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Field Trip Guides

ZEALANDIA IN SPACE AND TIME

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Field Guides

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FIELD TRIP –PALEOBIOLOGY WORKSHOP

Pleistocene cyclic stratigraphy, South Wairarapa, New Zealand

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Bluff in a gully near Mangaopari Stream showing the transition from Greycliffs Formation siltstone to Pukenui Limestone (ca 2.0Ma).

ITINERARY:

This field guide comprises three field stops (Fig 1). We will attempt the following itinerary.

9.30 am	Depart Wellington.
10.30 –10.45 am	Stop 1: Overview of Wairarapa Valley
11.15 – 2.00 pm	Stop 2: Walk through Greycliffs and Pukenui Formations with lunch break in field.
2.00 – 3.30 pm	Stop 3: Banana Bridge Gorge, walk through Pukenui Formation to contact with Hautotara Formation.
4.00 – 8.00 pm	Martinborough Hotel: Dinner
9.30 pm	Arrive back in Wellington

GEAR LIST:

The weather may be changeable so be prepared for sun and rain. We will be away from the vehicles for up to 2 hours, so a drink and snack are recommended. Lunch will be provided. Expect to get wet feet at a couple of the stops. Please bring:

- Study footwear
- Sunhat, sunglasses and sunscreen
- Large water bottle and light snack
- Warm jersey/jacket and raincoat
- Clean shoes/change of clothes for dinner so we don’t track mud into the hotel

INTRODUCTION:

This one day fieldtrip will take us north from Wellington and then east over the Rimutaka range to the southern Wairarapa region. We will view a well-exposed Pleistocene sedimentary sequence that includes several glacio-eustatic sea level cycles. We will make one stop on the way (Stop 1) to gain an overview of the tectonic and regional setting, and then examine the rocks via two stream traverses (stops 2 and 3) in the Mangaopari area (Fig 1).

As we drive from Wellington to the Wairarapa we cross the rapidly uplifting axial ranges, which trend north-south along the North Island (Figures 1, 2). The ranges are composed of the Jurassic age (150 – 200 million years old) ‘greywacke’ rock of the Torlesse Supergroup. We will then drive further east, over the rolling hills and plains of the Wairarapa Valley. This area contains Neogene age (<23 million years) marine sedimentary rocks and younger terrestrial deposits, which have been uplifted and deformed into a series of thrust and fold features by the compressional tectonic regime (Fig 2).

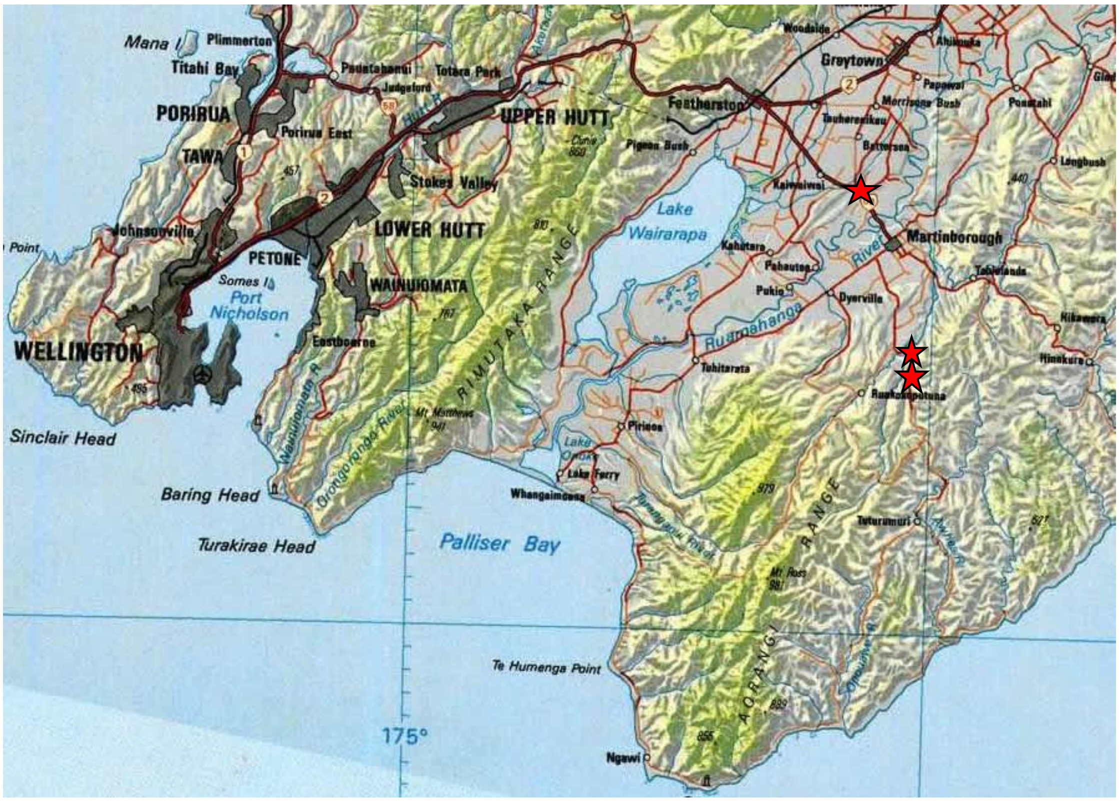

Figure 1. Map of Wellington and the southern Wairarapa Region showing sites we will visit.

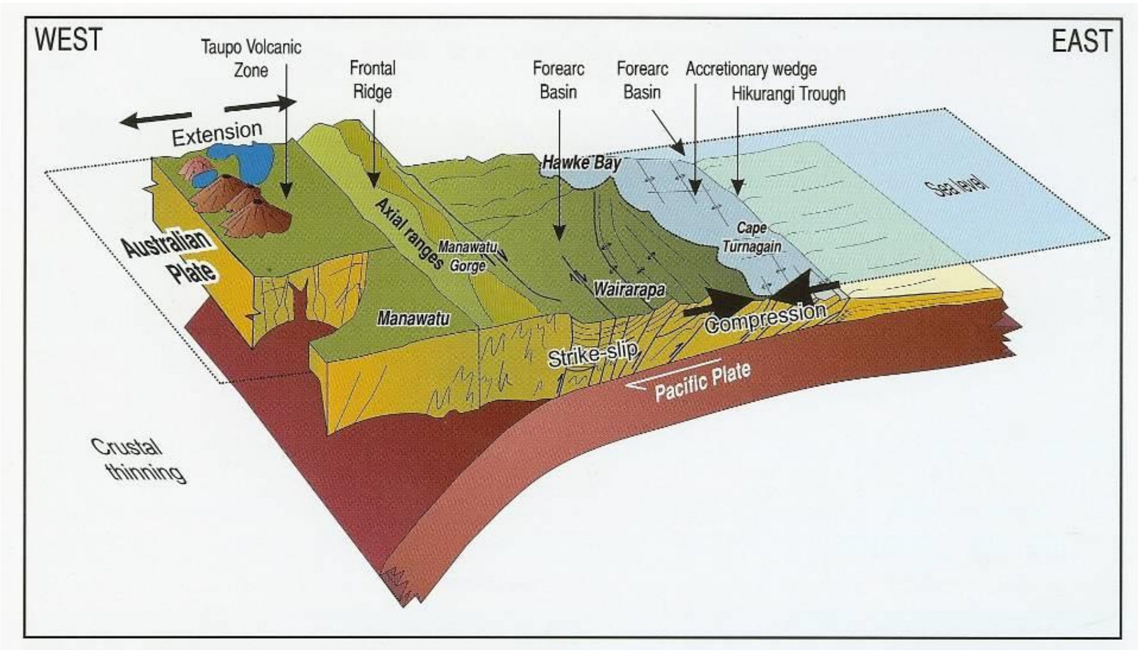

Figure 2. Schematic representation of the modern tectonic setting of the East Coast of the North Island. The Pacific plate is being subducted beneath the Australian plate at about 40mm/yr. (From Lee & Begg, 2002).

STOP 1 – Overview of central Wairarapa Valley

This stop allows us to view the central Wairarapa valley (Fig 3). The low range in the distance is the rapidly growing Windy Peak anticline. This range exposes marine, marginal marine and terrestrial rocks that accumulated in a tectonically active basin within the forearc basins above the Hikurangi subduction zone (Lewis and Pettinga, 1993, Fig 2). General uplift of the area beginning in the mid-Pliocene created a narrow elongate seaway along the forearc basin of eastern North Island (Fig 3 and 4). Mudstone, sandstone and limestone were deposited recording a tectonically induced regression of the seaway with a cyclical glacio-eustatic sea level signal overprinted since 2.2Ma. Marginal marine sediments (Hautotara Formation) at the base of the western limb of the anticline (foothills in distance) mark the paleoshoreline at about 1.8 – 1.6 Ma when the paleoseaway finally became emergent. In the foreground are Late Pleistocene alluvial plains that provide ideal conditions for the burgeoning wine industry around the town of Martinborough.

Figure 3. View looking east over Martinborough toward the Windy Peak anticline which is capped by early Pleistocene Pukenui Limestone. Torlesse 'greywacke' outcrops in the Aorangi Range is to the south (right).

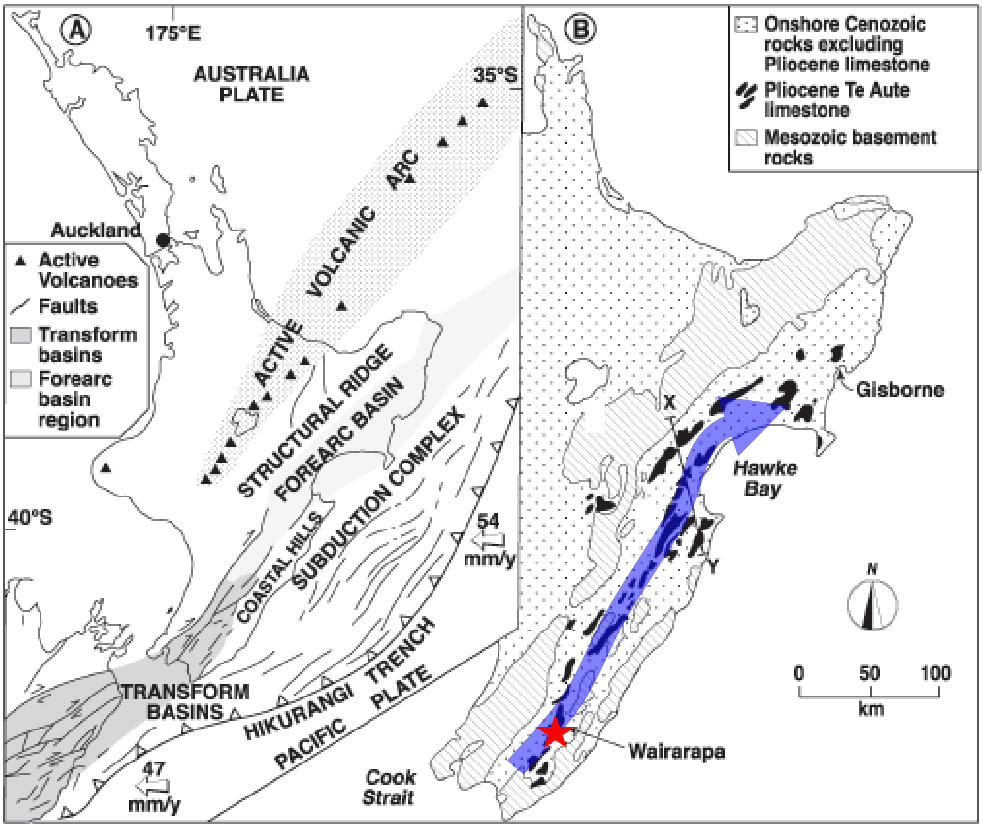

Figure 4. Tectonic setting of the North Island and general distribution of limestone delineating the paleoseaway (blue arrow) that existed within the forearc basin from the modern Cook Strait to Gisborne. Red star indicates the Mangaopari Basin. (Map from Nelson et al., 2003).

STOP 2: Walk through – Greycliffs and Pukenui Formations

Figure 5 shows the local geology of the Mangaopari area and location of the field stops 2 and 3. Stop 2 begins at the contact between the Greycliffs Formation and Pukenui Limestone and walk down a narrow gully through several limestone and mudstone interbeds. Stop 3 has the same sequence through a gorge in the Makara River.

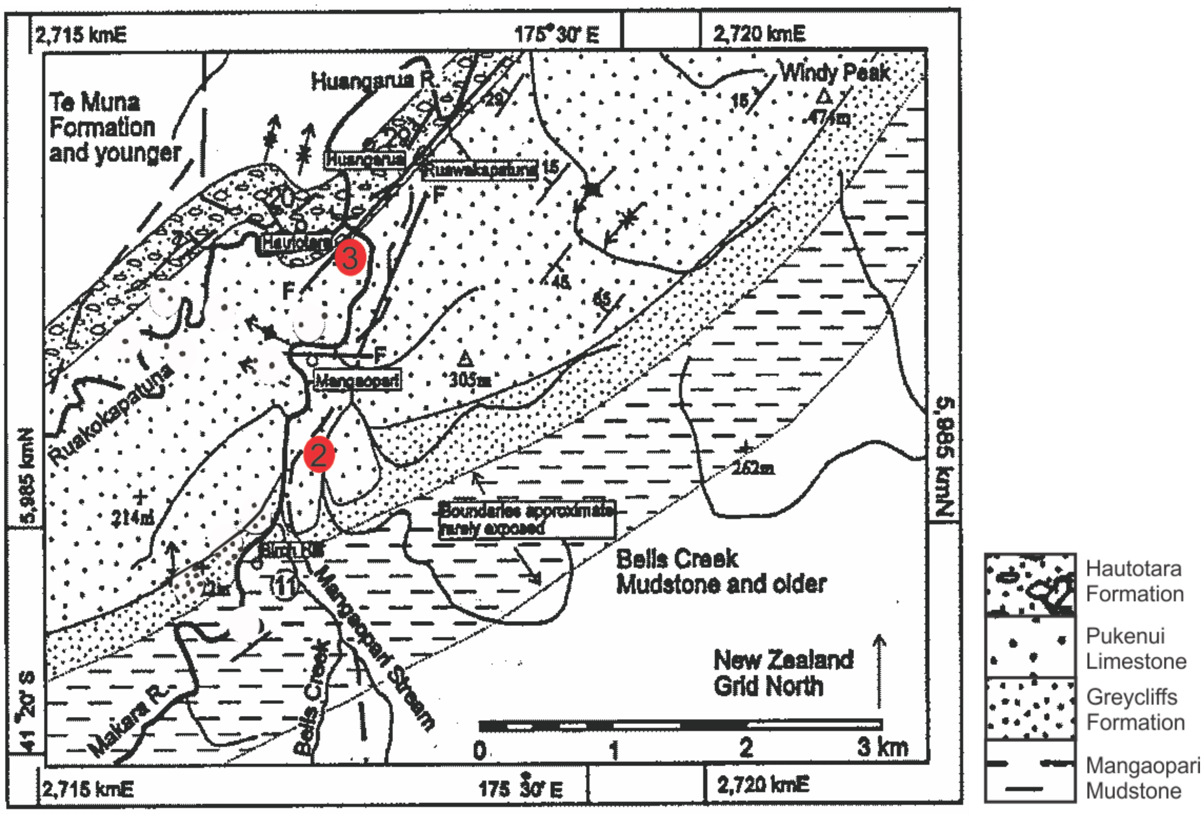

Figure 5. Geological map of the Mangaopari area and location of stops 2 and 3 (Modified from Gammon, 1997)

Vella (1963) was the first to recognise that the sedimentary cyclicity recorded in the rocks in the Mangaopari area was the result of glacio-eustatic changes in sea level and described several cyclothems. Subsequently, several classic papers on paleomagnetic and oxygen isotope stratigraphy were generated from the Mangaopari Stream section (e.g., Devereux et al., 1970, Kennett et al., 1971, Lienert et al., 1972). The sequence was formally defined by Vella and Briggs, (1971) and Collen and Vella (1984) and has been used in several studies of cyclic stratigraphy (e.g., Beu & Edwards, 1984). Victoria University of Wellington has run an undergraduate field sedimentology and stratigraphy course at Mangaopari for over 40 years and numerous student projects have been carried out in the area. A sequence stratigraphic interpretation of the Mangaopari section was carried out in the mid 1990's (e.g. Gammon 1995, 1997).

The late Pliocene Greycliffs Formation comprises alternating unfossiliferous massive silt and thin beds of massive, fossiliferous, fine sand. Macrofauna such as *Pelicaria vermis* indicate middle shelf environments (Carter et al., 1994). The appearance of the cold water scallop *Zygochlamys delicatula* (at c.2.2 Ma) in the lower Greycliffs Formation indicates the influx of cold water associated with the onset of glacial/interglacial cycles. The alternating beds in the Greycliffs probably represent 40 ky glacio-eustatic sea-level cycles of the late Pliocene although deposition remained entirely below storm wave base.

Conformably overlying the Greycliffs Formation is the Pukenui Limestone. This 80 m thick formation comprises alternations between three skeletal calcarenite (coquina) limestone members and two muddy sandstone members reflecting glacio-eustatically controlled sea level fluctuations between about 2.0 Ma and 1.8 Ma (Fig 6). The limestone members are dominated by cold water barnacles *(Fosterella tubulatus)*, bivalves (mostly *Zygochlamys delicatula*, but also *Ostrea chilensis, Panopea sp.)* and also rare chelae of the cold water crab *Jacquinotia edwardsii* (Figure 8). The limestone members have variable (but generally high) terrigenous component and are typical of Neogene temperate limestones of the east coast of New Zealand (Nelson et al. 2003, Beu, 1995).

Figure 6. Contact between Greycliffs Formation and overlying Pukenui Limestone.

The basal limestone is known informally as the 'A' limestone following the naming conventions of Rodley (1961), and shows a distinctive concentration of *Zygochlamys delicatula* valves in a variety of orientations and states of preservation (Fig 7a,b). The long-standing interpretation is that this transition represents a regression from inner/middle shelf to shoreface depths due to glacio-eustatic sea level fall (e.g. Vella, 1963, Vella and Briggs, 1971, Beu & Edwards, 1984).

In contrast, Gammon (1997) interpreted the muddy sandstone and thin shellbeds of the uppermost Greycliffs Formation as a low-stand deposit (shallow) and the overlying 'A' limestone as high-stand (deeper) deposit with the coquina representing outer shelf shell hashes similar to those on the outer parts of the eastern South Island shelf today (Carter et al., 1985). However, Atkins (1995) studied the beds of *Z. delicatula* in detail and found that the valves were found both convex and concave up, that there were both single and articulated valves, and varying levels of barnacle encrustion within the beds, and used this as evidence of episodic storm wave base disturbance of an *in situ* shell bank, concluding that the 'A' limestone is a lower shoreface deposit.

Figure 7 (Top) *Z. delicatula* bed at the base of the Pukenui 'A' Limestone. Scallop shells are up to 10cm diameter. (Bottom) *Fosterella tubulatus* (barnacles) encrusting a *Z. delicatula* valve.

STOP 3. Banana Bridge Gorge, walk through Pukenui Formation

This gorge provides another opportunity to walk through the Pukenui Limestone Formation. The contact between the Greycliffs Formation and the Pukenui 'A' limestone is again well-exposed, showing the distinctive basal concentration of *Zygochlamys delicatula*. The interbeds between the limestones comprise fine sandstone and muddy sandstone with scattered fossils and irregular blocky concretionary layers, interpreted as being deposited in deeper water than the limestone members, probably middle-inner shelf depth, and include mollusc fossils such as *Pelicaria vermis, Stiracolpus symmetricus, Dosinia greyi, Amalda* sp, *Alcithoe (Leporemax)* sp. (Figure 8).

Figure 8. (Top left) *Pelicaria vermis*. (Top centre) *Amalda* sp. (Top right) *Alcithoe (Leporemax)* sp. (Middle left) *Stiracolpus symmetricus*. (Middle centre) *Zethalia zelandica*. (Middle right) *Dosinia greyi*. (Bottom left) *Panopea* sp. (Bottom centre) *Tawera subsulcata*. (Bottom right) Chelae of *Jacquinotia edwardsii*.

The middle and upper limestone members 'B' and 'C' have *Zygochlamys delicatula* and barnacles, but also display some good in-situ examples of the infaunal bivalve *Panopea* sp. (Figure 8), and are generally sandier than the 'A' limestone. These are interpreted as shallow high energy shoreface deposits (Fig 9). The top metre of the 'C' limestone consists of a highly cemented shellbed, dominated by *Tawera subsulcata* (Figure 8).

Conformably overlying the Pukenui Limestone is the marginal marine Hautotara Formation. The sandstone, conglomerate and thin limestone beds of this formation record the structurally controlled regressive transition of the area from the entirely marine Pukenui Limestone to the overlying terrestrial Te Muna Formation, and therefore represent the last incursion of the sea into the eastern Wairarapa Valley (Collen & Vella, 1984). The lower Hautotara Formation comprises both well-sorted fine sand with common *Zethalia zealandica* (beach sands) and sandstone often containing *Panopea sp.* (lower shoreface to inner-shelf) (Figure 8). Thin lenses of greywacke pebbles and crushed shells occur throughout the section and are interpreted as transgressive surfaces of erosion, related to glacio-eustatic cycles.

The upper part of the Hautotara Formation comprises siltstone with some lenses of fluvial conglomerate, indicating an estuarine environment, supported by rare occurrences of estuarine molluscs such as the mussel *Limnoperna huttoni*. Within the Hautotara Formation, at least four and a half 40,000 year Milankovitch controlled glacio-eustatic cycles are observed (e.g. Gammon, 1995, Rampton, 1997, Nowland, 2010), representing a period of time between 1.82 Ma and 1.6 Ma (Rampton, 1997, Nicol et al., 2002). A generalised stratigraphic column correlated to the geological timescale, oxygen isotope, and polarity and obliquity curves is presented in Figure 10. Note the three limestone members of the Pukenui Limestone.

Figure 9. Outcrop of the A-B interbed with the underlying 'A' limestone outcropping at stream level and 'B' limestone outcropping at the cliff top.

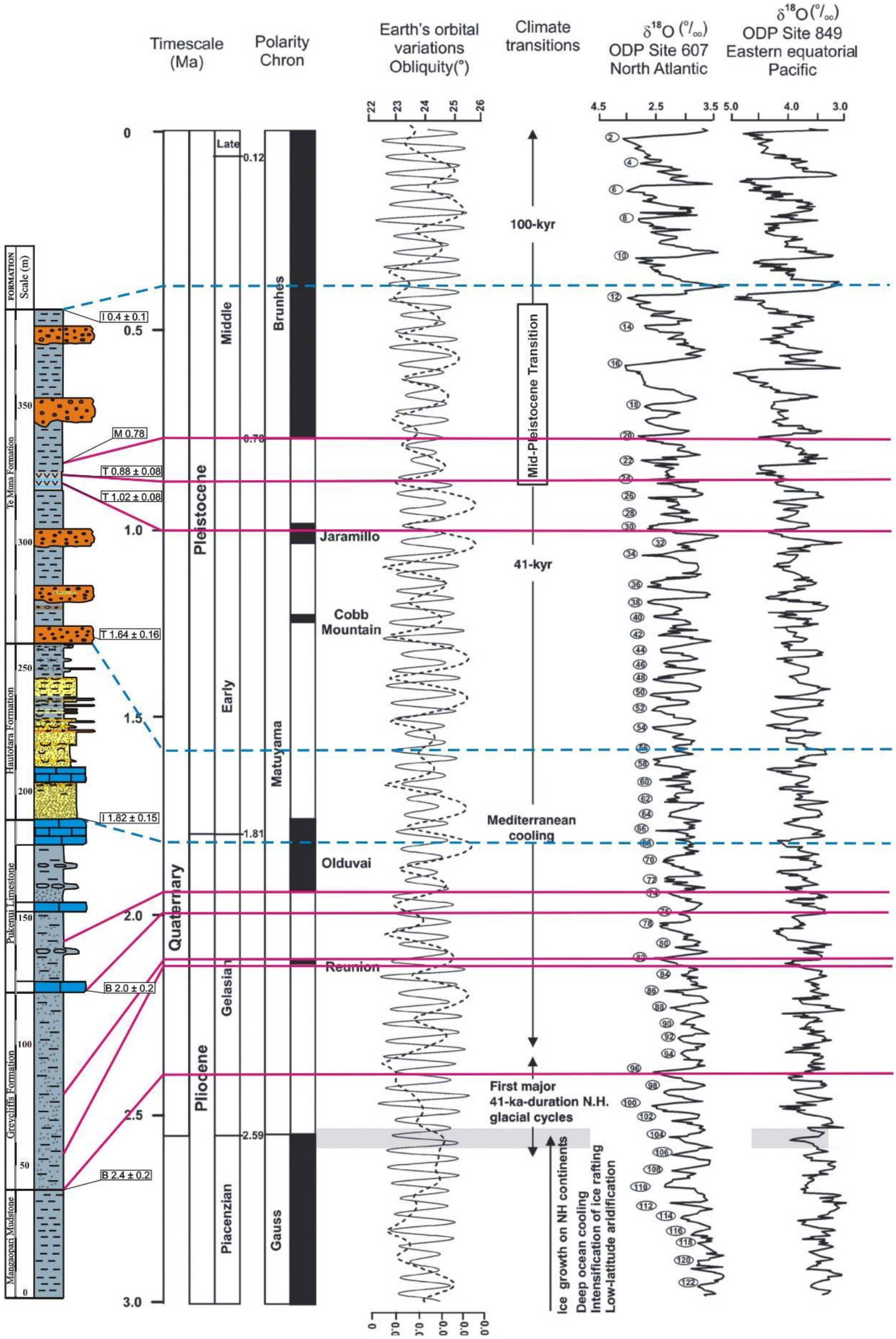

Figure 10. Generalised stratigraphic column for the Mangaopari area with oxygen isotope and magnetic polarity data. Age determinations (solid pink lines) are from palaeontological (B), magnetostratigraphic (M), and tephrochronological (T) sources. Dashed blue line indicates inferred ages (I). Data from compilations in Nicol et al., 2002, Shane et al., 1995. Timescale and polarity, obliquity and oxygen isotope curves from Naish, 2005. Modified from Nowland, 2010.

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