structure of diamond have a tetrahedral arrangement, while those in graphite (another form of pure carbon) are linked into flat sheets. Because this is more stable at standard temperature and pressure, diamonds at the Earth's surface will eventually (though very slowly!) turn to graphite.

Diamond fragments and powder are used in grinding, polishing and cutting rocks, gemstones and other hard materials.

Looking for harder materials

Researchers at the Carnegie Institution of Washington grew extra hard, but otherwise normal, diamond crystals using a special high-growth rate chemical vapour deposition (CVD) process (Hemley, 2004; Weiss, 2004). The crystals were then subjected to high temperatures of 2000℃ and high-pressure conditions of 50,000 to 70,000 times atmospheric pressure (5-7 GPa) for ten minutes (Weiss, 2004). This final process resulted in the ultrahard material, which was at least 50% harder than the conventional diamonds, and in fact broke their $10,000 hardness measuring equipment (Weiss, 2004).

University of California, Los Angeles (UCLA) scientists have made rhenium diboride, an "ultra-hard material" (Chung et al., 2007). Rhenium diboride made in two forms: in powder form, made from heating the elements in a furnace, and as a pellet made by a procedure called arc melting (Chung et al., 2007). This has about the same hardness and slightly less incompressibility than boron nitride, nicknamed "Borazon", which is a white or colourless synthetic mineral with cubic crystal structure (Wentorf, 2005). It is relatively fireproof and can scratch diamond (Wentorf, 2005). Diamond cannot be used to cut steel without ruining the blade through the formation of carbides, as at 700 ℃ it burns in air to form carbon dioxide (Bradley, 1993) – and so Borazon is used as a substitute, though it is even more expensive to synthetically produce than diamond (Chung et al., 2007).

Another material that is considerably harder than diamond has been created in the laboratory, by a German group from the University of Bayreuth (Dubrovinskaia et al., 2005), and separately synthesised by a team from Bar-Ilan University and Technion-Israel Institute of Technology (Itzhaki et al., 2005). It is created by packing together tiny "nanorods" of carbon (Dubrovinskaia et al., 2005). The new material, known as aggregated carbon nanorods (ACNR, also called ADNR with D for diamond), was created by compressing and heating super-strong carbon molecules called buckminsterfullerene, buckyballs or carbon-60 (Bradley, 1993; Patel, 1993; Dubrovinskaia et al. 2005; Itzhaki et al. 2005). These molecules consist of 60 atoms that interlock in hexagonal or pentagonal shapes and resemble tiny soccer balls. The super-tough ACNR was created by compressing carbon-60 to 200,000 times normal atmospheric pressure (20GPa), while simultaneously heating it to 2500℃ (Itzhaki et al., 2005). The researchers found their ACNR to be 0.3% denser than ordinary diamond and more resistant to pressure than any other known material (Dubrovinskaia et al., 2005).

The same team of scientists from Bar-Ilan University and the Technion-Israel Institute of Technology broke the world hardness record by combining quantum mechanics, chemistry and mechanical engineering. They synthesized *polyyne,* a superhard molecular rod comprised of acetylene units - that resists 40 times more longitudinal compression than a diamond (Itzhaki et al., 2005). Ironically, these glittery gems are comprised from the element carbon and have the weakest type of chemical bonds, while polyyne has the strongest bonds in carbon chemistry (Itzhaki et al., 2005).

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PUPUKE'S BURIED HORNITO
Bruce Hayward

A year or two ago, GeoClub member Rod Martin mentioned to me that he had found basalt spatter in a recently cleared road cutting near the Pupuke Canoe Club end of Northcote Rd, Takapuna. During the November 2008 Geoclub trip to Pupuke Volcano, I kept a good look out for it and sure enough on the east side of the road about 50 m down from the overlook into Smales Quarry pond (R11/673893) we found a lens of spatter about 2 m across and 1 m thick sandwiched between two basalt lava flows (Fig. 1). The spatter appears to have been a mound on top of the lower flow. The upper flow appears to have flowed around and over it without carrying it away.

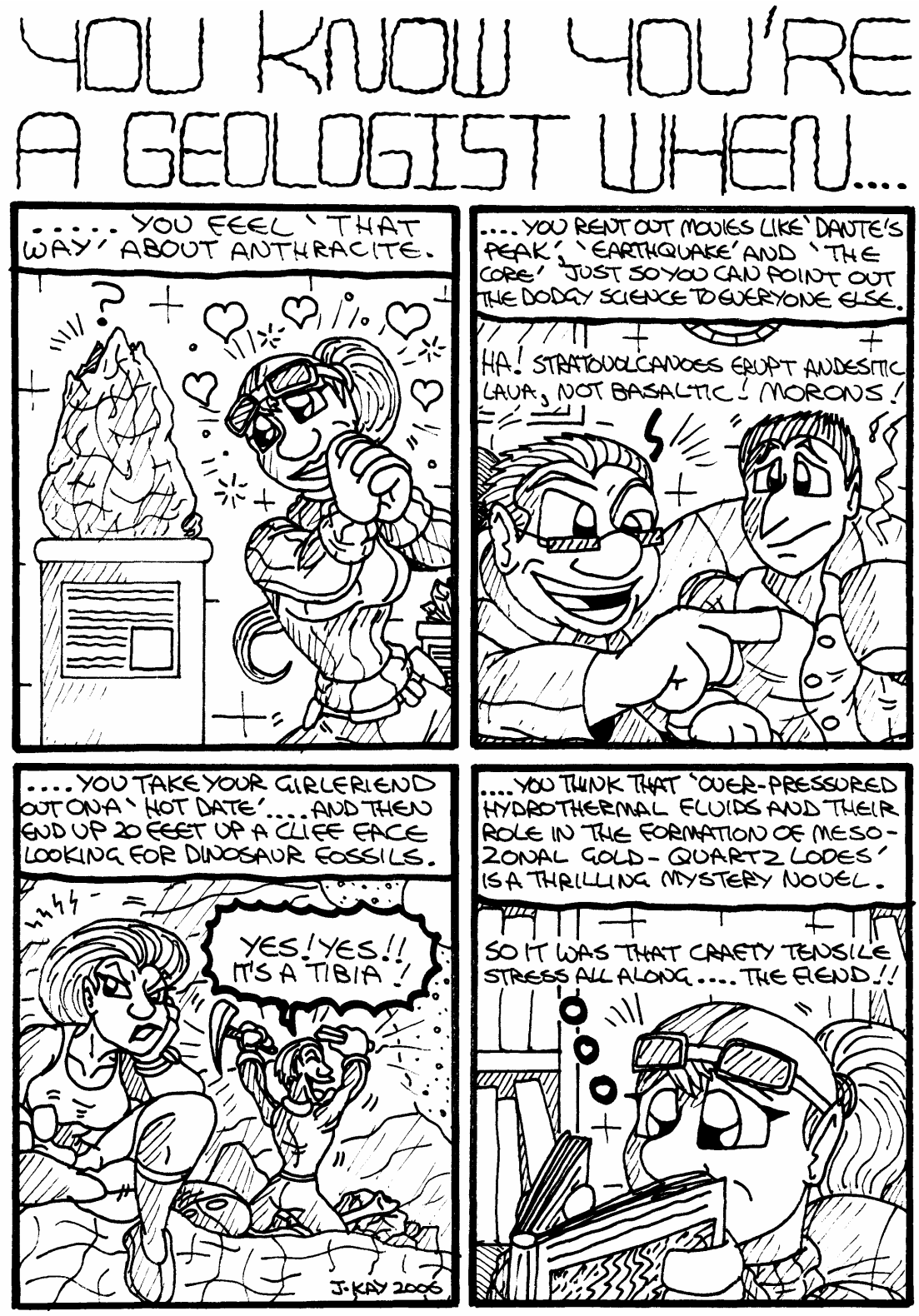


Fig. 1. GeoClub members examine the buried Pupuke hornito – a lens of spatter between two lava flows on Northcote Rd, Takapuna.

Spatter is dense, usually viscous lava that is sporadically thrown out of a lava lake or from a vent on the surface of a lava flow. The ejected lava solidifies as it flies through the air or just after it lands close to the vent. The spatter may have aerodynamically twisted or drawn-out shapes and sometimes the individual pieces fuse together. On the surface of a lava flow these spatter bombs may form fused mounds or "miniature volcanoes" sometimes still with a central vent preserved. The lens of spatter on the surface of a lava flow at Pupuke is inferred to have been one of these small hornitos.

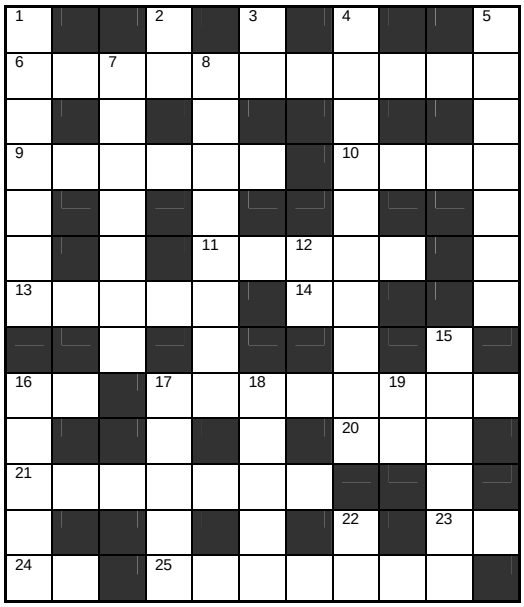
The best known hornito in New Zealand is close to the track to the lava caves near the summit of Rangitoto (Ballance and Smith 1982). Here now, at Pupuke volcano, we have a second occurrence in the Auckland Volcanic Field (and maybe also in New Zealand) of a small basaltic hornito, only in this instance it has been buried by a later lava flow.

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YOU KNOW YOU'RE A GEOLOGIST WHEN....
..... YOU FEEL 'THAT WAY' ABOUT ANTHRACITE.
.... YOU RENT OUT MOVIES LIKE 'DANTE'S PEAK', 'EARTHQUAKE' AND 'THE CORE' JUST SO YOU CAN POINT OUT THE DODGY SCIENCE TO EVERYONE ELSE.
HA! STRATOVOLCANOES ERUPT ANDESITIC LAVA, NOT BASALTIC! MORONS!
.... YOU TAKE YOUR GIRLFRIEND OUT ON A 'HOT DATE'.... AND THEN END UP 20 FEET UP A CLIFF FACE LOOKING FOR DINOSAUR FOSSILS.
YES! YES!! IT'S A TIBIA!
J.KAY 2006
.... YOU THINK THAT 'OVER-PRESSURED HYDROTHERMAL FLUIDS AND THEIR ROLE IN THE FORMATION OF MESO-ZONAL GOLD-QUARTZ LODES' IS A THRILLING MYSTERY NOVEL.
SO IT WAS THAT CRAFTY TENSILE STRESS ALL ALONG.... THE FIEND!!

GEOQUIZZES – Rhiannon Daymond-King

CROSSWORD



ACROSS

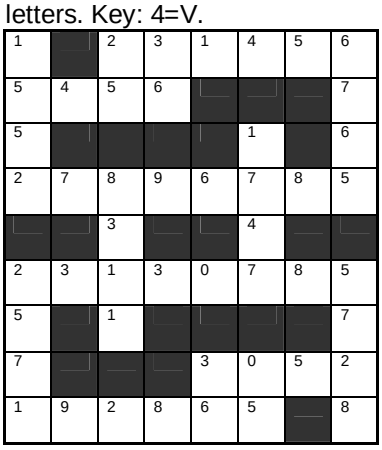
6. Changed rocks
9. Uncommon property
10. Water-filled hole
11. Wind-blown dust
13. Revolving digger
14. First transition element
16. Hard, dense bluish metal
17. Radioactive, from pitchblende
20. Weathered bare hill
21. Rock out of place
23. Continentally reactive rare earth
24. US coin of stainless steel
25. Sea level change

DOWN

1. Green gemstone
2. 56, heavy alkaline earth metal
3. Mostly high-strength steel alloys
4. Dichroic, but opaque
5. S-joined parallel faults
7. The lie of the land
8. Like scandium to mercury
12. Element of physical genius
15. Mapping of land
16. Intercontinental brine
17. Banded chalcedony
18. Joined partner crystals
19. Volcanically active moon
22. Skeletal element

TAKE 5 #4

Each number corresponds with a letter. To work out the crossword, replace the 10 numbers with letters. Key: 4=V.



GEOWORDOKU

Fill the grid so every column, every row and every 3x3 box contains the full nine letters of the word (They can be in any order). There is only one solution to each.

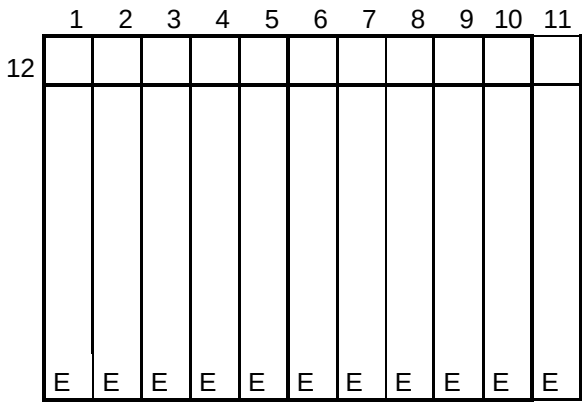
Word: LONGITUDE

I E O N	T N L	T L G I
O U D E	T U	L D I O
U N D T	N G U	E O I N

Word: VOLCANISM

N V	V S N C	A C O L S
C M I	I	S N L
C O S L A	S L C O	M C

DOWNWORDS



1. A crack in the rock
2. Away from the land
3. Blue gemstone with hardness 9
4. Younging towards centre of upright fold
5. To harden and cement rocks
6. A mineral that makes lapis blue
7. Extremely faulted and cross-veined rock
8. Mineral property of breaking along planes
9. Moderate-SiO2 volcanics
10. Low-SiO2, viscous volcanics
11. This and heat, at depth, make diamond

12. Old landform

WORD MATCHING

Match the Colours: create geological terms

BLUE		STONE
GREEN	BEDS	
YELLOW		SAND
RED		WACKE
GRAY		SCHIST

WORD CHANGING

Turn one Geology word into another!
Change only one letter each time, to make a new word. Each letter change must be to a word in English. (no foreign words, or names; e.g. John cannot follow join, but coin can.)

Change: ORE to OIL
Change: BEACH to SHORE

WORDFIND

E	R	A	G	L	A	E	R	A	T	E
T	E	R	T	N	E	C	I	P	E	S
O	I	C	H	N	O	L	O	G	Y	K
D	C	H	O	A	N	L	I	A	O	E
I	L	I	L	S	S	A	L	F	T	R
P	A	T	E	E	Y	P	F	L	O	W
E	G	E	I	T	S	S	A	A	P	O
B	O	C	I	I	E	R	T	K	A	L
B	O	T	T	T	O	E	A	E	Z	L
L	N	U	E	C	R	D	R	I	M	A
E	E	R	N	A	U	U	N	A	E	H
N	V	E	R	L	T	C	E	N	R	S
D	E	U	A	A	I	T	M	U	C	E
E	R	R	G	T	S	I	O	C	U	R
G	I	T	E	S	N	O	D	A	R	E
A	L	S	E	T	I	N	O	L	Y	M

This WordFind contains these 54 words. They can be found in any direction - left, right, up, down, or diagonal - but the words are always in a straight line.

ADULARIA	LONG
AEONS	MERCURY
AERATE	MERES
AGED	MYLONITE
ARCHITECTURE	NEVER
BLENDE	OFFSET
COAL	OIL
COAT	ONSET
COL	PEBBLE
CORAL	RADON
DOME	RARE
ECOSYSTEM	RATE
ENTITY	REALGAR
EPICENTRE	REDUCTION
EPIDOTE	RUT
ERA	SHALLOW
ESKER	SPALL
EYOT	SPLAYS
FLAKE	STALACTITES
FLOW	TARN
GARNET	TEAM
GLACIER	TESLA
GRID	THOLEIITE
ICHNOLOGY	TOPAZ
IN SITU	TRUE
LACUNA	VUGS
LAGOON	ZINC