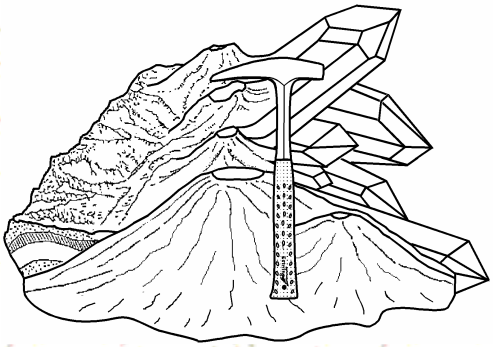


# Geocene

**Auckland GeoClub Magazine**
**Number 1, June 2006**

## CONTENTS

**The relationship between Purchas Hill and Mt Wellington**
**Bruce W. Hayward** **2-3**

**Double delight, *Polydora* in *Austrovenus stutchburyi***
**Margaret S. Morley and Bruce W. Hayward** **4**

**Takahiwai Peninsula - rhodoliths and other Things**
**Helen Holzer** **5-7**

**One Tree Point, Whangarei Harbour**
**Rhiannon Daymond-King** **8-11**

**"Harold Wellman - A Man Who Moved New Zealand"**
**Book Review** **Malcolm Simpson** **12**

**Geoquizzes**
**Rhiannon Daymond-King** **13-15**

**Geocene is a periodic publication of GeoClub, a section of the Auckland branch of the Geological Society of New Zealand.**

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

**Please contact the Editor, Helen Holzer <heleneh_at_xtra.co.nz> (substitute @ for _at_)**

**THE RELATIONSHIP BETWEEN PURCHAS HILL AND MT WELLINGTON VOLCANOES**

Bruce W. Hayward

In 2005, a GeoClub field trip visited the remains of Purchas Hill volcano and surrounds in the former Mt Wellington aggregate quarry land, which at the time was being reshaped for a housing subdivision and new netball centre. In one locality, earthworks and quarrying had created temporary exposures in the western portion of the Purchas Hill tuff ring and overlying cover beds of scoria and a Mt Wellington lava flow.

Our knowledge of the volcanic landforms of Mt Wellington and Purchas Hill in this area comes from the published maps and observations of Heaphy (1860) and Hochstetter (1864, translated by Fleming, 1959), who appear to have visited the area together in late 1859 or early 1860, before falling out over claims and counterclaims of plagiarism (Mason, 2002). At that time, the area that we recently examined was buried beneath a c. 10-20 m thick lava flow that they traced back to Mt Wellington and inferred had flowed over the top of this part of the Purchas Hill tuff ring (Fig. 1). In recent years, Les Kermode (in Kermode, 1992 and Kermode et al., 1992) inferred that Purchas Hill and Mt Wellington erupted essentially at the same time from the same batch of magma and in counting 48 volcanoes in the Auckland Volcanic Field he lumped these two together as one centre. Ian Smith (pers. comm.) has subsequently undertaken geochemical studies that imply that the two came from different batches of magma with different composition and therefore Purchas Hill and Mt Wellington were counted separately as two centres and led to the recognition of 49 volcanoes in the Auckland Volcanic Field (Allen and Smith, 1994).

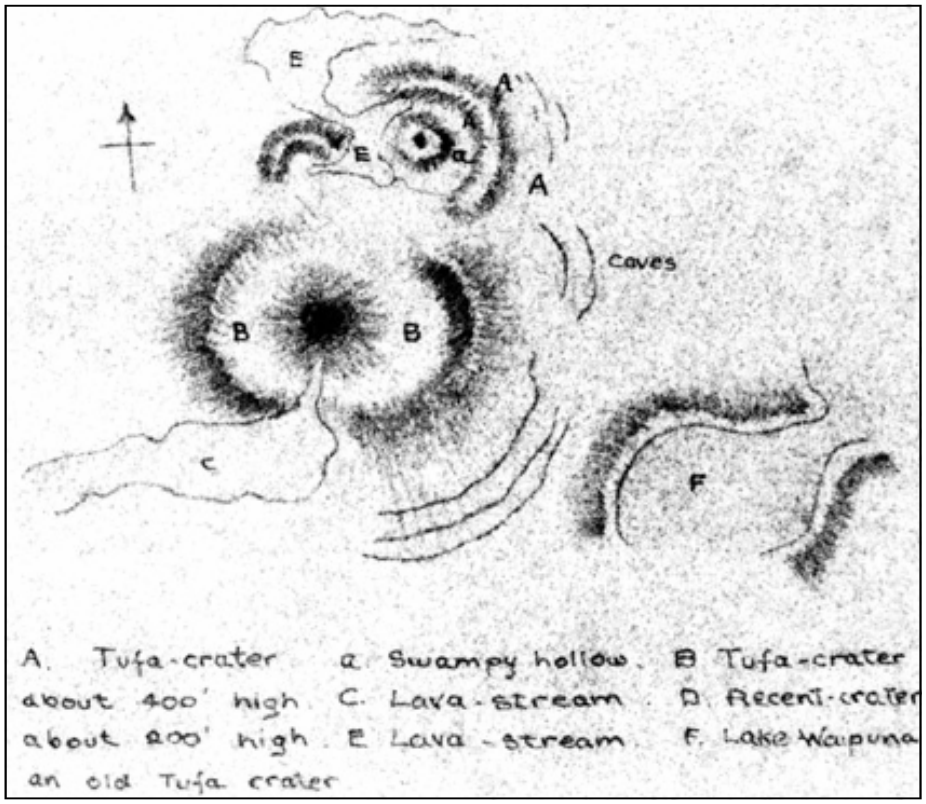



*Fig. 1. Heaphy's (1860) sketch map of Mt Wellington (B), Purchas Hill (A,a) and Panmure Basin (F). The exposures described in this note show the relationship between tuff ring A overlain by lava flow E, which Hochstetter (1864) clearly showed could be traced back to the western base of Mt Wellington.*

When we visited, the relationship between the Purchas Hill tuff ring and the overlying Mt Wellington lava flow was exposed in four cuttings, all within 100 m of each other and all showing the same sequence (Fig 2):

Bottom: 5 m+ bedded lithic tuff (near western crest of Purchas Hill tuff ring) containing bombs of Waitemata Sandstone (up to 0.6 m) and of finely vesicular basalt (up to 0.3 m, sometimes cooled around a core of Waitemata Sandstone).

1-5 m+ crudely bedded vesicular scoria (thicker and coarser in the south-east).

0.05-0.1 m pink-red, laminated ash (medium-coarse sand size).

0.1-0.8 m massive, dense lapilli and brecciated basalt.

5 m+ basalt lava flow (from Mt Wellington; Hochstetter, 1864).

Contacts between all units appear to be fresh with

no evidence of weathering or soil development that might be expected if there was any significant time period (>c. 5 years) between them. In the north-western exposures all units appear to be conformable, but in the south-east the thickest section of scoria abuts up against a steep scarp cross-cutting the tuff and then laps over the upper part of the tuff ring.

I infer that this steep scarp (Fig. 2), which could be traced for over 25 m, was formed by part of the

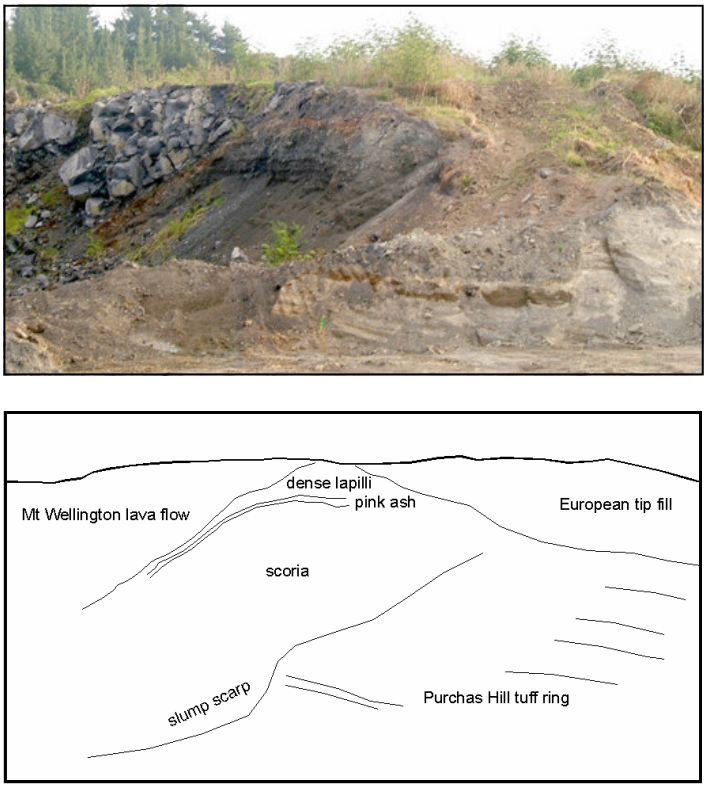



*Fig. 2. Photo and sketch of photo of one of the temporary exposures that showed the relationship between erupted volcanic units from Purchas Hill and nearby Mt Wellington.*

tuff ring sliding into the Purchas Hill crater shortly before eruption of the scoria from a nearby vent. I suspect the scoria came from a vent related to Purchas Hill (possibly one of its central scoria cones) and that the overlying thin fine ash possibly came from a more distant source, such as Mt Wellington. The final phase represented is the Mt Wellington lava flow which appears to have flowed out from near the western base of Mt Wellington scoria cone, along with most of the Mt Wellington flows.

Thus it would appear that both Purchas Hill and Mt Wellington may have been active at about the same time, but may best be counted as two separate centres within the Auckland Volcanic Field.

**References:**


Allen, S. R., and Smith, I. E. M., 1994, Eruption styles and volcanic hazard in the Auckland volcanic field, New Zealand. *Geoscience Reports of Shizuoka University 20*: 5-14.

Fleming, C. A. 1959: Hochstetter's geology of New Zealand. Wellington, Government Printer. 320 p.

Heaphy, C. 1860: On the volcanic country of Auckland, New Zealand. (Fossils identified by T. Rupert Jones). *Quarterly Journal of the Geological Society of London 16*: 242-52.

Hochstetter, F. v. 1864: Geologie von Neu-Seeland. Beitrage zur Geologie der Provinzen Auckland und Nelson.\ *Novara-Expedition, Geologie Thiel 1 (1)*. 274 p.

Kermode, L. O. 1992: Geology of the Auckland urban area.1: 50 000., Institute of Geological and Nuclear Sciences geological map 2.

Kermode, L. O.; Smith, I. E. M.; Moore, C. L.; Stewart, R. B.; Ashcroft, J.; Nowell, S. B.; Hayward, B. W. 1992: Inventory of Quaternary volcanoes and volcanic features of Northland, South Auckland and Taranaki. *Geological Society of New Zealand Miscellaneous Publication 61*. 100 p.

Mason, A.P. 2002: The Hochstetter - Heaphy controversy or Whose map was it ?. *geological Society of New Zealand Historical Studies Group Newsletter 25*: 31-40.

**DOUBLE DELIGHT, *POLYDORA* IN *AUSTROVENUS STUTCHBURYI***

**Margaret S. Morley and Bruce W. Hayward**

During a heavy rainstorm in the eastern Bay of Plenty (18th May, 2005), a debris flow came down a small valley behind Matata and wiped out many of the houses. This debris flow brought down numerous large boulders of mudstone and ignimbrite. Matata resident and rock hound Neville Harris later noticed a boulder with a concentration of cockle shells in it. He had never seen any fossils coming out of this

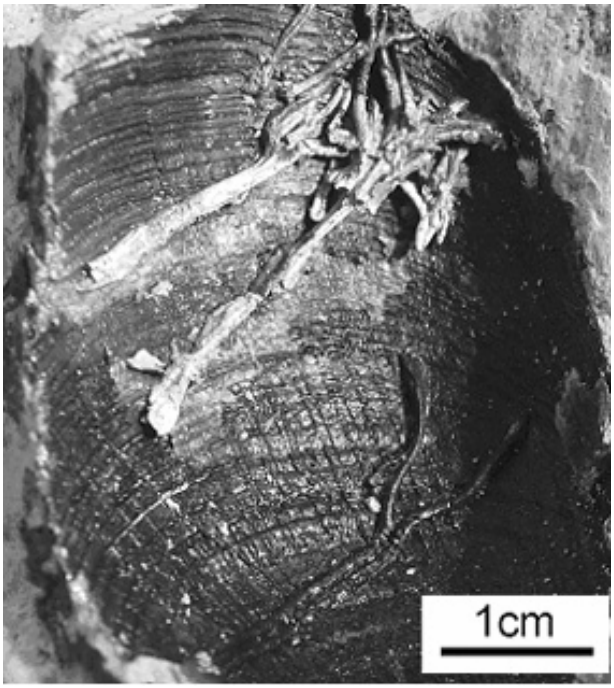



Fig. 1 The tubes of *Polydora polybranchia* on the internal cast of *Austrovenus stutchburyi.* Photo Hugh Grenfell

valley previously and so he was intrigued and collected some and sent them off to one of us (BWH) for identification and comment.

The specimens' shells had been dissolved away leaving behind both internal and external moulds of their shape. They have the distinctive sculpture of concentric and radial ridges identifying them as large cockles, *Austrovenus stutchburyi.*

Some white, calcareous tubes standing proud on the internal cast (Fig. 1) were intriguing. Because they were within the thickness of the shell when it was living it was caused by a boring organism. It is likely that the tube survived while the cockle shell dissolved away because the tube filled with sediment. The tube would have been situated near the siphons which provided nutritious water currents (Neville Hudson pers. comm.).

When compared to similar bore holes in cockle shells living today the position and arrangement of the tubes confirms them to be the spionid worm *Polydora polybranchia.* It bores into the outer layers of the cockle shell and constructs a hairpin bend

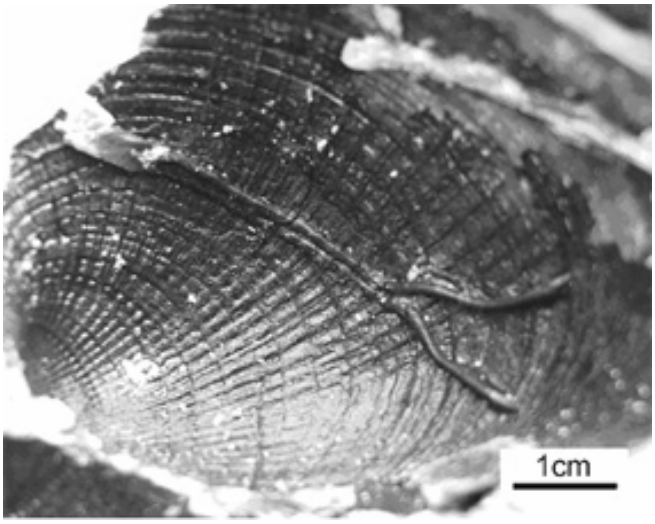



Fig. 2 The hair pin tube of *Polydora polybranchia* on the internal cast of *Austrovenus stutchburyi*. Photo Hugh Grenfell.

tube (Fig. 2) whose flexible tips stand clear of the surface to allow the feeding palps to be waved continuously and rhythmically through the water overhead (Morton and Miller, 1968, p 487, 488). This common animal also bores into sandstone, mudstone, limestone and stiff clay (Morton and Miller, 1968).

The mudstone in which the fossils were found is of middle Pleistocene age (Castlecliffian) and several km further west it contains a rich shellbed containing subtidal molluscs (Edbrooke, 1977). This new locality is unusual in its sheltered coastal lagoonal or harbour fauna.

**References**

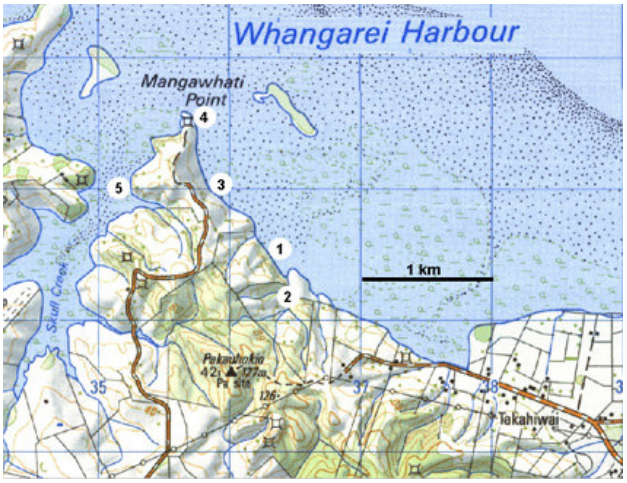
Edbrooke, S.W. 1977. Geology of the marine Castlecliffian strata in the Whakatane-Ohope Beach area, eastern Bay of Plenty. Unpublished MSc thesis, University of Auckland.

Morton J.E. and Miller, M.C. 1968. *The New Zealand Seashore*. Collins, 650 pp.

**TAKAHIWAI PENINSULA - RHODOLITHS AND OTHER THINGS**

Helen Holzer

In February 2005 GeoClub, led by Bruce Hayward, went on a field trip to One Tree Point and Takahiwai Peninsula on the south side of the Whangarei Harbour. This account is of the Takahiwai section of the trip.




Takahiwai Peninsula with stops made on the field trip.

Stop 1: The first stop was on the foreshore which was a platform of fossiliferous Ruatangata Sandstone, Runangan (Ar), Late Eocene, in age. Within this platform were found large fossil bivalves of the genus *Cucullaea* and the internal casts of many other bivalves, echinoids and crabs - *Tumidocarcinus giganteus*. Many of the latter were incomplete but a few whole ones were found.



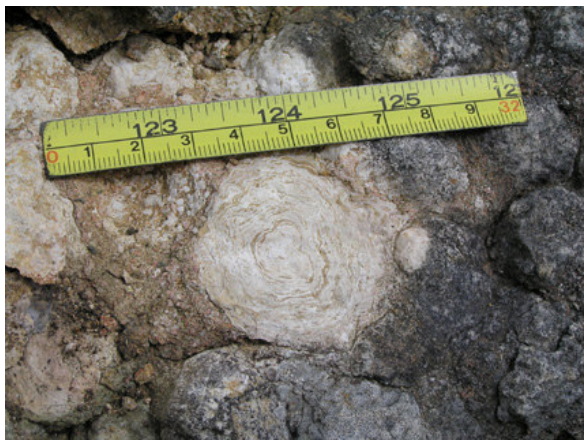
Legs and carapace of *Tumidocarcinus giganteus*

Stop 2: This stop was higher up beyond the shoreline where outcrops of rhodolithic limestone were exposed. This is a calcareous algal limestone in which concentric rhodoliths have grown on the sea floor and been deposited in the layers - quite a different process from concretions which grow within the rock. The rhodoliths were of variable size.

The limestone is flaggy, fracturing along the bedding. When the bedding layers have been exposed it is very knobbly and the rhodolithic growth patterns are clearly seen.



Rhodolith limestone




Knobbly exposed rhodoliths showing concentric growth patterns.



Fracturing along bedding.

This limestone is also Runangan in age and lies beneath the Ruatangata Sandstone in the stratigraphic column. It sits unconformably on the basement greywacke. Here at Takahiwai Peninsula the Eocene strata are tilted to the north, presumably during uplift in the early Miocene.

Stop 3: On the foreshore towards Mangawhati Point a large loose block of lozenged black chert is present. This is believed to be Waipawan (Dw), early Paleocene, in age. It is identical to the dark chert horizons that occur within the Waipawan black shale sequence which many of us saw in Black's Quarry (near Taipa) on an earlier club trip to Northland.



Lozenged black chert

This black chert unit occurs within the Northland Allochthon, which lies stratigraphically above the Whangarei limestone in Northland. Here it is above the Runangan and appears to be below the Whangarei Limestone. Thus faulting has occurred to bring it down to this level.



*Scolicia* burrows through the calcareous sandstone

Stop 4: Further north along the foreshore and above the Ruatangata Sandstone is a calcareous sandstone unit with numerous prominent *Scolicia* burrows through it.

This sandstone conformably underlies cream, crystalline Whangarei Limestone which forms Mangawhati Point. The Whangarei Limestone is Whaingaroan/Duntroonian (Lwh-Ld), Oligocene, in age. It is thinly bedded and dipping gently to the north. There is no sign of the overlying allochthonous units above it.



Mangawhati Point with the Whangarei Limestone sitting conformably on the calcareous sandstone.

From here some of the group followed the limestone around the point and up Skull Creek on the other side of the peninsula.

Stop 5: The last stop was reached by only two people. Here the foreshore was Ruatangata Sandstone as seen on the other side of the peninsula, except it could be seen to clearly dipping beneath the younger Whangarei Limestone along this piece of coast.



Skull Creek with Bruce holding up the in situ Whangarei Limestone

Summary:
Takahiwai Peninsula stratigraphically has four units (all belonging to the Te Kuiti Group): rhodolithic, calcareous algal limestone overlain by Ruatangata Sandstone, overlain by calcareous sandstone with *Scolicia* burrows, then Whangarei limestone. These units are Runangan to Duntroonian (Late Eocene-Oligocene) in age. The greywacke basement beneath has only a small outcrop on the marine terrace on the surface (although it outcrops in the hills to the south). The allochthonous units are seen only in the lozenged black chert that has sheared into the Whangarei Limestone and now lies loose on the Ruatangata Sandstone. The area has been uplifted and tilted to the north, probably after the emplacement of the Northland Allochthon.

Millions of years of exposure has allowed erosion to remove all the overlying rocks with the most eroding off from the higher south end. Other allochthonous units, present in other parts of Northland have all but been removed from above Takahiwai Peninsula.

Acknowledgements:
Thanks to Bruce Hayward and Hugh Grenfell for assistance with this article.



**ONE TREE POINT, WHANGAREI HARBOUR**
Rhiannon Daymond-King

One Tree Point is located within the Whangarei Harbour, northwest of Marsden Point, northern New Zealand (Figure 1). As such the area is sheltered by Marsden Point and by Bream Head from strong waves and currents. One Tree Point is formed of unconsolidated Quaternary sediment (Nichol, 2002). Wave dynamics can be important in the formation of such deposits (Fraser et al., 2005). One Tree Point deposits do not appear to match the morphologies of tide-dominated sand bodies discussed by Nio and Yang (1991b).




*Figure 1: Map of One Tree Point and surrounding area*

I focused on the first part of the section, from 0 to 25m. The outcrop is a long cliff face of unconsolidated yellow-brown quartz sand weathered to white on the surface. Trace fossils and cross-bedding are clearly visible in the cliffs and shore platform. The section, visited by GeoClub in 2005 and studied by the Auckland University Geology 721 class in April 2005, has been the cause of some controversy, especially following the International Ichnological Workshop held in Auckland at the beginning of that year. During a day's field-trip to One Tree Point after the lecture part of the Workshop, experts in the ichnofossil field gave two main interpretative opinions on the stratigraphy and fossils: that they either represented a sub-aqueous dune/megaripple environment, or an aeolian or sub-aerial dune environment.

The main work on the Bream Bay and One Tree Point area was done by Scott Nichol in 2002; a morphological, sedimentological and stratigraphical study of the relict beach ridges that he suggests formed on a prograded coastal barrier (Nichol, 2002). Bioturbation and trace fossils have been largely ignored in aeolianites (Ahlbrandt et al., 1978; Hasiotis, 2002) or improperly cited as evidence against an aeolian origin. An attempt is made here (following the work by the Geology 721 class) to form an educated opinion on which model is more accurate for this setting, based on the lithostratigraphy, palaeoecology and ichnology of the cliff outcrop.

Lithologic and Ichnologic Descriptions:
The light coloured sands of all units are proposed to be of the same origin; they have a high proportion of sub-rounded quartz crystals, sub-angular to sub-rounded lithic fragments, and sub-angular dark heavy mineral crystals. The exact proportion of quartz to lithics to dark fragments does vary a small amount between facies.

There is a thick iron sand layer at the very base of the section, mostly visible towards the carpark. Moulds of *Pecten novaezelandiae* (see figure 2F) have been found in this layer along with borings attributed to modern trace makers on the shore platform.

Above the iron sand, the main part of this facies contains beds of orange-grey laminated fine to medium sands, exposed on the modern day shore platform, containing trace fossils (see figure 2E). The bottom of the cliff 20m along has a 65cm set of beds including rare *P. novaezelandiae* fossils (and common casts of the same in some places), and heavy bioturbation in two sizes: ichnologists on the Workshop discussed whether or not they should be split into two different species, but a consensus was not reached (Figure 2D shows large size). The lower beds of this section have clear trough cross-bedding, possible herringbone cross-bedding and lag deposits including pebbles and green-grey cemented mudstone clasts. The upper part is more massive fine sand, with a higher proportion of quartz, with some faint cross-bedding visible. It is split by an intensely bioturbated or cryptobioturbated bed of heavy mineral sand (see Figure 2B). The next facies, above the previous, has thinner bedded sands with tabular to laminar bedding including several sets of dark heavy mineral-rich layers which show a lot of bioturbation (see Figure 2A and C) including many vertical traces and some escape traces which show clear upwards movement through the layers (the dark layers are displaced upwards; Fig. 2C). One of the dark mineral layers is an arcuate dune form described as prograding in a direction out of the cliff wall. Upper layers include a sparsely bioturbated layer with what looks like an eagle ray feeding trace or the resting trace of a large fish. These dark layers splay upwards and vanish going north-west along the section (left in the pictures).

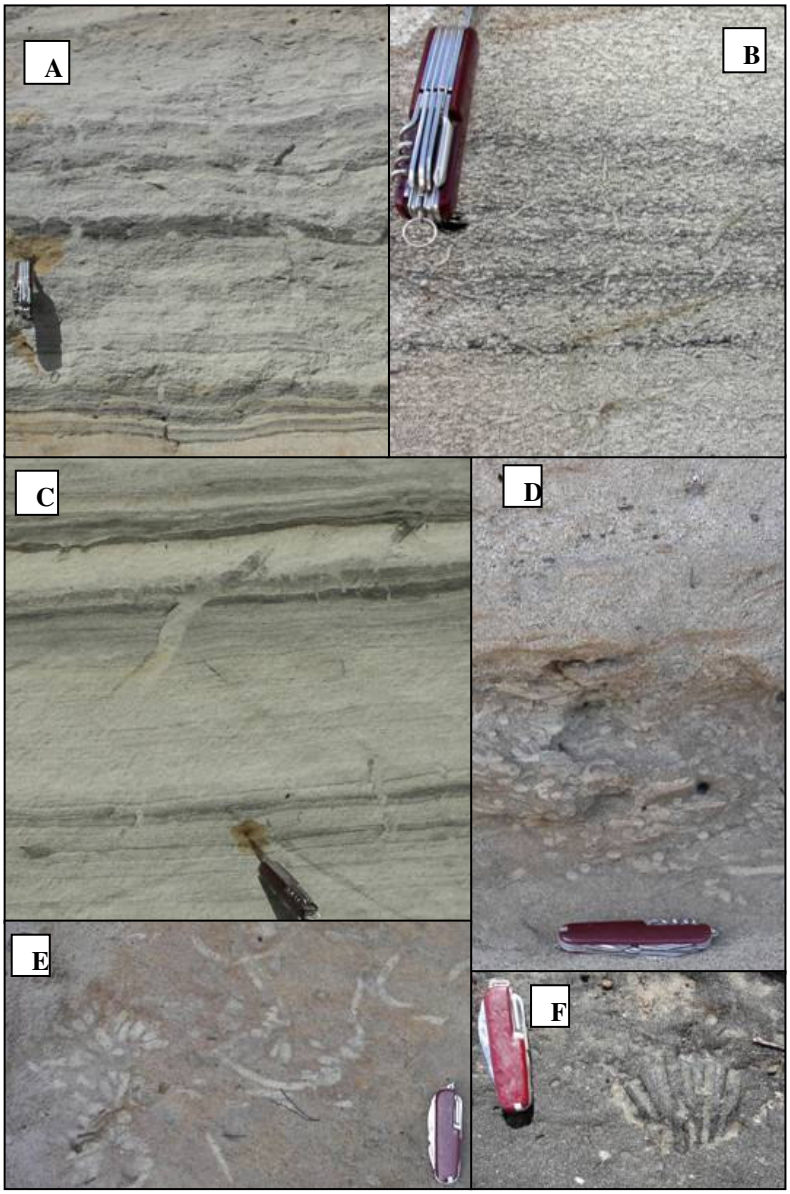



*Figure 2A: Facies 2 iron sand layers, bioturbation 2B: Intense bioturbation in one iron sand layer in lower Facies 1 – cryptobioturbation. 2C: escape traces and bioturbation in Facies 2: note upwards displacement of iron sand layer in large trace. 2D: traces in lower Facies 1. 2E: traces seen on the foreshore in Facies 1. 2F: Pecten novaezelandiae in base iron sand.*

The topmost sand facies is a more massive sandstone with sets of large scale cross-bedding, which in some areas is difficult to see because of the heavy mineral-poor uniformity of the medium-grained sand. Above this is a soil layer of brown iron staining and root structures, containing large burrows

(probably recent kingfisher nests, but heralded by the 721 class as a set of burrows made by mini subterranean bovines!)

Hypotheses:
There are three possible overall models of deposition of these cliffs: transgression, regression (Nichol's model) or a mixture of the two. In a transgressive environment of continuous sea level rise the first, lowest facies should be a shoreface/platform deposit or lower progradational unit (Fraser et al., 2005), the second facies would be deepening and the iron sand layers would be deposited by storm surges, and the higher facies would be sub-aqueous dunes. In a regressive model of continuous sea level fall, or Nichol's "record of progradational deposition, incorporating nearshore, beach and dune facies" (Nichol, 2002, page 156).

Discussion:
Trough crossbedding, as found in the lower part of Facies 1, is often a feature of nearshore environments (Nichol, 2002). Sigmoidal bedding and herringbone crossbedding are both important criteria with respect to discerning whether or not a particular sequence is associated with a tidal deposit (Nio and Yang, 1991a). Sigmoidal bedding has been used as a tool for recognising clastic deposits in the field, but the sigmoidal shape is a result of the weathering of the finer grained parts of the original bedding (Nio and Yang, 1991a) so it may not be as useful an indicator as previously thought. Convolute laminations, wave ripples, coarse-grained lags and scours are put forward as evidence of sub-aerial environments (Donselaar and Nio, 1982) but these do not seem to be in evidence in any of the facies seen at One Tree Point. Common features of aeolian sand seas, or ergs, are large sets of cross strata with prominent bounding surfaces (Kocurek, 1991) as seen in the section, although the bounding surfaces are not as prominent as would be liked. The direction of dune progradation can give some ideas of wind palaeodirection – but dunes can also modify the wind flow (Kocurek, 1991).

If the transgression model is to be believed, the large cross-bedding seen would be megaripples or sand bar deposits. However the formation of such megaripples may require a confined channel (Yang and Nio, 1989), which we do not find evidence of in this facies (although the small duneform may represent a small channel) Large moving sandbars in low tidal flats may have a similar deposit sequence (de Vries Klein, 1970, especially Table 1) – however one would expect a higher rate of bioturbation and traces, even in sand. The main problem with the sub-aqueous dune/megaripple hypothesis is that they are likely to be deposited 10-20m below sea level (see figure 4 in Yang and Nio, 1989, deposited at 15m below m.s.l.) and there has been no record of tectonic activity within the One Tree Point area which would subsequently raise the land up 20 or so metres to its present position. Nor has there been a lasting sea-level change this large within the relevant time period.

Conclusions:
The model of regression (Nichol, 2002) is the most applicable model to the One Tree Point section. Facies 1 represents a shoreface/shore platform deposit. Facies 2, the ironsand facies, represents beach deposits prograding outwards, with storm deposits of dark, heavy mineral rich sand. Facies 3, with the large crossbedding sets, represents aeolian or sub-aerial dune formation, driven by predominant westerly winds. Further work being done on the section includes a more complete cataloguing of the trace fossils and in-depth interpretation based on the sedimentology and traces found (Murray Gregory and Kathy Campbell pers comm.)

Acknowledgements:
Thanks to Murray Gregory and Kathy Campbell for discussions about the One Tree Point section.

References:


Ahlbrandt, T.S., Andrews, S., and Gwynne, D.T., 1978, Bioturbation in Aeolian Deposits: Journal of Sedimentary Petrology, v. 48, p. 839-848.

de Vries Klein, G., 1970, Depositional and dispersal dynamics of intertidal sand bars: Journal of Sedimentary Petrology, v. 40, p. 1095-1127.

Donselaar, M.E., and Nio, S.-D., 1982, An Eocene tidal inlet/washover type barrier island complex in the south Pyrenean marginal basin, Spain: Geologie en Mjinbouw, v. 61, p. 343-353.



Ahlbrandt, T.S., Andrews, S., and Gwynne, D.T., 1978, Bioturbation in Aeolian Deposits: Journal of Sedimentary Petrology, v. 48, p. 839-848.

de Vries Klein, G., 1970, Depositional and dispersal dynamics of intertidal sand bars: Journal of Sedimentary Petrology, v. 40, p. 1095-1127.

Donselaar, M.E., and Nio, S.-D., 1982, An Eocene tidal inlet/washover type barrier island complex in the south Pyrenean marginal basin, Spain: Geologie en Mjinbouw, v. 61, p. 343-353.



Fraser, C., Hill, P.R., and Allard, M., 2005, Morphology and facies architecture of a falling sea level strandplain, Umiujaq, Hudson Bay, Canada: Sedimentology, v. 52, p. 141-160.

Gregory, M.R., Martin, A.J., and Campbell, K.A., 2004, Compound trace fossils formed by plant and animal interactions: Quaternary of northern New Zealand and Sapelo Island, Georgia (USA): Fossils and Strata, v. 51, p. 88-105.

Hasiotis, S.T., 2002, Part I: continental ichnology: terrestrial and freshwater trace fossils for environmental interpretations, Continental Trace Fossils, SEPM Short Course Notes, Volume 51, p. 1-53.

Kocurek, G., 1991, Interpretation of ancient aeolian sand dunes: Annual Reviews, Earth Planet, Science, v. 19, p. 43-75.

Nichol, S.L., 2002, Morphology, Stratigraphy and Origin of Last Interglacial Beach Ridges at Bream Bay, New Zealand: Journal of Coastal Research, v. 18, p. 149-159.

Nio, S.-D., van den Berg, J.H., Goesten, M., and Smulders, F., 1980, Dynamics and sequential analysis of a mesotidal shoal and intershoal channel complex in the Eastern Scheldt (Southwestern Netherlands): Sedimentary Geology, v. 26, p. 263-279.

Nio, S.-D., and Yang, C.-S., 1991a, Diagnostic attributes of clastic tidal deposits: a review, *in* Smith, D.G., E., R.G., Zaitlin, B.A., and Rahmani, R.A., eds., Clastic Tidal Sedimentology, Volume Memoir 16: Canada, Canadian Society of Petroleum Geologists, p. 3-28.

—, 1991b, Sea-level fluctuations and the geometric variability of tide-dominated sandbodies: Sedimentary Geology, v. 70, p. 161-193.

Yang, C.-S., and Nio, S.-D., 1989, An ebb-tide delta depositional model - a comparison between the modern Eastern Scheldt tidal basin (southwest Netherlands) and the Lower Eocene Roda Sandstone in the southern Pyrenees (Spain): Sedimentary Geology, v. 64, p. 175-196.

**"HAROLD WELLMAN – A MAN WHO MOVED NEW ZEALAND "**
**Simon Nathan, Victoria University Press, 2005.**

Book reviewed by Malcolm Simpson

It would be fair to say that any New Zealander who has an interest in geology would at least know of Wellman and his link with the Alpine Fault. Simon Nathan, as Wellman's biographer, has traced the 90 years of Wellman's life in a book of 272 pages, many black and white photographs, maps and diagrams, several colour plates and a bibliography of the 112 published papers in his own name and a not inconsiderable number written in partnership with others.

The first part of the book consists of a memoir , written by Wellman, and follows his childhood in England, move to NZ when he was 18, his induction into surveying, and his travels and travails as a goldminer on the West Coast and NW Nelson during the Depression.The surveying and gold exploration were valuable pre- cursors to the future geologist. In the remainder of the book Nathan follows the professional career of Wellman as an apprentice geophysicist with the Geological Survey , his MSc degree, work with the Survey as a geologist, oil company geologist and his time as a Lecturer in the Geology department at Victoria University.

Wellman emerges as a complex character. He was what my father's generation described as "a bit of a character", which with typical Kiwi understatement, meant he was distinctly queer (read "odd" not "gay"). To his colleagues Wellman appeared dedicated, bright, intolerant and argumentative, at times aggressive and with the lubrication of alcohol somewhat exuberant. Some of the anecdotes of his escapades verge on the outrageous! The author portrays Wellman with warts and all , but at the same time shows his admiration of the abilities and passion of the man.

One thing that is obvious is the almost complete lack of women in his professional career – Geology was an all-male preserve. The exception was his wife, Joan, who buttressed his family life and who appears to have been an able aid and adversary to his masculine ambitions. Anecdotes of their competitiveness in vegetable gardening and home-brewing are hilarious.

Nathan carries through the arguments on plate tectonics and the understanding of the Alpine Fault, showing how it was developed, and the work of Wellman over the years. I found this part of the book provided a coherent exposition of the evolution of Wellman's theories and of the eventual acceptance of plate tectonics, placing these into a NZ perspective.

In conclusion I would recommend those whose interest lies in the development of geology in NZ to read this book and contemplate on those attributes which made Harold Wellman the man that he was and the contribution he made to our country's geology. A thanks must also go to Simon Nathan for the terrific amount of research in producing this book.

GEOQUIZZES
Rhiannon Daymond-King

Wordfind 1:

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

This Wordfind contains these 61 words. They can be found in any direction - left, right, up, down, or diagonal - but the words are always in a straight line.

abyssal
acid
aeolian
agate
alluvial
alum
anoxic
arid
augite
boulder
coal
conglomerate
diapir
dike
dried
dust
earthy
eocene
facet
gas
glacial
gneiss
guyot
igneous
indurate
jet
kerogen
lahars
land
lazurite
lee
levee
lode
loess
moraine
mountain
mud
nacre
ocean
older
opals
ophiolite
orogen
radar
reservoir
ridge
seas
slide
slip
stasis
stress
talc
talus
tar
taxa
varved
vein
viscous
vug
water
young

Wordfind 2:

| S | O | L | U | T | I | O | N | N | A | F | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| E | T | E | E | C | A | F | O | O | N | Y | X |
| T | E | R | R | A | C | E | L | C | R | C | D |
| A | P | R | O | P | A | N | O | O | G | A | L |
| R | H | A | C | M | M | R | C | R | O | L | A |
| D | R | T | K | I | A | L | I | R | L | D | R |
| Y | A | I | S | L | A | T | E | R | D | E | E |
| H | D | C | B | S | R | I | O | U | E | R | N |
| A | I | I | T | U | R | T | N | L | M | A | I |
| G | T | I | B | R | F | E | L | S | I | C | M |
| E | C | Y | A | I | C | E | B | U | T | T | E |
| N | O | B | R | A | C | O | I | D | A | R | E |

This Wordfind contains these 35 words. They can be found in any direction - left, right, up, down, or diagonal - but the words are always in a straight line.

| | | | |
|---|---|---|---|
| aeon | face | later | stromatolite |
| age | fan | maar | solution |
| adit | felsic | mineral | tephra |
| albite | flood | onyx | terrace |
| barrier | gold | pyroclastic | time |
| butte | grit | radiocarbon | |
| caldera | hydrates | rift | |
| coral | ice | road | |
| dune | impact | rocks | |
| erratic | lagoon | ruby | |

For the Sudoku players - RHYOLITES and HYDRATING

Sudoku 1

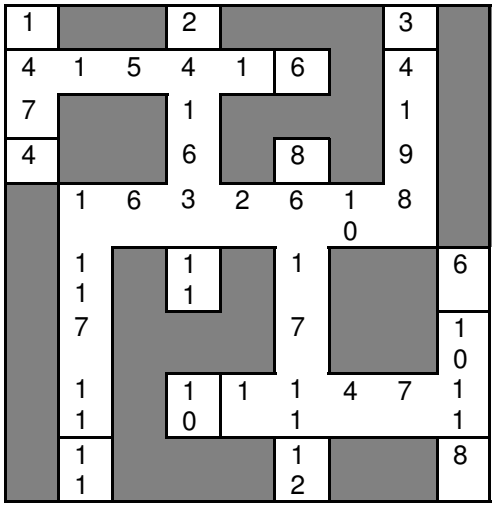
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | H | Y | | | I | | E | |
| E | | | R | | | | L | |
| T | | O | | S | | I | R | |
| L | | S | T | | O | | Y | I |
| | | | | | | | | |
| I | Y | | L | | H | O | | R |
| | R | | | O | | S | | T |
| | I | | | | Y | | | L |
| | T | | S | | | E | H | |

Sudoku 2

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | D | R | A | | | | G |
| | I | | | D | | | | H |
| | | R | | H | | T | | |
| D | | | G | | | | I | |
| Y | N | | | | | | G | T |
| | T | | | | D | | | R |
| | | T | | G | | H | | |
| G | | | | Y | | | T | |
| N | | | | R | I | | | |

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 puzzle.

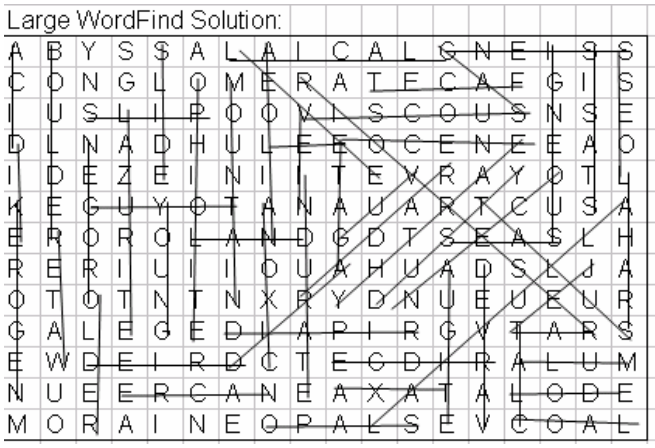
Take 5



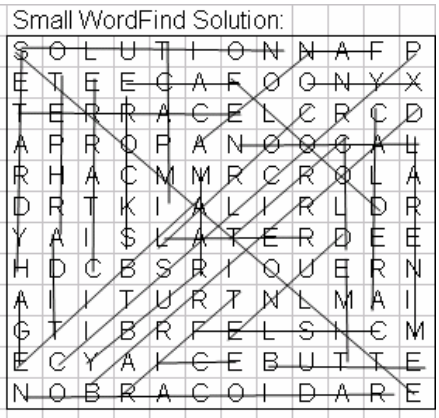
Each number corresponds with a letter. To work out the crossword, replace the 12 numbers with letters. Clue: 7=V, 8=S

SOLUTIONS:

Large WordFind Solution:



Small WordFind Solution:



Sudoku Solutions:

| | | |
|---|---|---|
| R H Y | O L I | T E S |
| E S I | R H T | Y L O |
| T L O | Y S E | I R H |
| L E S | T R O | H Y I |
| H O R | I Y S | L T E |
| I Y T | L E H | O S R |
| Y R E | H O L | S I T |
| S I H | E T Y | R O L |
| O T L | S I R | E H Y |

| | | |
|---|---|---|
| H Y D | R A T | I N G |
| T I N | Y D G | A R H |
| A G R | I H N | T D Y |
| D R H | G T Y | N I A |
| Y N A | H I R | D G T |
| I T G | A N D | Y H R |
| R D T | N G A | H Y I |
| G A I | D Y H | R T N |
| N H Y | T R I | G A D |

Take 5 Solution:

