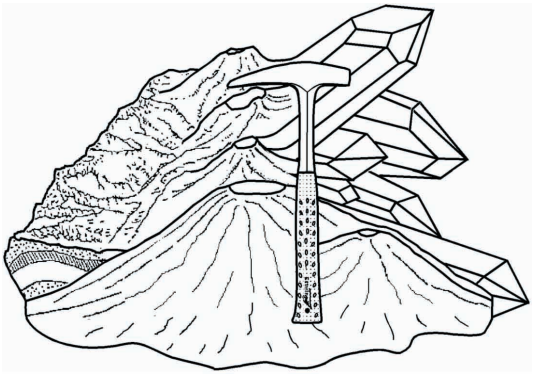


Geocene

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

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

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BRYOZOANS ON KAURI GUM AND AMBER

Seabourne Rust

Kauri “Gum”, copal (subfossil) or amber (fossil) is the solidified sap or resin, produced by the Kauri tree *Agathis australis* or its ancestors (Araucariaceae) that have lived in northern New Zealand since the Cretaceous. It is a light glassy aromatic material that is buoyant in water. It was once very abundant in Holocene–Pleistocene Interglacial terrestrial deposits in northern New Zealand, and was mined by diggers during the peak period from 1860–1960 (e.g. Hayward 1989, Matich *et al*. 2011, Reed 1972). Kauri gum can still erode out naturally from local strata or be reworked from material associated with the once-extensive industry. As a result, occasional pieces enter the marine environment and wash up on the beaches of Northland, New Zealand. These are usually sub-rounded, and vary widely in size, typically 1–30 cm across.

Of the Kauri gum pieces from Northland coast we have examined, a few specimens (<5%) are encrusted by marine organisms. This Recent epifauna consists predominantly of small colonies of cheilostome bryozoans. Other attached organisms include rare serpulid worm tubes.

Of the encrusting Cheilostomata, some are members of the Membraniporidae. These very widespread cosmopolitan bryozoan taxa (e.g. *Membranipora* spp.) with cyphonautes (pelagic) larvae were also found to be the most common bryozoans fouling pumice (Rust 2015) and drifting plastic in the northern New Zealand area (Stevens *et al*. 1996).

However, in contrast to the above (which have been found on objects such as long-distance oceanic drifting material), on the Kauri gum samples other cheilostome bryozoans are also present, such as *Exochella tricuspis* (Fig. 1), *Manzonella lepida*, *Micropora mortenseni*, *Smittina torques*, *Crassimargniatella* (*corbullea*) sp. (Fig. 2) and *Chaperiopsis* spp. (Fig. 3). As to be expected, these taxa are all found in northern New Zealand/Kermadec waters (Gordon 1984, 1986, 1989). This is consistent with the encrusted gum having local (Northland, New Zealand) provenance and subsequent limited dispersal, perhaps in some cases remaining entrained in local harbours and embayments (Kaipara, Hokianga for example).

Epifaunal organisms observed encrusting Kauri gum, such as bryozoan colonies, are mostly small patches (<20 mm across), found in concave or cryptic areas, which may reflect larval settlement/habitat preference and/or preservational bias. Bryozoan colonies of this size may have grown over several months to years (based on rates of several mm per year, see Smith 2014), indicating minimum periods of immersion in seawater. On our specimens, having been washed ashore, probably reworked, and finally left high and dry by the surf and tides, none of these recent epifaunas were still living.

Finally, fossilised bryozoans have been occasionally recorded encrusting ancient kauri amber in older deposits and on other resins elsewhere in the world, for example the Cretaceous of Spain (Navarro *et al*. 2010). One must be cautious as to how close the age(s) of the encrusting epifaunas are to that of the original amber!



Fig. 1. *Exochella* sp. encrusting a translucent piece of gum from Hokianga.

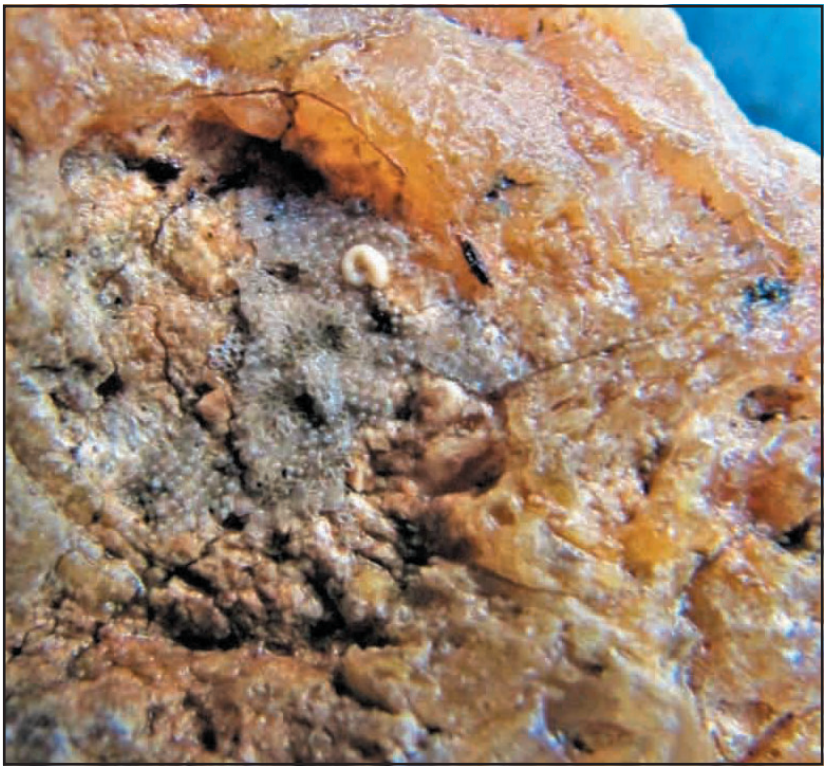


Fig. 2. Colonies of bryozoans *Crassimarginatella* and *Manzonella* sp. and a small serpulid wormtube encrust the gum in the centre of this image.



Fig. 3. A small *Chaperiopsis* sp. colony encrusting the worn piece of gum in the foreground.

My thanks to Diane Yanakopulos, Daphne Lee and Bruce Hayward for assisting with this initial study.

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THE NAMING, ORIGIN AND SIGNIFICANCE OF WELLINGTON'S "K-SURFACE"

Bruce W. Hayward

In May 2017, Auckland Geology Club had a field trip to Wellington. On one day we were fortunate to have local geology guru Hamish Campbell as our guest leader. One of our first stops was a walk to the top of 358 m-high Wright Hill. Here Hamish pointed out all the major geological and landform features. One prominent feature seen in many directions west of the Wellington Fault was Wellington's K surface (Fig. 1). Hamish explained that it was named "K-surface" after the Cretaceous (K) when it was mostly eroded and the peneplain that we see today at various elevations west and northwest of Wellington was mostly formed.

That it was named after the Cretaceous was news to me as I am sure I had previously heard that it was named after Mt Kaukau, a prominent 445 m-high hill that overlooks the Wellington suburbs of Ngaio and Johnsonville. Later Hamish and I discussed the origins of the name and both agreed that we were not certain of our explanations and that maybe a little more historic research was needed. I was also keen to better understand the age of this planar surface that is recognised and mapped on the ridge crests of Wellington (Ota *et al*., 1981; Begg and Mazengarb, 1996) and undoubtedly provides clues to the more recent tectonic history and faulting in the region.

Turns out we were both misinformed. Cotton (1912) recognised this flat surface on ridge crests west of Wellington. He believed it was eroded during a pause in tectonic uplift and named it the Kaukau Cycle and nominated Mt Kaukau as the reference surface (Cotton, 1912). In 1957 Cotton (Fig. 2) introduced the term "K-surface" with the K standing for "key-surface" for understanding the deformation of the region. Cotton (1957, p. 775) wrote: "It might be so-called because of its "key" character, …, but the initial K also recalls, for this purpose replaces, the rather uneuphonious name "Kaukau", which has been applied to the surface by Gage (1940) and has since been used by active investigators (e.g. Stevens, 1957) as well as orally by casual observers who have latterly recognised its key significance for the elucidation of primitive tectonic form."



Fig. 2. Sir Charles Cotton

Hamish is probably correct that considerable erosion of the uplifted greywackes of Wellington occurred in the Cretaceous. Their prehnite-pumpellyite metamorphic grade (Mortimer *et al*., 1993) and thermochronology (Kamp, 2000) indicate that they had been buried to a depth of 10–12 km in the Jurassic and that now they have been uplifted and this huge thickness eroded off. Unfortunately in the Wellington region there are few clues as to the erosional history of the K-surface. It was probably eroded nearly flat by coastal marine erosion at or just below sea level, but when did this happen? We know that in the late Oligocene most of Zealandia



Fig. 1. Dissected remnants of the K-surface looking southeastwards from south of Porirua across to the head of Wellington Harbour. Photographer Lloyd Homer, GNS Science.

had been eroded down to a nearly flat surface and most of it was submerged beneath the sea. Slowly accumulating shell banks (limestone) and greensand were deposited on top of this "Great New Zealand Unconformity" (Ballance, 2017) during the Oligocene. This presumably also occurred in the Wellington region with the nearest remnant of these sediments sitting unconformably on greywacke 40 km to the north at Otaihanga (Grant-Taylor and Williams, 1977). Presumably these Oligocene sediments completely covered the region and have subsequently been removed, most likely during the Miocene.

Fission track ages in the Wellington greywackes now at the surface were reset ~ 8.5 Myr ago at 110ºC when still buried by 4 km of rock (Kamp, 2000). Thus 4 km of uplift and erosion has occurred since then. At Makara, 10 km north of Wellington, a down-faulted inlier of early-middle Pliocene (4–5 Myr), shallow-marine sediments unconformably overlie a greywacke surface (Grant-Taylor and Hornibrook, 1964) and was also visited during Geoclub's Wellington field excursion in 2017. This suggests that some or maybe all of the region was once again under the sea and maybe another regional unconformity had been eroded – certainly most of the Oligocene sedimentary rocks had been removed and probably much of the 4 km of greywacke that has been removed since 8.5 Myr ago. Begg and Mazengarb (1996) infer that yet another period of coastal marine erosion swept across the region after deposition of the Pliocene Makara beds and that this inlier was preserved because it had already been down-faulted into a narrow graben. They infer the age of erosion of the "K-surface" we see today as being between 4 and 0.4 Myr. It cannot be younger than the age of the oldest sediments that overlie the surface in the downfaulted basins around Wellington (Begg and Mazengarb, 1996).

The most significant conclusion from the "K-surface" around Wellington is how young the deformation that created the present topography has been. Essentially it implies that the mountain range of western Wellington extending north to the Ruahines has largely been uplifted from a coastal planar surface within the last million years.

I thank Hamish Campbell and John Begg for their helpful comments on this note.

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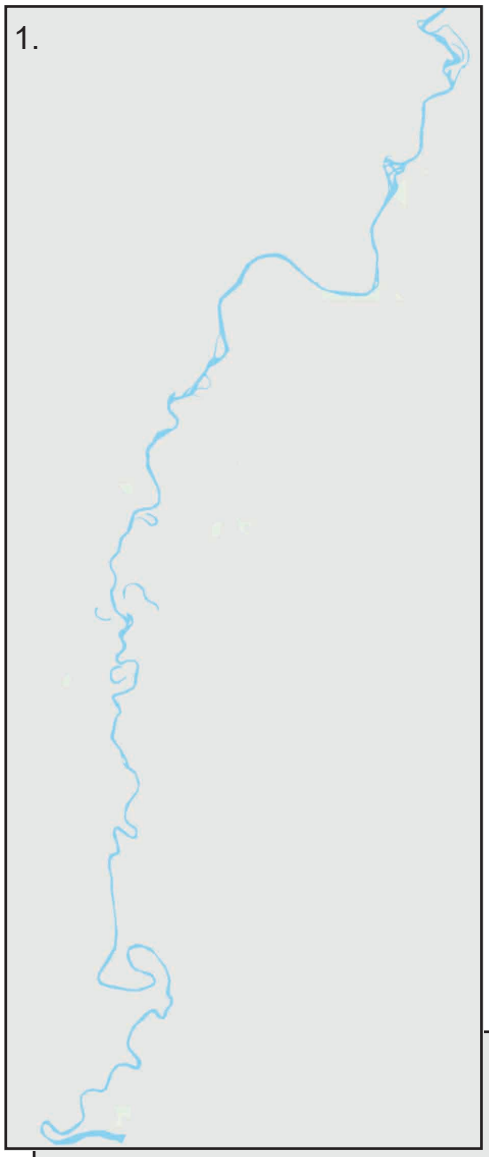
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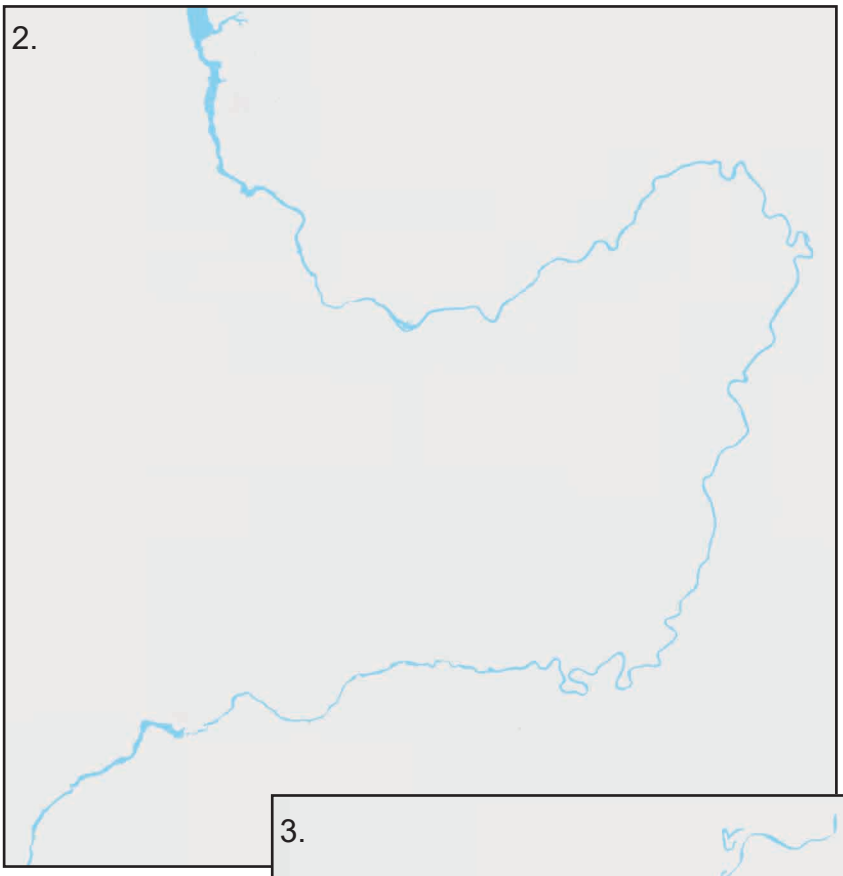
QUIZ Know your meanders. Match maps 1 – 6 with river names A – F.
(apologies for the lack of colour contrast)

(Answers on last page)

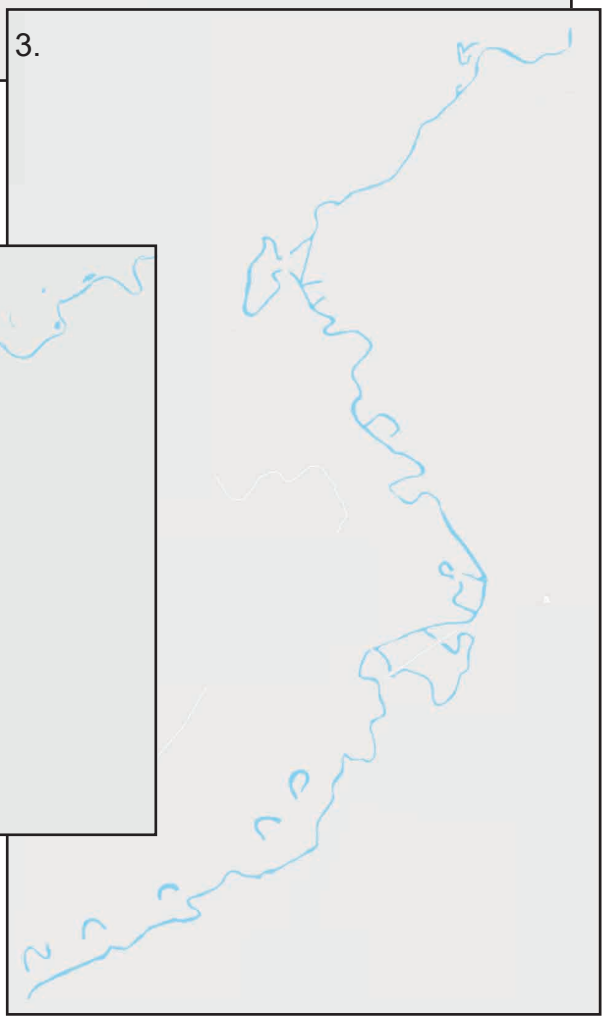
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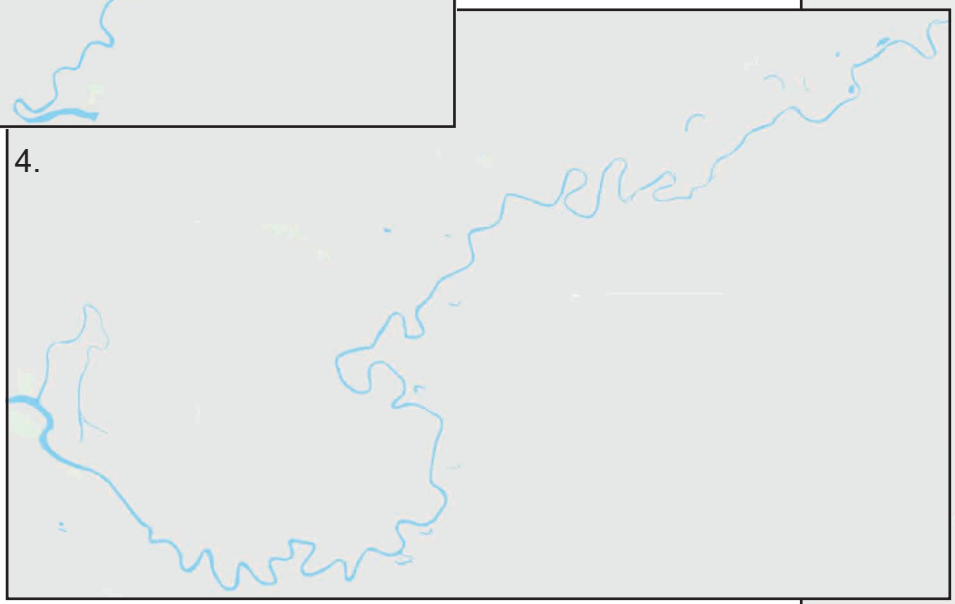
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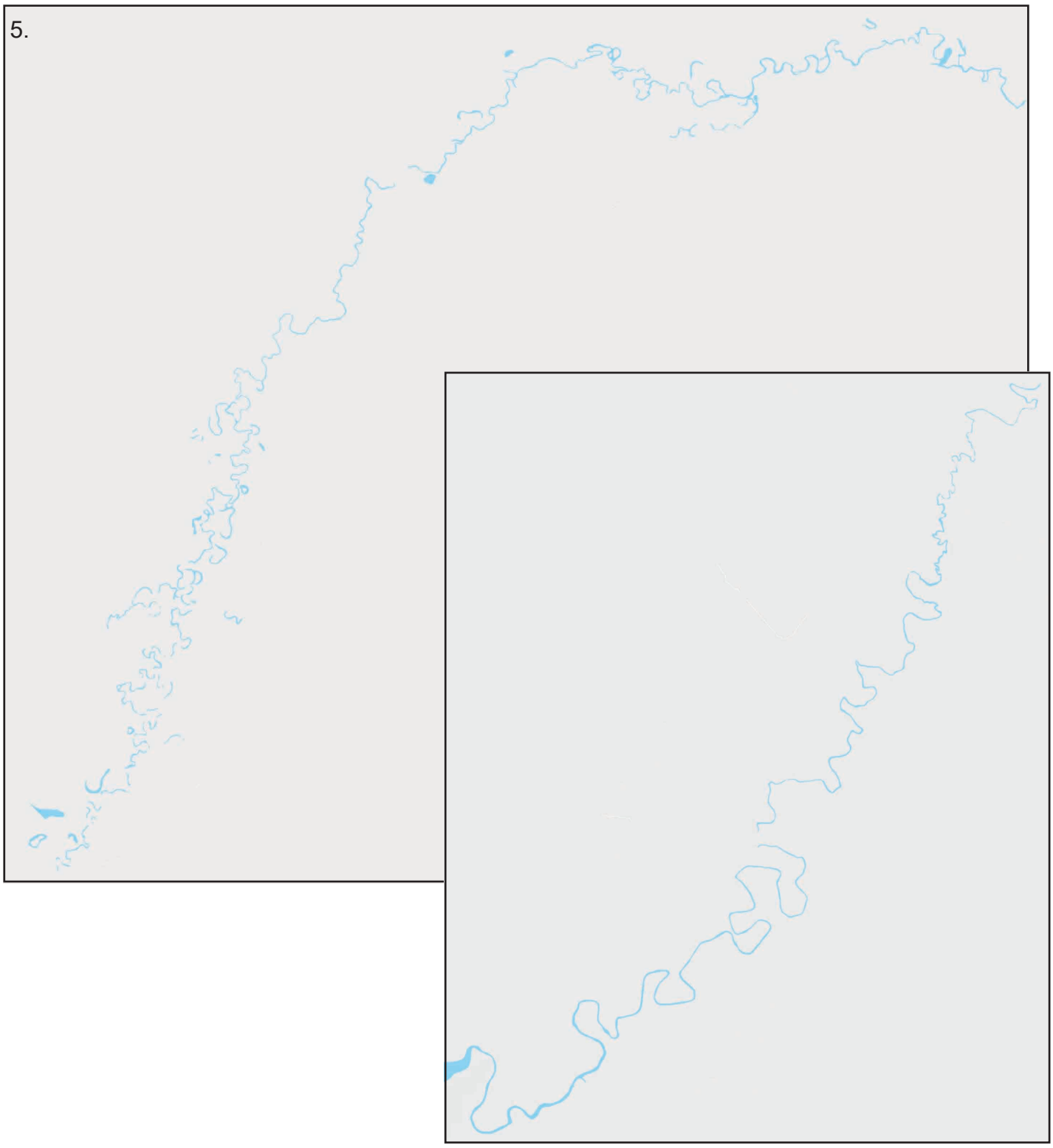


4.



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5.



Possibilities to choose from:-

A upper Wairua River, Hikurangi Swamp, Northland
B Hoteo River, Kaipara District
C Waikato River from Huka Falls to Lake Ohakuri
D Manawatu River from Palmerston North to Foxton
E upper Taieri River, Otago
F lower Mataura River south of Wyndham, Southland

(Answers on last page)

NOTORYNCHUS PRIMIGENIUS (Agassiz, 1843), AN EXTINCT SEVEN-GILLED SHARK, FROM THE EARLY MIOCENE OF PAKURANGI POINT, KAIPARA HARBOUR, NORTHLAND

Jack Grant-Mackie

Abstract

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

Introduction

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

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

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

The tooth was collected by Tricia O'Callaghan during a Geology class excursion in August 1998. The site (Fig. 1) is of early Altonian age (mid Burdigalian; Early Miocene; ~ 18.2 Ma (Jones, 1969, Hayward and Triggs, 2016)), and catalogued as Q08/f0585 (grid reference Q08/750650 NZMG) in FRED, the national register of fossil localities jointly run by the Geoscience Society of New Zealand and GNS Science Ltd, Lower Hutt.

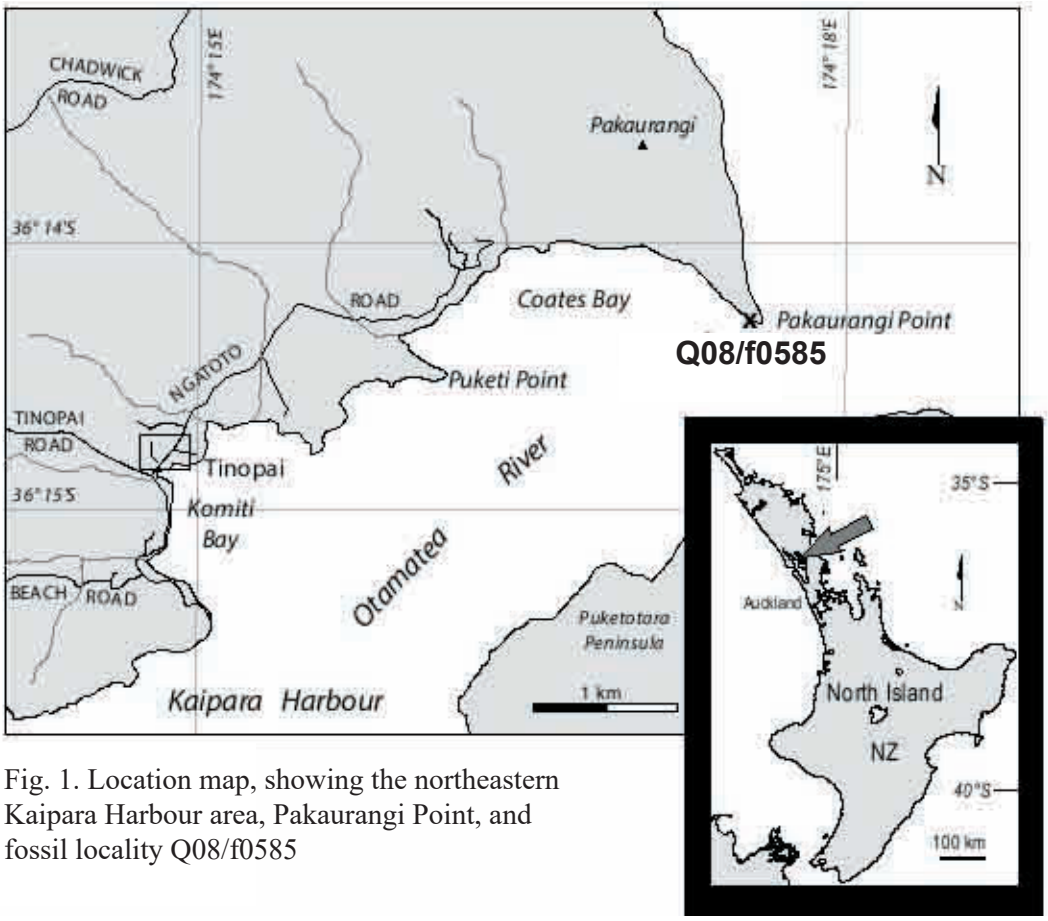


Fig. 1. Location map, showing the northeastern Kaipara Harbour area, Pakaurangi Point, and fossil locality Q08/f0585

This find follows on from an earlier one reported in this journal (Grenfell, 2007), in which the same species was collected from Parnell Grit (Waitemata Group) at Kaitarakihi, near the northern head of the Manukau Harbour, a unit of comparable age to the Pakaurangi *Miogypsina* Sandstone. That report also refers to comments indicating that other teeth of this species are known from other New Zealand localities, also of Miocene age, so the species was widespread around New Zealand seas during this time.

Systematics

Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Order Hexanchiformes Buen, 1926
Suborder Hexanchoidei Garman, 1913
Family Hexanchidae Gray, 1851
Genus *Notorynchus* Ayres, 1855
Type: *N. maculatus* Ayres, 1855, Recent.

Diagnosis. Teeth compressed labio-lingually, less expanded transversely than in *Hexanchus*; each tooth shows regular conule size decrease laterally; acrocone (main cone) only slightly larger than first accessory conule, with 4–7 accessories; root high, flat, with rectilinear basal edge, straight or concave mesial and distal edges, face may have several narrow shallow grooves over whole surface (after Cappetta, 1987).

Range. Early Cretaceous to Recent; Europe, Japan, North and South America, Australia, New Zealand.

Notorynchus primigenius (Agassiz, 1843)

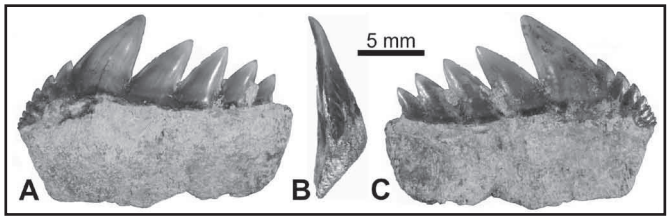


Fig. 2. *Notorynchus primigenius* (Agassiz, 1843), from locality Q08/f0585. Lower lateral tooth in (A) labial, (B) lateral, and (C) lingual views.

1843. *Notidanus primigenius* Agassiz, 218, pl. 27, fig.6–8, 13–17.
1888. *Notidanus primigenius*, Davis, 33, pl. 6, fig. 6.
1918. *Notidanus primigenius,* Chapman, 5, pl. 6, fig. 6.
1991. *Notorynchus primigenius,* Kemp, 513, pl.7, fig. P–U.
2014. *Notorynchus primigenius,* Reinecke *et al*., 8, pl. 1, 2.
2016. *Notorynchus primigenius,* Szabo and Kocsis, 37, fig. 10–13; plus more extensive synonymy.

Diagnosis. *Notorynchus* with seven mesial conules; principal cusp slightly longer than four subsidiaries; apical and basal edges of root parallel, mesial and distal edges inclined inwards.

Description. Solitary, complete lower lateral tooth, of moderate size, with subrectangular mesodistally oriented crown. Crown consisting of seven mesial conules decreasing in size mesially (i.e. towards the middle of the mouth) and oriented apically or apicomesially, principal cusp only slightly longer than four subsidiaries which decrease in size distally and are oriented apicodistally; all cutting edges smooth. Apical and basal edges of root parallel, mesial and distal edges inclined inwards; labial face inflated, inflation diminishing each side of principal cusp (acrocone); lingual face flat to slightly concave; surface subrugose.

Dimensions (all in mm). Breadth 21.4; length of acrocone 7.7; maximum height of root 7.2; maximum thickness of tooth 4.3.

Comments. This fossil species is known only from teeth which have been found in Oligocene–Miocene rocks of Europe, North America and Australasia (Cappetta, 1987). It has been claimed to be a synonym of the modern *N. cepedianus* (Péron, 1807) but this has not been generally supported, with conules being more erect in that species, and *primigenius* has recently been judged (Bor *et al*., 2012) to be a validly separable species. Teeth in *Notorynchus* differ significantly in upper and lower jaws (Kemp 1991) and the specimen previously recorded by Davis (1888) and Chapman (1918) under this name is an upper jaw lateral and differs from the present tooth by being much less broad, with fewer (3) conules.

Notorynchus primigenius has been reported from the Oligocene-Miocene of Oamaru (Davis, 1888, Chapman, 1918), both of whom figured an upper jaw tooth, as noted above. The species has also been reported (Campbell *et al*., 1993) from Chatham Island in the Matanginui Limestone, dated as late Waipawan (Early Eocene, early Ypresian; ~ 53 Ma - New Zealand Geological Timescale Project, 2012), but given the Oligocene–Miocene range reported for this species (Cappetta, 1987), this identification requires confirmation.

The Kaitarakihi specimen (Grenfell, 2007) very closely resembles the present sample and is of comparable size, with the acrocone and six auxiliary conules, and with four subsidiaries along the mesial edge of the acrocone; the mesial edge of the root is more concave than in the Pakaurangi specimen, but is still overall inclined inwards.

This species has also been reported from Early and Middle Miocene of Victoria, Australia (Kemp, 1991). A lower Miocene specimen from Hungary has recently been

figured (Kocsis, 2007); like the more complete Victoria specimens, it corresponds very closely with the Kaipara specimen, although lacking most of the root area. Chapman (1918: 5) referred to another specimen, from the 'uppermost beds, Waipara Formation, Waipara', Canterbury, as having been erroneously identified as *N. primigenius*, and he reassigned it to *N. marginalis* (Davis).

Associated Fauna

The unit that has yielded the shark tooth is almost a foraminiferal limestone, although the carbonate content is not high enough to allow that designation. It is dominated by larger foraminifera (*Miogypsina*) generally 2–3 mm in diameter and accompanied by rarer fragments of Bryozoa and occasional oysters. The smaller foraminifera have a low specific diversity and indicate Sub-Association C3 of Hayward and Triggs (2016), with dominant *Amphistegina aucklandica* and subdominant *Cibicides mediocris*, and a paleodepth of 70–100 +/- 65 m, inner to mid shelf.

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PRELIMINARY GEOLOGICAL SURVEY OF DOG ISLAND, FOVEAUX STRAIT

Ross Ramsay, Estelle Leask, Gabby Wahrlich, Max Siddell-Bradbourne

Abstract

A 3-day geological survey was undertaken on Dog Island, Foveaux Strait on 18th–20th January, 2017. The island comprises a basement of 0.5+ km early Permian volcaniclastic sediments, breccias, pillow lavas, interbedded thin amygdaloidal lava flows, and uncommon intrusive dykes. The sequence strikes generally 55–90 degrees (true north) with near vertical dips, or steeply to the north, though some overturning was recorded at the western end of the island. Younging of the sequence is to the north. The basement rocks are present over much of the island as a wave cut platform some 2–3 m above current water level. This platform has a veneer of Quaternary marine gravels of variable thickness, unconformably sitting on this basement. These gravels (3/4 derived from the island and 1/4 from Fiordland) are in turn overlain by extensive peat approximately 1 m thick. What is deemed to represent an old former Pleistocene sea stack of Permian basement comprises some 1/6th of the island surface and is the site of the current Dog Island lighthouse.

Introduction

On January 18th, 2017, a party of four from the Southern Institute of Technology arrived on Dog Island to carry out a preliminary geological survey (Fig. 1). Dog Island is located in Foveaux Strait approximately 5 kms SE from Bluff Hill (Fig. 2). The lighthouse is the tallest in New Zealand (2158554 E and 5385303 N on the NZ Map Grid, on map reference E47, 46^0 39' 2.66"S, 168^0 24' 34.66"E). The island is reported to cover 18.7 hectares. Participants were:

- Dr Ross Ramsay,
- Estelle Leask,
- Gabby Wahrlich, and
- Max Siddell-Bradbourne.



Fig. 1. Participants arriving on Dog Island, c. 9 am, January 18th, 2017.

Physiography

Dog Island comprises an extensive flat area covering some 85% of the island. This flat area is interpreted to represent an old wave cut platform of basement Permian volcaniclastic rocks now unconformably overlain by a thin veneer of shallow marine gravels, which in turn is overlain by extensive peat dominated by flax and introduced *Coprosma repens* (Fig. 3). The remaining 15% of the island comprises upstanding exposed Permian basement located around the Dog Island lighthouse. It is suggested that this protruding knoll represents a former sea stack.

Stratigraphy

Stratigraphically, Dog Island has been grouped with the Greenhills Group, comprising volcaniclastics, breccias, sandstone and tuff, rare limestone and dolerite of hornfels facies (Turnbull and Allibone, 2003). These authors state that the Greenhills Group is generally attributed to the Brook Street terrane. Correlative rocks to Dog Island have been mapped on the eastern side of Ruapuke Island, western Tiwai Point, Tikore and Colyers Islands in Bluff Harbour and along the eastern flanks of Greenhills through to Mokomoko Inlet. The Mokomoko sediments contain macrofossils indicative of a late Early Permian age (Mossman and Force, 1969).

This group of dominantly volcanogenically-derived rocks can reasonably be correlated with a sequence of basaltic

Fig. 2. *Next page*



Fig. 3. View looking west over Dog Island with Bluff Hill in the background. In the foreground and middle ground are exposed Permian volcaniclastic sediments representing a former sea stack. The bright green vegetation is introduced *Coprosma repens* now regarded as a pest plant.



Fig. 2. Locality map of Dog Island (lower map) and its position in Foveaux Strait, southeast of Bluff (upper map). Background map and aerial photograph courtesy of Google Maps.

flows, pillow lavas, and breccias found at Riverton and mapped as the Heartbreak Formation, part of the Takitimu Subgroup, which in turn is a component of the Brook Street Volcanics Group.

Basement Permian rocks to Dog Island

The basement rocks of Dog Island comprise a 0.5+ km thick sequence of interbedded volcanogenic breccias, sandstones, siltstones, pillow lavas and thin amygdaloidal lava flows with uncommon dykes. The thickest dyke recorded was a fine grained, low Colour Index (CI~30) rock of possible dacitic composition at the western end of the island (Locality D21). The entire sequence strikes between 055–095 degrees (True North) with near vertical dips to the north, although minor overturning was recorded at the western end of the island. Younging directions were found to face consistently to the north. Volcanogenic sandstones vary from thinly bedded to massive units. Volcanic breccias show thicknesses up to 4 m and clasts typically up to cobble size. Clasts are generally subangular and are dominated by porphyritic clinopyroxene-plagioclase andesites. These breccia units appear to be dominantly monolithologic and no exotic clasts were recorded (Fig. 4). In places the clasts are distinctly amygdaloidal, as are thin interbedded units recorded as lava flows.

The base of several massive breccia units give younging directions based on load features and underlying soft sediment deformation (Fig. 5).

Pillow lavas are common and generally appear to have been transported from their initial site of extrusion. Individual pillows are typically no bigger that cobble size and are disaggregated (Fig. 6). At the western end of the northern extensive boulder beach is exposed a 3+ m thick sequence of cobble-sized pillows, apparently in place, striking 070° with a vertical dip (Fig. 7).



Fig. 4. Sub angular cobbles and pebbles of monolithologic porphyritic andesite. The sequence strikes to 070° and is vertical. Locality D15 near to the old boat shed on the north side of the island.



Fig. 5. Basal soft sediment deformation underlying a massive breccia unit taken to indicate younging direction towards the top of the page. Locality D7, SW end of the island.



Fig. 6. Single disaggregated pillow lava with distinct selvedge margin set in sequence comprising both broken pillows and breccia clasts of andesitic composition. Locality D4, SW end of the island.



Fig. 7. Sequence of small pillow lavas apparently close to or adjacent to their site of extrusion. The sequence strikes 070° and is vertical. Facing is to the top of the image.

Several dykes were recorded at the western and south-western ends of the island. At D10 a cross-cutting dyke 20–25 cm wide (Fig. 8) is spatially associated with a possible sill intruded parallel with bedding (Fig. 9). On the western coast at D21 a 7.5m thick dyke comprising fine grained rock of possible dacitic composition was recorded. This dyke cuts adjacent sediments at a low angle and strikes 075° / vertical.

Thin lava flows were identified where possible by greyish chilled margins and importantly the abundance of amygdules containing what appears to be zeolites.

At the western tip of the island there is local overturning of the sequence with steep dips to the south (Fig. 10).

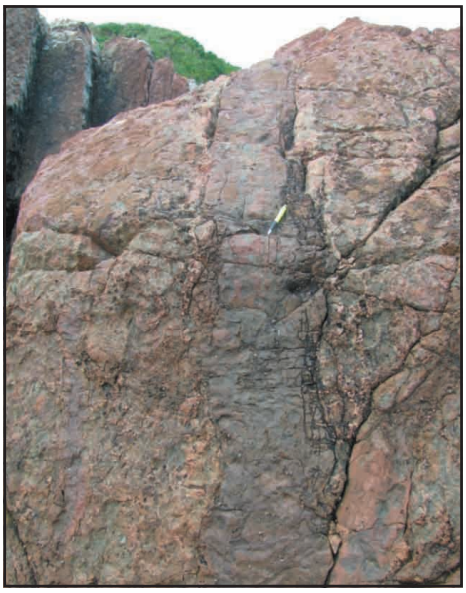


Fig. 8. Intrusive 20–25cm thick vertical dyke cutting volcaniclastic sediments. Locality D10.



Fig. 9. Sub vertical intrusive sill with what are taken to represent chilled margins. Locality D10 at SW end of island.



Fig. 10. Partly overturned sequence of breccias and pillow lavas sitting on massive to bedded volcaniclastic units. Loading features at the base of the massive breccia unit indicate younging direction to the right. Max Siddell-Bradbourne as scale. Locality D20. Image taken looking west to Bluff Hill.

Quaternary Rocks

The basement early Permian volcaniclastic sequence has been wave-cut and in turn is unconformably overlain by a thin veneer of poorly consolidated, shallow marine gravels of varying thickness, similar to other localtions along the southern margin of Southland. The clasts range from pebble to cobble size. This gravel appears to comprise by volume 25% well-rounded and spherical plutonic clasts derived from Fiordland and 75% sub-angular volcaniclastic clasts derived from Dog Island. Semi-continuous exposures of this conglomerate lacking much matrix, can be seen along the northern boulder beach line (Fig. 11). At no time was the unconformity



Fig. 11. Exposure of semi-consolidated 1.5+ m gravel overlain by peat. This exposure comes from the northern side of Dog Island. The white boulders in the foreground are present-day beach deposits. Tape measure as scale. Locality D16.

with the Permian basement observed. Small 'blowouts' in the western end of the island have exposed loose gravel apparently representing lag deposits that once were overlain by peat.

Much of the wave cut platform on the island appears to be covered by extensive peat approximately 1 m thick, except where there has been what is assumed to represent 'blowouts' down to the underlying gravels.

Structure

The early Permian basement sequence on Dog Island comprises a 0.5+ km-thick deposit of volcaniclastic sediments, lavas, pillow lavas, and thin intrusives, which typically strike between 055–095° east to north-east and consistently young to the north. Dips are generally near-vertical with localised overturning of the sequence at the western end of the island. A significant joint set prominently cuts the island striking north–south.

Acknowledgements

The Trustees to the Dog Island Trust are thanked for access to Dog Island, to DoC for the loan of a portable electricity generator, and to the Southern Institute of Technology for funding of this project.

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PAST SEA LEVELS REFLECTED IN COASTAL LANDFORMS ON GREAT BARRIER ISLAND

Bruce W. Hayward

During the May 2018 Geoclub trip to Great Barrier Island, we became aware of a strange-looking horizontal line in the landscape to the west of the road to Claris when driving from the south (Fig. 1). After driving up the only road that transects it, Kaitoke Lane, we discovered that the line was the top of grazed grassy slopes that led up to the near-horizontal crest of a former sand dune ridge. When seen from the east, the line was accentuated by the bush-covered slopes in the background. The road cut through this ridge exposed relatively hard limonite-stained medium-coarse sand that was clearly older than Holocene (last 10 kyr).

In the field we speculated on the height of the dune and the elevation of the relatively flat land behind that was utilised as playing fields for Claris School and hypothesised that this could be an uneroded coastal feature from the Last Interglacial high sea-level stand. Once back on the internet I was able to use the Auckland Council GIS site with Lidar contours at 1 m intervals (Fig. 2) to investigate this hypothesis.

Previous work

Horrocks *et al*. (2000) reported on two vibrocores they took in the low-lying drained swamp just west of the main Claris Rd and seaward of our linear sand-dune ridge (Fig. 3). One core taken just south of the end of Kaitoke Lane at a present elevation of 3–4 m above MSL, encountered estuarine shell-bearing sediment from 3 m below present MSL (dated at 7500 yrs ago) to 1 m above MSL (dated at 5500 yrs ago). They record a switch from salt marsh to freshwater swamp ~3000–2500 yrs ago at a depth of 1–2 m above MSL in the second core.

Description of coastal landforms

South of Claris at the south end of Kaitoke Beach, the coastal landforms are from east to west, moving inland (Figs 2, 4):

a. Modern exposed sand beach
b. Holocene sand dune belt (~8000 yr to present) (Horrocks *et al*., 2000)
c. Late Holocene freshwater swamp, now drained grassland (~3000 yr to present) Mid Holocene subtidal to intertidal estuary (~8000 to 3000 yr ago) (Horrocks *et al*, 2000)
d. Last Interglacial sloping exposed sandy beach, now grazed grassland (Fig. 5)
e. 1.3 km-long, linear, near-horizontally crested sand dune in grass, with an elevation rising gently from 11 m above MSL near Kaitoke Lane to 25 m above MSL at its northern end.
f. Partly grazed land and partly modern freshwater swamp lowland, 5–8 m above MSL, extending ~1 km inland up valley mouth at north end of dune (Figs 2, 3).
g. Shallow, narrow stream valley draining this lowland and eroded 1–2 m into it at the southern end.
h. Steeply sloping hills of weathered Miocene andesite.

Interpretation of coastal landforms

Coastal dunes often partly or fully block valley mouths creating estuaries or lakes and swamps behind. Over time these fill up with sediment. Eventually estuaries will naturally fill to high water level, whereas lakes and/or swamps will fill up to the water table level, which initially will be controlled by sea level because of natural drainage through the sand dune barrier, but as this may gradually block so the water table and sediment fill will slowly also rise.

The level of sediment fill in the lowlands behind the Holocene sand dune belt, just west of the Claris Rd, is 2.5–3.5 m above MSL (=~0.5–1.5 m above present high water level). There is ~2 m of freshwater swamp peat and other sediment beneath this flat (Horrocks *et al*, 2000) that has accumulated in the last 3000 yrs. Thus the top of the tidally-influenced estuarine sediment here is ~0.5–1.5 m below present high water level. At first glance this appears rather low, as sea level 3000–6000 years ago around New Zealand has been reported to have been 1–2 m higher than now (e.g. Hayward, 2017, fig. 11.27). If there has been no subsidence in the lowland since then (and there probably has been some related

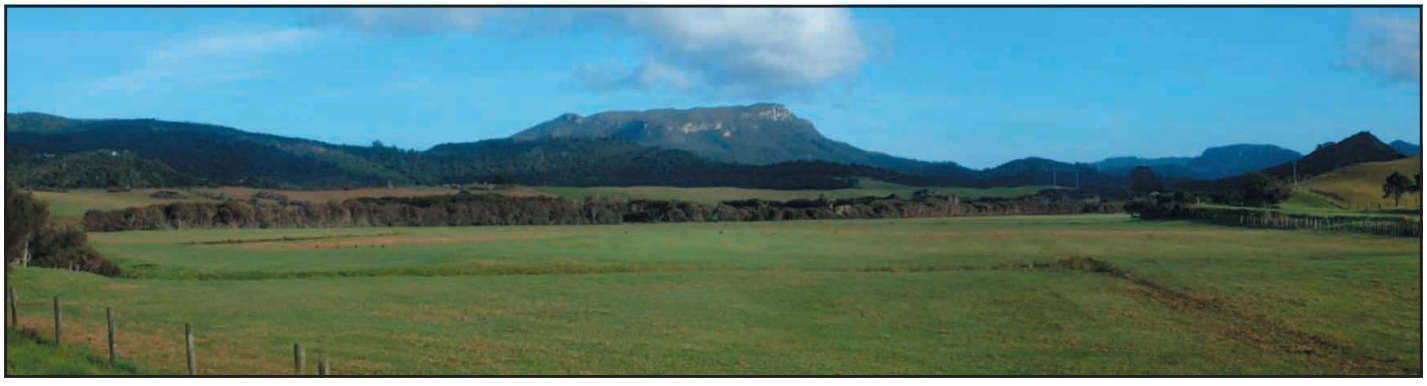


Fig. 1. View west from south of Claris showing distinct horizontal crest of grassed Last Interglacial foredune. (Te Ahumata plateau in the background.)



Fig. 2. Road and aerial photograph base maps of study area with 2 m Lidar contours showing the location of young landforms discussed in the text.

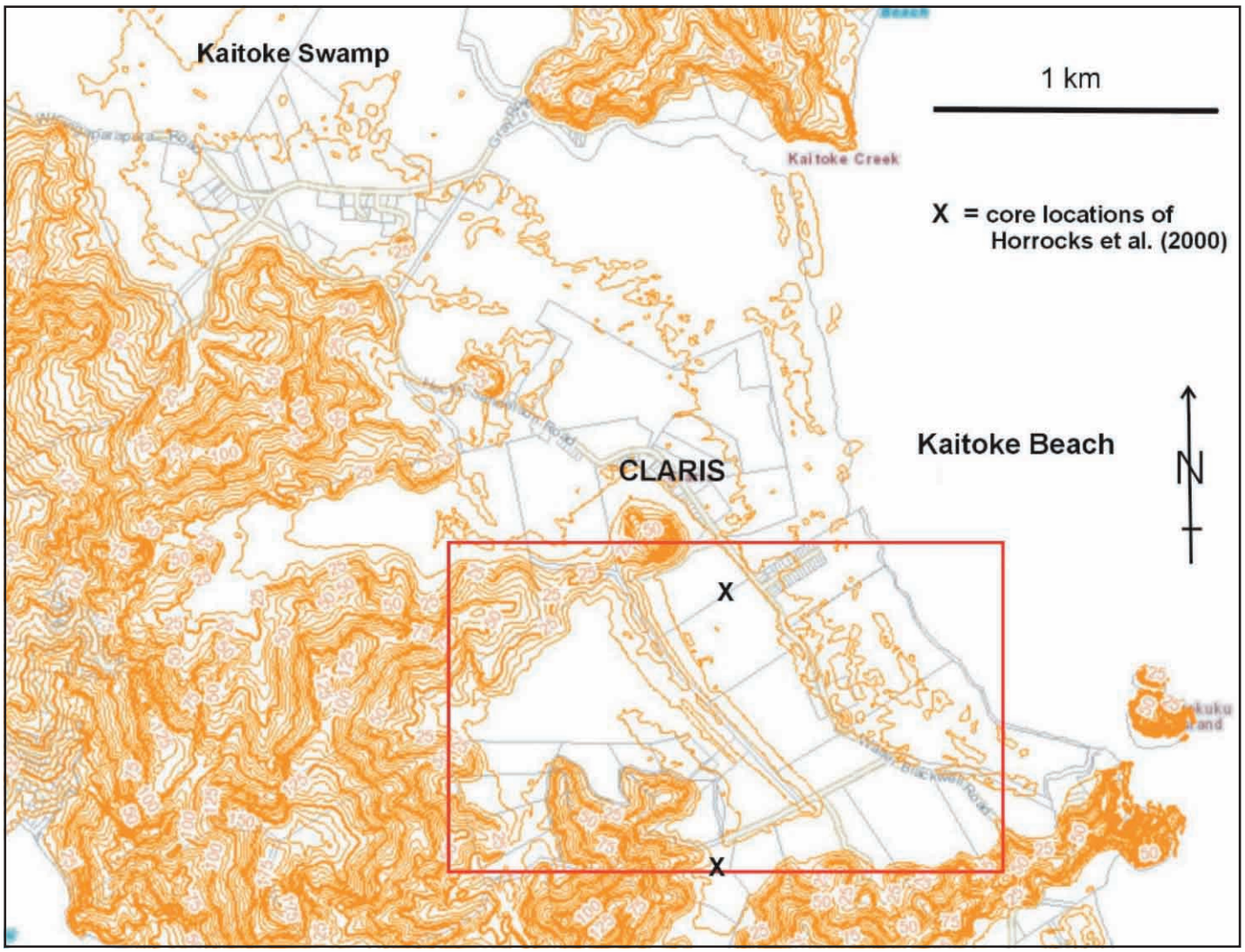


Fig. 3. Map of east central Great barrier Island showing Kaitoke Beach backed by Holocene sand dunes which form the dam across the largest freshwater swamp remaining in the Auckland region, Kaitoke Swamp. The study area, south of Claris, is in the red box.

to compaction of the muddier sediment) the estuary had only filled to ~mid tide levels by 3000 yrs ago. There is believed to have been a significant fall in sea level between 3000 and 2000 years ago that likely resulted in a pulse of sand accretion and dune building on Kaitoke Beach. It is possible that this extra sand may have cut off this south Kaitoke estuary from its connection with the sea at that time and turned it into a freshwater lake/swamp. It is not easy to determine exactly how much compaction may have contributed to the present elevation of the marine-freshwater contact.

The weathered and hardened sand of the inland linear sand dune clearly shows that it is not of Holocene age. The elevation of the partly stream-eroded lowland inland of this higher and older dune is 6–7 m above MSL or 4–5 m above high tide level or ~3–4 m above the low area in behind the Holocene dunes. This indicates that sea level was probably ~3–5 m higher than present when this dune was formed and created the estuary or lake/swamp in behind. Once again some compaction of muddier sediment or peat can be expected to have occurred and thus a sea level of ~4–6 m higher than present would not be an unreasonable estimate. This fits best with the Last Interglacial period (~120,000 yrs ago) when sea level around New Zealand is inferred to have reached up to 6 m higher than now (e.g. Hayward, 2017, fig. 11.1). This seems to confirm our initial hypothesis that the relict beach face, linear foredune and lowland in behind are of Last Interglacial age.

Here at Claris then, we have a rare example for New Zealand, of a well-preserved coastal sand dune and enclosed wetland of Last Interglacial age sitting inland of its Holocene modern analogue. It could possibly be the best example of its kind in the country. Similar Last-Interglacial coastal dunes must have existed around much of New Zealand's coast, but most appear to

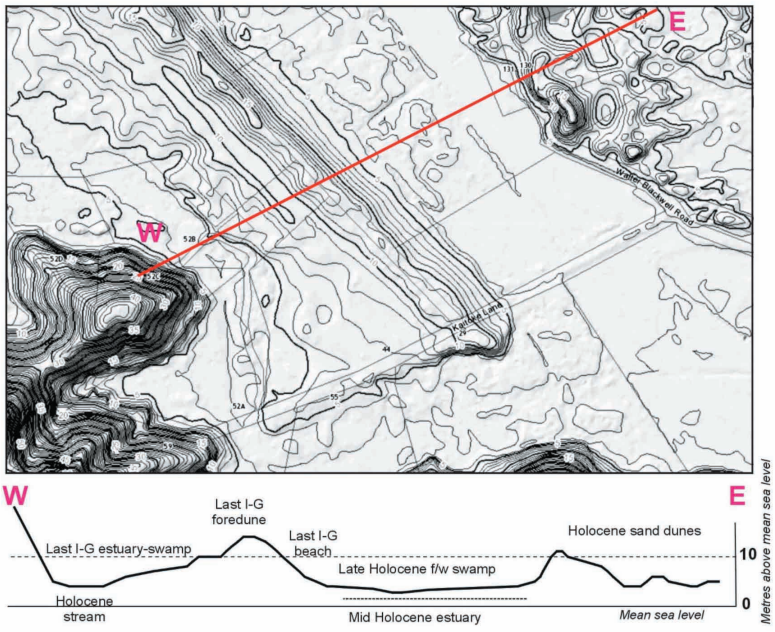


Fig. 4. Map with 1 m contours of the south end of the linear sand dune study area with west to east transect showing elevations above mean sea level.

have been eroded away since then or been buried beneath young Holocene dunes.

Along >70% of New Zealand's coastline there has been significant vertical tectonic movement (>2 m) of the land in the last 100,000 yrs. Northern New Zealand is thought to be the largest tectonically-stable area over that time period and this tectonic stability seems to be confirmed by the elevation of these coastal dune-wetland landforms on Great Barrier Island.

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Fig. 5. View north across face of Last Interglacial beach from Kaitoke Lane.

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SMOKE AND MIRRORS - WELLINGTON AUSTRALIAN ANZAC MEMORIAL

Hugh Grenfell

As part of the 2017 GeoClub field trip to the Wellington area, we visited the National War Memorial, Pukeahu. Of interest naturally were the building stones used in the former National Museum (1936) and the Carillon Memorial (1932). Both originally clad in Putaruru Ignimbrite although the latter was changed to Takaka (Caanan) Marble in 1982.

What was new was the Australian ANZAC Memorial, which forms part of the new Pukeahu National War Memorial Park opened in April, 2015. The memorial consists of 15 six metre tall sandstone block columns (some with strips of polished black "granite"), with a few eucalyptus trees all surrounded by an expansive paved area made of grey basalt and red sandstone.

It is always nice to see interesting rock on display and clearly the inference from the rock types used was to create links to Australia. The grey basalt was easy to figure out and as it turned out wrongly attributed. But many of us on the trip, familiar with Australian geology, were left scratching our heads immediately as to where in Australia the sandstone had possibly come from? As it turned out our "doubts" were well founded.

In the memorial narrative the sandstone columns are supposed to stand for the red earth that Australia's servicemen left behind when they went off to war. And the paving supposedly linked Australia (red sandstone) and New Zealand (grey basalt).

"The rugged red sandstone columns represent the heart of Australia: the 'red centre'. Each column stands on a band of the same red stone, between them bands of grey stone symbolise the New Zealand landscape: the interweaving is a perpetual reminder of the united destiny of the two nations."

The Australian architects of the memorial, Tonkin Zulaikha Greer, described it as a "*landform of Australian red sandstone, forming an iconic and appropriate place of memory and reflection, embodying the Australian character and responding to the urban and heritage qualities of the site*"

Australian Prime Minister at the time, Tony Abbott, went on the record saying "*It's the first foreign war memorial in New Zealand. It's a magnificent memorial. It's basically columns of Australian stone*." But after all that rhetoric we now know the real source of the red sandstone was India. Even then, when the jig was up, the Australian War Graves director Chris Appleton insisted it was almost identical to that which would have come from Australia, as both countries were originally part of the ancient land mass of Gondwanaland. Yeah right. The real reason was no doubt that it was a quick, cheap fix.

So what have we learnt? That the red columns and paving are a ?Triassic sandstone, probably quarried near Agra, India, such as "Agra Red Dholpur" (e.g. the Red Fort, paving around the Taj Mahal), there is some polished black "granite" from, well, anywhere and grey basalt paving, which has distinctive vescile trails, and although widely used around New Zealand as paving, is not from here but from Victoria, Australia. The latter is commonly called "Australian Bluestone" (e.g. as produced by Bamstone, Port Fairy, Victoria). Most importantly be wary of narratives, especially political ones.



Fig. 1. Australian ANZAC Memorial, Wellington.



Fig. 2. Close up Indian red sandstone.

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HYPERLINK INSTRUCTIONS

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QUIZ ANSWERS

Know your meanders.

1 = F lower Mataura River south of Wyndham, Southland - flows into the Toetoes Harbour (just visible at the bottom of the map, deliberately cropped), east of Bluff

2 = C Waikato River from Huka Falls to Lake Ohakuri - from Huka Falls (bottom left corner of map) the Waikato heads northeast, through the Aratiatia Dam (slight thickening of the river visible bottom corner), then eventually turns back on itself, through Orakei Korako geothermal site just before the next dam, Lake Ohakuri (top left)

3 = A upper Wairua River, Hikurangi Swamp, Northland - redesigned to improve drainage, but many oxbow lakes still visible (although this is north of Whangarei, the Wairua River flows southwestwards, joins with the Mangakahia River near Tangiteroria, and flows out as the Wai**roa** River to Dargaville and the Kaipara Harbour)

4 = D Manawatu River from Palmerston North to Foxton - note the unusual river remnant just before the river mouth, far left of map (the Manawatu River up stream from Palmerston North is one of the few antecedent rivers in New Zealand, flowing right through the axial ranges)

5 = E upper Taieri River, Otago - the drainage pattern of the Taieri River is one of the strangest in New Zealand, with the upper reaches (mapped here for this quiz) flowing northeast nearly to Ranfurly, then doubling back in a parallel trace, but southwestwards through Middlemarch, before reaching the coast south of Dunedin

6 = B Hoteo River, Kaipara District - another river in northern New Zealand rising near the east coast but draining to the west coast (cf. Wairua River above) - see also Hayward *et al*. 2007. The west-flowing "Clevedon River", Auckland. *Geocene* 2: 9–11, Fig. 4, p. 10

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