Late Miocene-Early Pliocene Matemateaonga Formation in eastern Taranaki Peninsula: A new 1:50,000 geological map and stratigraphic framework

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Abstract

In recent years the Matemateaonga Formation has become an additional exploration play in Taranaki Basin. Exploration interest has been stimulated by the success of Swift Energy Company in the Rimu/Kauri prospect (38719), located near south Taranaki Coast. At this location, sandstone lithofacies, commonly termed "Manutahi Sandstone" in the lower parts of the Matemateaonga Formation have been intersected by the Kauri-A2 and Kauri-A3 wells at depths of ~1100-1200 m and are yielding commercial quantities of oil.

As part of a FRST-funded sedimentary basins research programme, we have geologically mapped in detail Matemateaonga Formation within an 1800 km^2 area of the eastern peninsula region (Fig. 1), incorporating license areas 38739, 38718, 38753, 38138, 38139, 38141, 38140, 38716, 38758, 38728 and 38760. Mapping at 1:50,000 scale has revealed an ~1100 m-thick succession of cyclothemic, unconformity bounded shelfal strata of Late Miocene-Early Pliocene (Late Kapitean to Early Opoitian) age (c.5.5-4.7 Ma). This succession formed as a result of the interplay between climatically-driven 6th-order (41 k.y.) eustatic sea-level changes, high rates of basin subsidence and a substantial southerly-derived sediment flux. Individual sequences or groups of sequences are the fundamental mapping entities. The mapping area sits astride the southward-plunging Whangamomona Anticline, which has deformed the Late Neogene succession, producing a regional dip on its western flank of 2 to 4 degrees to the southwest. Northeast-southwest trending normal faults are relatively common and offset Matemateaonga Formation strata with throws of 2-50 m.

This improved knowledge of Matemateaonga Formation stratigraphy enhances the understanding of the distribution and geometry of potential reservoir sandstone units and associated mudstone seal units in the region.

Introduction

The degree of exposure of Miocene and Pliocene beds in eastern Taranaki Peninsula is such that the large scale stratigraphic architecture (geometry) of the sedimentary succession can be established by mapping and stratigraphic analysis. The Matemateaonga, Kiore, Urenui and Mt Messenger Formations (Whangamomona Group, Kamp et al. 2002) constitutes a progradational paleo-continental margin wedge disrupted by uplift and erosion. These strata pass southward and westward into subsurface parts of the Peninsula, where they are known to contain aquifer water and possibly petroleum resources.

Relatively inexpensive field mapping has improved the possibility to identify prospects (stratigraphic features or structures) that could be investigated by more expensive methods of data acquisition (e.g. seismic reflection survey) and possibly site specific exploration (e.g. drilling). An outcome of the geological mapping is reduced exploration risk for companies holding exploration licenses in Taranaki Peninsula.

One of the main objectives of this research is to establish a lithostratigraphy and chronostratigraphy of the Matemateaonga Formation and undertake a facies analysis to determine the depositional paleoenvironments. This is complemented with sequence stratigraphic analysis to establish the depositional architecture and to constrain the contemporary paleogeography.

The approach taken in this project is to maximise the information (distribution, age, architecture, depositional paleo-environments, sequence stratigraphy) that can be extracted from these units, and use this to better understand correlative units in the subsurface. The only previous work undertaken in the eastern Taranaki Peninsula outcrop belt was done by oil companies in the 1940s and 1950s (Arnold 1957, 1958, Thoms 1942). Since then there have been major

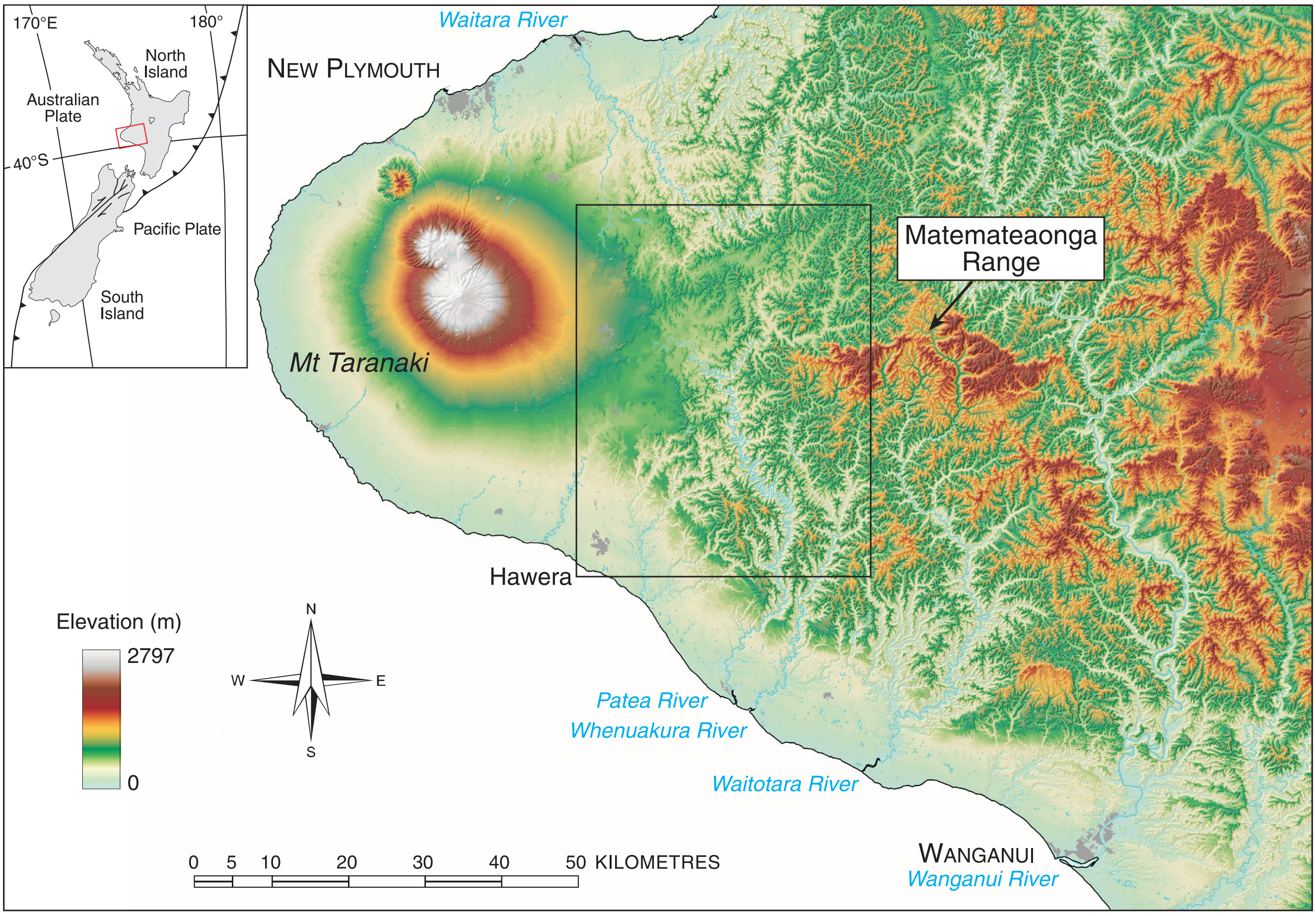


Figure 1. Digital elevation model (DEM) of the Taranaki Region showing the location of the study area.

developments in stratigraphic concepts (e.g. sequence stratigraphy) and in technologies and it is timely to re-examine the outcrop stratigraphy to improve the knowledge base for resource exploration.

The fundamental stratigraphic units of the Matemateaonga Formation are depositional sequences (reflecting a relative sea level cycle). The description and correlation of sequences over a large area requires detailed and careful field mapping. This has been aided by the field identification of age diagnostic macrofossils.

The approach has involved compiling all of the existing information together with new geological information from substantial field mapping, and incorporation in a GIS platform. Compilation of the geological map was conducted at scales ranging from 1:1,000 to 1:10,000 with the final map presented at a 1:50,000 scale.

The aim of this paper is to briefly describe the geological units encountered within the ~1800 km^2 mapping area of eastern Taranaki Peninsula (Figs 1 and 2). The new 1:50,000 scale geological map will be presented at the pre-conference workshop.

Geological setting

The study area is located on the boundary between the Taranaki and Wanganui Basins (i.e. astride the Taranaki Fault) (Figs 1, 2). The Miocene-Pliocene marine succession is contiguous throughout these two basins. These strata have been subsequently uplifted and erosionally truncated as a result of long wavelength up-doming of the central North Island (Kamp *et al*. 2002, 2004). A regional stratigraphic framework at a second order sequence scale and its relationship to the geological development of the eastern Taranaki Peninsula Region is provided by Kamp *et al*. (2002).

A general geological map in Fig. 2 shows the distribution of major formations in central-western North Island. Note the broad west-east trending belts of the major formations. Post-depositional uplift and differential movement on the Patea-Tongaporutu High has gently deformed the Miocene-Pliocene succession, thereby forming the southward-plunging Whangamomona Anticline. The limbs of this fold have dips of two to four degrees to the southwest. The outcrop pattern provides an opportunity to examine the paleo-continental margin strata, and in particular, the Matemateaonga Formation. Topographic dissection is marked, with the best exposures occurring in the major river valleys.

The area of relatively high relief shown in the digital elevation model (DEM, Fig. 1) makes up the Matemateaonga Range. This range has a steep escarpment on its northern flank and a variably incised dipslope on its southern flank. The base of the northern escarpment approximates the contact between the Matemateaonga and Kiore Formations. This arises because the Matemateaonga Formation contains tabular, well-cemented shellbeds, which are relatively resistant to weathering and form bluffs. The Kiore Formation comprises predominantly sandy siltstone, which is more prone to erosion than the Matemateaonga Formation. The prominent scarp is likely to have migrated south over time as a direct result of increasing uplift in central North Island, coupled with erosion and in the process has exposed the Matemateaonga and Kiore Formations.

A new geological map and stratigraphic framework

A combination of lithostratigraphic mapping and sequence stratigraphic analysis have been applied to subdivide and interpret the stratigraphy in Eastern Taranaki Peninsula. The geological map units include the **Kiore** and **Matemateaonga Formations** of the **Whangamomona Group**; **Tangahoe Mudstone (Formation)** and **Whenuakura Subgroup** of the **Rangitikei Supergroup**, Late Pleistocene marine terraces, river terraces; undifferentiated alluvium and Taranaki Volcanic ring plain deposits have also been mapped.

The new 1:50,000 scale geological map contains the following geological units:

Whangamomona Group

The Whangamomona Group includes a transgressive and regressive succession of Late Miocene – Early Pliocene (Tongaporutuan – Early Opoitian) age in the King Country region and eastern Taranaki Basin (Kamp et al. 2002, 2004). The lowermost unit is the shelfal Otunui Formation, which accumulated through Middle Miocene flooding of the King Country region. This unit is 100-200 metre thick. During the late-Middle Miocene the basin subsided to bathyal basin floor depths, allowing the accumulation of the Mt Messenger Formation at lower slope and basin floor positions. This represented the start of progradation of a regressive phase, followed by accumulation of middle and upper slope deposits, Urenui and Kiore Formations, respectively. The Matemateaonga Formation represents the progradation of a shelf setting across the underlying slope and basin floor environments.

Late Miocene (Late Tongaporutuan – Early Kapitean) Kiore Formation

KIORE FORMATION (Kf). This unit accumulated beneath Matemateaonga Formation as massive to parallel laminated siltstone, sandy siltstone and sandstone, punctuated by discontinuous channels infilled with fine-grained sandstone, siltstone, basement-derived well-rounded pebble to cobble conglomerate, and whole to highly fragmentary bioclastic material. The Kiore Formation can be distinguished from the overlying Matemateaonga Formation by the absence of continuous shellbeds with tabular geometry, and from the underlying Urenui Formation by the more volumetrically abundant sandstone content and a higher frequency of channel occurrences. Approximately 500 m thick.

Late-Miocene – Early Pliocene (Early Kapitean – Early Opoitian) Matemateaonga Formation

Cyclicity within the Matemateaonga Formation

A fundamental 6th order cyclicity exists within the shelfal deposits of the Matemateaonga Formation. The sequence stratigraphic model proposed by Naish and Kamp (1997) and modified by Kamp and McIntyre (1998) and McIntyre (2001) from Late Pliocene to Pleistocene shelfal strata in Wanganui Basin, is highly applicable to the sequence architecture of the Matemateaonga Formation. The Matemateaonga Formation succession accumulated in

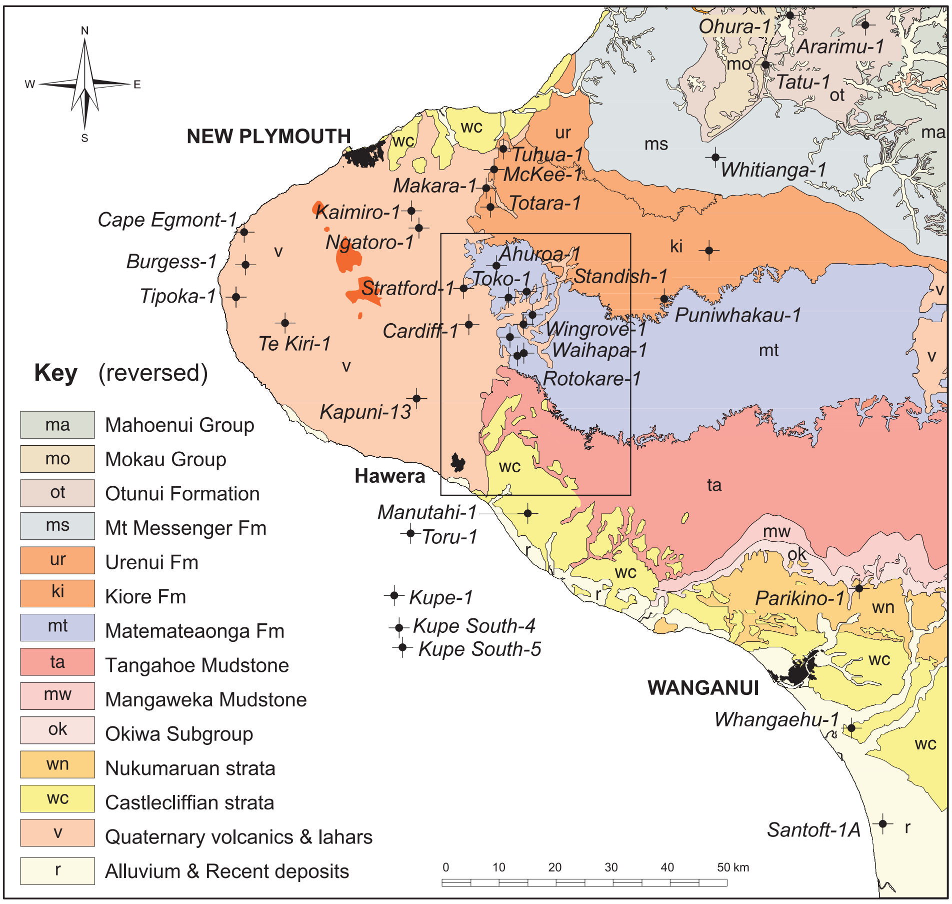


Figure 2. Generalised geological map of the Taranaki Region showing broad distribution of major geological units.

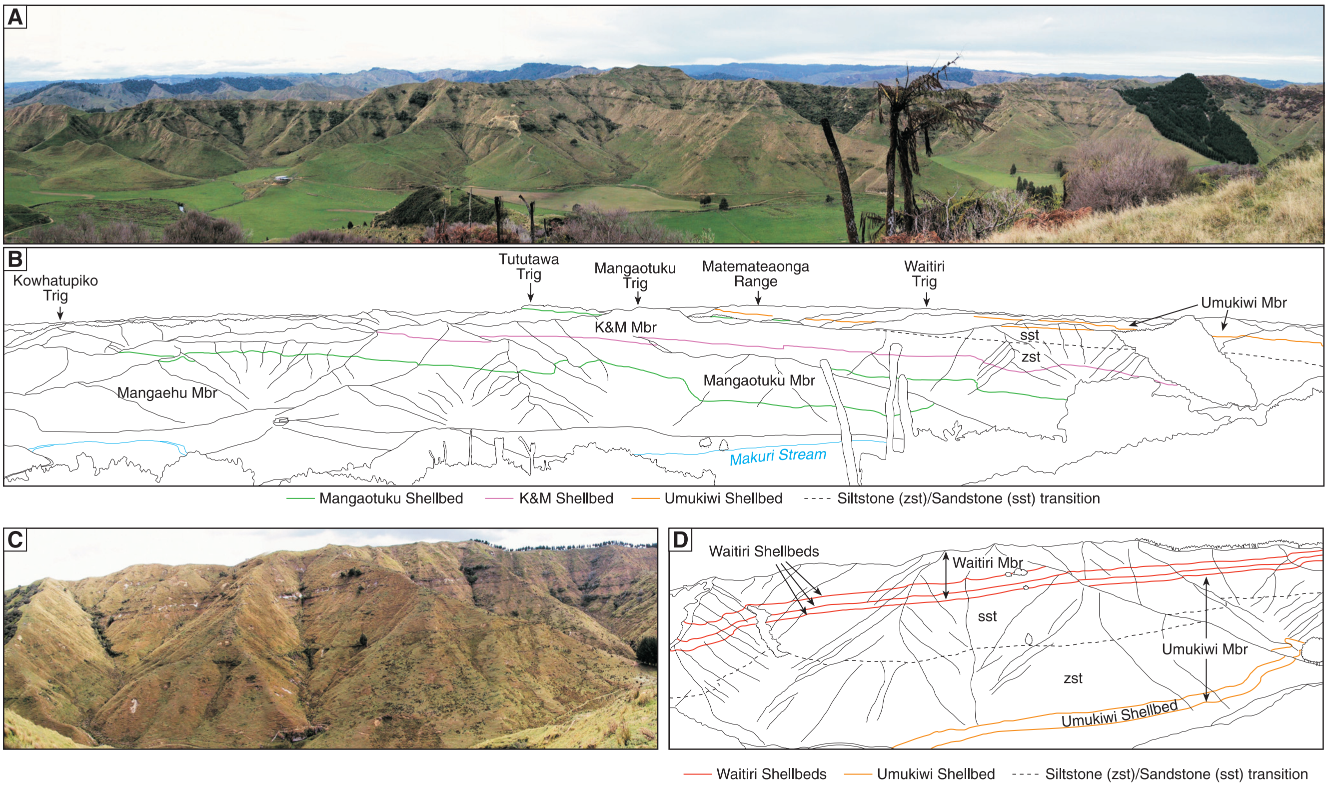


Figure 3. **A,** View of the south-west dipping Mangaehu, Mangaotuku, K&M and Umukiwi Members of the Matemateaonga Formation cropping out in the west-facing hills of the Makuri Stream Valley, near Mangaotuku Trig. **B,** Interpretive sketch of **A,** showing the stratigraphic relationships between the members. Note linear vegetation bands correspond to shellbeds or siltstone-sandstone contacts. **C,** View of north-east facing hills in the valley at the end of Tauwharenikau Road. **D,** Interpretive sketch showing the relationship between the Umukiwi and Waitiri Members in **C**.

shoreface to mid-shelf environments. This occurred on a broad, extensive continental shelf with a shoreline to the south and a broad progradational front to the north-northwest. The marked cyclicity in these shelfal deposits is a direct result of eustatic sea-level change shifting the depositional environments laterally on the paleoshelf. Details of the sequence architecture of the Matemateaonga Formation are reported in Vonk *et al*. (2002).

Lithostratigraphic subdivision of the Matemateaonga Formation

The Matemateaonga Formation is characterised by the cyclical repetition of coquina shellbed, siltstone and sandstone lithofacies. Lithostratigraphic members forming the geological map units are either individual sequences, or groups of sequences. Sequences are typically 10-90 m thick and comprise vertically stacked shellbed, siltstone and sandstone lithofacies, which are ascribed to the transgressive (TST), highstand (HST) and regressive (RST) systems tracts, respectively. The names of each of the lithostratigraphic members are derived from the enclosing shellbeds. The following members are identified within the Matemateaonga Formation in eastern Taranaki Peninsula, from oldest to youngest:

HUIROA MEMBER (Mhr). Metre-scale amalgamated beds of massive to planar to low-angle cross-bedded, well-sorted, fine-grained, slightly to moderately bioturbated, micaceous sandstone separated by mm-cm scale wavy mudstone beds. Grades downward into massive to planar bedded, moderately bioturbated silty sandstone containing near situ *Pratulum, Maorimactra, Atrina, Austrofusus, Chlamys, Xenostrobus* and barnacles. This in turn, grades downward into similar amalgamated sandstone facies as at the top of the unit with channelised and discontinuous 0.2-6 m thick matrix-supported, unfossiliferous conglomerates (HUIROA CONGLOMARATE AND HUIROA GRIT (hcl); Thoms 1942), comprising pebble to cobble sized, well-rounded, basement clasts (quartz, greywacke, argillite, jasper, schist, granite, chipwacke and gneiss) and rare larger elongate to oblate mudstone clasts (10-400 mm dia.) within a moderately loose, planar bedded (dm scale) fine-grained well-sorted sandstone matrix. 140-180 m thick in the vicinity of the Makino Stream but becomes finer-grained moving eastward.

GRAY'S MEMBER (Mgr). 2-3 m thick well-cemented, tabular, shellbed with fine sub-angular granule to pebble sized quartz, greywacke, argillite, jasper, schist and gneiss throughout (GRAY'S SHELLBED; Thoms, 1942), tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten, Tucetona*), erosional lower contact sharp upper contact. Overlain by wavy interbedded sandstone and mudstone, which is sharply overlain by massive to planar to low-angle cross-bedded, well-sorted, fine-grained, micaceous sandstone. 25-35 m thick.

CAVE MEMBER (Mcv). 2-2.5 m thick well-cemented, tabular, pebbly shellbed (CAVE SHELLBED; Thoms, 1942) tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten, Tucetona*), erosional lower contact sharp upper contact. Overlain by wavy interbedded sandstone and mudstone, which is sharply overlain by massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 6-12 m thick.

RAILROAD MEMBER (Mrr). 2-2.5 m thick well-cemented, tabular, pebbly shellbed (RAILROAD SHELLBED; Thoms, 1942) tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten, Tucetona*), erosional lower contact and sharp upper contact. Overlain by massive sandy siltstone, which grades upward into massive to cross-bedded med.-fine grained sandstone. 20-30 m thick.

MAKARA MEMBER (Mmr). 2-5 m thick tabular shellbed (MAKARA SHELLBED; Arnold, 1958) typically underlain by pebble to cobble basement conglomerate, with basal shellbed comprising planar bedded (5-20 cm) pebbly well-cemented shell hash, which grades upward into well-cemented, tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten).* Typically overlain by fine-grained sandstone or silty sandstone with well-rounded mudstone intraclasts. 0.5-2 m thick shellbed (Upper Twin Shellbed; Thoms, 1942) typically occurs 2-5 m above the Makara Shellbed. Both shellbeds grade into cross-bedded limestone (skeletal grainstone) in the Waipapa Stream, Puniwhakau Road. Makara Shellbed replaced by a 3 m-thick cross-bedded clast supported conglomerate in hill sections south of the Strathmore Golf Course (Makuri Road). 60-100 m thick.

MANGAEHU MEMBER (Mmg). Basal tabular shellbed (MANGAEHU SHELLBED; Thoms, 1942) 1- 3 m thick, well-cemented, tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten, Tucetona, Cucculaea, Eumarcia, Maorimactra, Zenatia*) in a silty sandstone matrix (Fig. 3). Not identified northeast of Kaikoura Fault. Typically overlain by sandy siltstone grading upward to massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone with pebble conglomerate lenses. Contains 10 m of cross-bedded, barnacle and sandstone hash immediately below the upper contact with the Brachiopod Bed. 50-80 m thick.

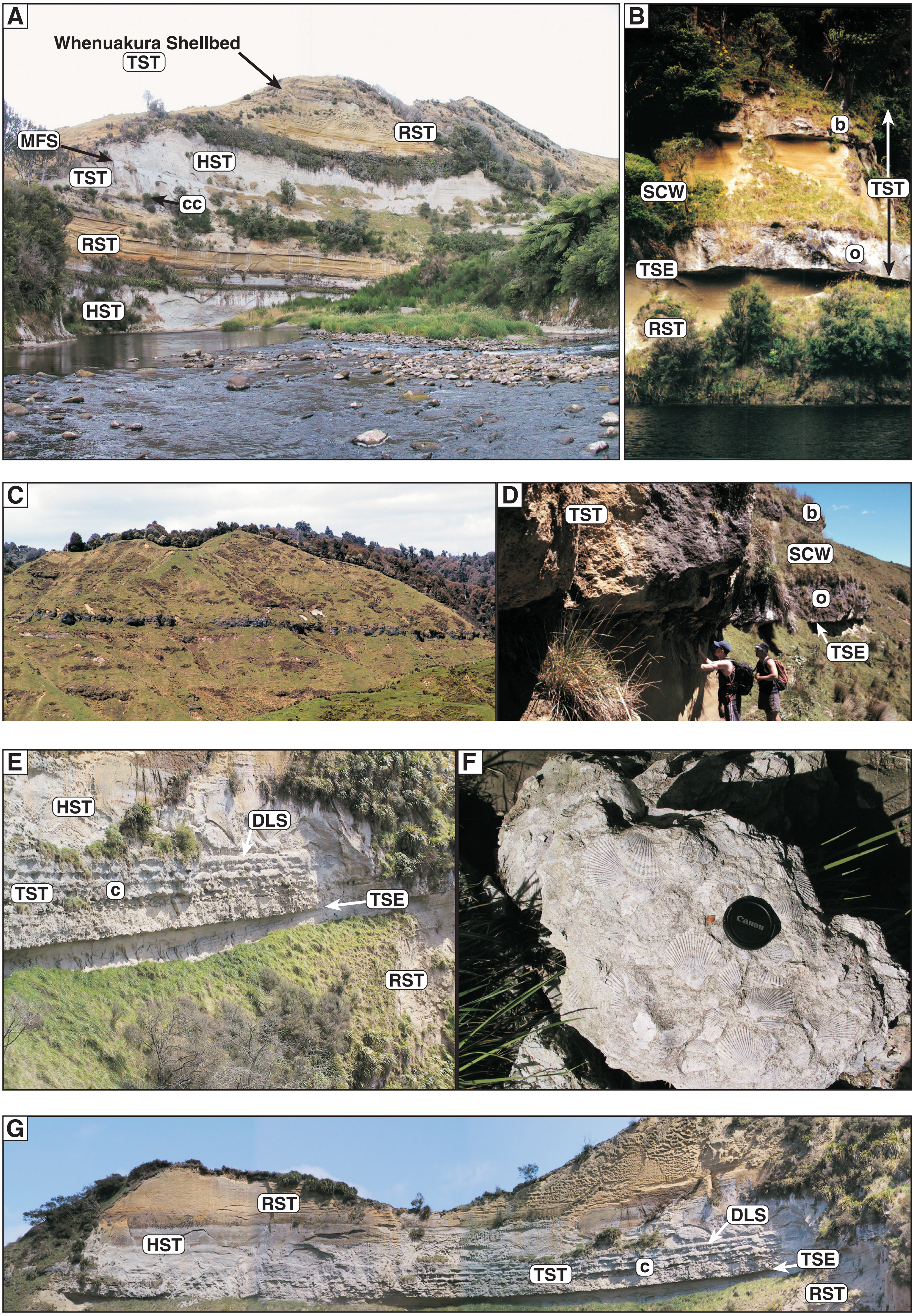
MANGAOTUKU MEMBER (Mbb). Basal shellbed comprises - southeast of Strathmore Saddle (MANGAOTUKU SHELLBED; Thoms, 1942) Massive, tabular, well-cemented conglomeratic shellbed 2-6 m thick, underlain by clast supported pebble to cobble basement conglomerate, overlain by 20 m massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone with rare pebble conglomerate lenses (Fig. 3). Fines upward into massive sandy siltstone. Northwest of Strathmore Saddle (BRACHIOPOD SHELLBED; Thoms, 1942) 5-8 m thick, well-cemented, dm bedded, cemented and non-cemented, barnacle dominated shell hash, grading upward into tightly-packed reworked bioclasts (*Ostrea, Crassostrea, Sectipecten, Purpurocardia, Mesopeplum, Xenostrobus*). The upper 50 cm has a siltstone matrix and contains well preserved specimens of the brachiopod *Neothyris sp.* and *Sectipecten wollastoni.* Typically overlain by 10-15 m of siltstone, which contains rare thin (2-10 cm) redeposited sandstone beds, coarsening upward to massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 20-30 m thick.

K & M MEMBER (Mkm). Comprises a basal tabular, well-cemented shellbed (K & M SHELLBED; Thoms, 1942) of poorly preserved, tightly-packed reworked bioclasts (*Phialopecten, Ostrea, Crassostrea, Tawera, Tucetona, Glycymeris)*, highly dissolved fabric, sharp lower and upper contact (Fig. 3). Typically overlain by 20 m of massive silty sandstone with a sparse, 0.5-0.7 m thick matrix supported pebble conglomerate with whole and fragmentary *Ostrea, Dosina, Austrofusus coerulescens* and *Zeacolpus* (ROGER'S CONGLOMERATE; Thoms, 1942). Roger's Conglomerate is typically overlain by massive, blue-grey to orange brown sandy siltstone grading successively upward into massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone, wavy interbedded mudstone and sandstone (cm-dm scale), and pebble conglomerate near the upper contact with the Umukiwi Shellbed. 50-90 m thick.

UMUKIWI MEMBER (Mum). Prominent 4-8 m thick well-cemented tabular pebbly shellbed (UMUKIWI SHELLBED; Thoms, 1942) comprised of tightly-packed reworked bioclasts (*Phialopecten marwicki* (First occurrence in eastern Taranaki)*, Ostrea, Crassostrea, Tawera*), moderately to well preserved, variably stratified within a fine-grained sandy matrix (Figs 3 & 4). Sharp to erosional lower contact, sharp upper contact. Shellbed is often separated into lower (onlap) and upper (backlap) parts by a 0.5-2 m thick massive fine-grained sandstone (Waitiri Trig section and outcrop immediately south of Mangaotuku Trig). Northwest of Wawiri Road the Umukiwi Shellbed is underlain by a clast-supported pebbly conglomerate with well cemented fine-grained sandstone lenses. On rare occasions north and west of Rainy Point, the conglomerate forms the marker horizon with no shellbed present. Overlain by massive, bioturbated siltstone, which in turn grades upwards into, or is sharply overlain by massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 60-100 m thick.

WAITIRI MEMBER (Mwt). Multiple shelfal sequences comprising vertically stacked shellbed, siltstone and sandstone lithologies (Figs 3 & 4). 70-100 m thick. Contains three well-cemented shellbeds (WAITIRI SHELLBEDS; Arnold, 1958) informally named Waitiri a, b and c. These are best exposed in the Tauwharenikau Valley (a, b and c) and the Waitiri Trig section (a, c) and are separated by 4-8 m of sandy siltstone. Shellbeds reduce in number moving east from the Tauwharenikau Valley to a single shellbed (Waitiri c) encountered in exposures along Raupuha Road.

WHENUAKURA MEMBER (Mwh). Prominent thick (4-7 m) tabular, well-cemented pebbly shellbed (WHENUAKURA SHELLBED; Thoms, 1942) comprised of tightly-packed reworked bioclasts of diverse infaunal and epifaunal taxa (*Phialopecten, Tawera, Ostrea, Crassostrea, Purpurocardia, Trachycardium, Eumarcia, Neothyris*), moderately to well preserved, variably stratified within a fine- to medium-grained


A
Whenuakura Shellbed
TST
RST
MFS
HST
TST
cc
RST
HST
B
b
TST
SCW
o
TSE
RST
C
D
TST
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SCW
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TSE
E
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DLS
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c
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F
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G
RST
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sandy matrix (Figs 3 & 4). Sharp to erosional lower contact, sharp upper contact. Overlain by massive, bioturbated siltstone which in turn grades upwards into, or is sharply overlain by, massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 10-20 m thick.

HOLMWOOD MEMBER (Mhw). Thin 0.1-1 m well cemented shellbed comprised of tightly to loosely-packed reworked bioclasts of infaunal and epifaunal taxa (*Phialopecten, Ostrea, Phialopecten, Trachycardium, Purpurocardia, Chlamys, Alcithoe, Neothyris*), moderately to poorly preserved, within a fine-grained sandy matrix. Sharp to erosional lower contact, sharp upper contact. Shellbed thins to a sparse horizon of in-situ *Maorimactra* to the east of Holmwood Station and to the west of the Mangamingi bridge. Overlain by massive, bioturbated siltstone, which in turn grades upwards into massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 20-40 m thick.

RAWHITIROA MEMBER (Mrt). Tabular, well-cemented shellbed (RAWHTIROA SHELLBED; Arnold, 1958) comprised of tightly-packed reworked bioclasts of diverse infaunal and epifaunal taxa (*Phialopecten, Ostrea, Crassostrea, Purpurocardia, Lima, Trachycardium, Eumarcia, Neothyris*), moderately to well preserved, variably stratified within a fine- to medium-grained sandy matrix. Sharp to erosional lower contact, sharp upper contact. Thins westward from the Mangamingi Bridge. Overlain by massive, bioturbated siltstone, which in turn grades upwards into massive to planar to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 20-30 m thick.

MABEN MEMBER (Mmb). Multiple shelfal sequences comprising vertically stacked shellbed, siltstone and sandstone lithologies. 80-180 m thick. OMOANA SHELLBED (Mom) 30-50 cm thick, pebbly with sparse shells within silty sandstone matrix, whole and fragmented shell *(Xenostrobus, Phialopecten, Tawera, Tucetona, Glycymeris, Dosina, Eumarcia, Chlamys, Amalda*) commonly leached. MABEN SHELLBED (Mms) two 40 cm horizons of sparse disarticulated valves in massive sandy siltstone matrix (Maben Road, west of bridge). MOREA SHELLBED (Mmo) well-cemented tightly-packed reworked bioclasts of infaunal and epifaunal taxa (*Ostrea, Crassostrea, Tawera, Oxyperas, Phialopecten, Zeacolpus*), poorly to moderately preserved, variably stratified within a fine- to medium-grained sandy matrix. Sharp to erosional lower contact, sharp upper contact. Overlain by sandy siltstone in the Whenuakura River section and fines eastward to massive blue-grey frittery claystone at Moeroa. TURANGA SHELLBED (Mtr) 50 cm well-cemented shellbed, sharp base and top, only encountered in cliff sections of the Whenuakura River.

REHU MEMBER (Mrh). Comprises a basal 2 m thick, tabular, well-cemented shellbed (REHU SHELLBED; Arnold, 1958), which grades laterally to a 1.5m thick moderately cemented, horizon of flaser to wavy interbedded (cm scale) fine sandstone and mudstone with a sharp erosional base northwest of Hauha Stream (Mangamingi Valley)(Fig. 4). Massive, bioturbated siltstone overlies the basal shellbeds, which in turn grades upwards into massive to planar bedded, well-sorted, fine-grained micaceous sandstone. 50-70 m thick.

KURAITI MEMBER (Mkr). Two 2.5 m thick well-cemented shellbeds (KURAITI TWIN SHELLBEDS; Arnold, 1958) separated by 0.5-2 m of massive to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone (Fig. 4). Massive, bioturbated siltstone overlies the basal shellbeds, which in turn grade upwards into massive to planar- to low-angle cross-bedded, well-sorted, fine-grained micaceous sandstone. 30 m thick in the cliffs of the Patea River and thicken eastward to 120 m in the lower Moeawatea Valley.

PARANGAREHU MEMBER (Mpr). Tabular, well-cemented shellbed (PARANGAREHU SHELLBED; Arnold, 1958) comprised of tightly-packed reworked bioclasts of infaunal and epifaunal taxa (*Ostrea, Crassostrea, Tawera, Oxyperas, Phialopecten*), poorly to moderately preserved, variably stratified within a fine- to medium-grained sandy matrix. Sharp to erosional lower contact, sharp upper contact. Overlain by 6 m of well-sorted, silty sandstone, which grades into Tangahoe Mudstone over several metres. 5-10 m thick.

Figure 4. Selected lithologies, systems tracts and unconformities within the Matemateaonga Formation. **A,** Cliff exposure of part of the Waitiri and Whenuakura Members in the Patea River, near the mouth of the Makaria Stream (NZMG Q20 E2634244, N6200966). Here the upper cycle of the Waitiri Member exhibits a symmetrical sequence architecture with no shellbed forming on the sequence boundary; rather a deeper-water correlative conformity marked by a rapid transition from massive to planar-bedded, fine-grained sandstone into bioturbated sandy siltstone. The deepest part of this sequence is represented by a 1 m-thick siltstone horizon, which is in turn overlain by massive, bioturbated sandy siltstone. The maximum flooding surface (base of 1 m thick siltstone) separates the TST from the HST. The Whenuakura Shellbed forms the TST of the overlying sequence (Whenuakura Member). **B,** Onlap and backlap shellbeds of the Kuraiti Member (Kuraiti Twin Shellbeds), exposed in the banks of Lake Rotorangi (NZMG Q21 E2640135 N6186412). **C,** Superb exposure of the 7 m-thick Umukiwi Shellbed in the Pipi Stream Valley, near Tututawa (NZMG Q20 E2643897 N6205106). **D,** Onlap shellbed of the Kuraiti Member (Kuraiti Twin Shellbeds) erosionally overlying the regressive sandstone of the underlying sequence (Rehu Member) in a hill section near the Kuraiti Trig, Lake Rotorangi (NZMG Q21 E2639569 N6188944). **E,** The Whenuakura Shellbed truncates the underlying planar-bedded sandstone of the Waitiri Member, forming a subtle angular unconformity. This outcrop is exposed in a cliff section of the Patea River near the mouth of the Maruarau Stream (NZMG Q20 E2635303 N6199696). **F,** Float block from the backlap (upper) part of the Whenuakura Shellbed, exposed in the Whenuakura River (NZMG Q20 E2647074 N6196220). The scallop *Phialopecten marwicki* dominates the species within these epifaunal-dominated backlap shellbeds, suggesting firm substrates and a low terrigenous sedimentation rate during deposition. **G,** Cliff exposure of the Whenuakura Member in the Patea River near the mouth of the Maruarau Stream (NZMG Q20 E2635303 N6199696; same section as that in photo E). Abbreviations for A, B, D, E, G: (TST) transgressive systems tract; (HST) highstand systems tract; (RST) regressive systems tract; (SCW) shore-connected sediment wedge; (MFS) maximum flooding surface; (cc) correlative conformity; (TSE) transgressive surface of erosion; (DLS) downlap surface; (o) onlap shellbed; (b) backlap shellbed; (c) compound shellbed.

The basal strata of the Matemateaonga Formation are of particular interest. A 280 m thick sandstone-dominated interval comprising the Railroad, Cave, Gray's and Huiroa Members, which crops out in the Huiroa-Te Popo-Kupe region, are correlative units, both chronologically and lithologically, of the "Manutahi Sands" and/or "Waiouru Sandstone" named in exploration well reports for sites south of the mapping area (i.e. Manutahi-1; Kauri and Rimu wells). These sequences become increasingly finer-grained in eastern outcrop areas of the western Matemateaonga Range and ultimately grade into Kiore Formation, suggesting a localised paleoslope from west to east.

Late Pliocene (Late Opoitian to Waipipian) Rangitikei Supergroup (Taihape Group)

TANGAHOE MUDSTONE (Tm). Massive, to faintly parallel laminated, blue-grey, variably bioturbated mudstone. Contains 0.1-5 m thick, fine-grained, well-sorted, micaceous redeposited sandstone units with wavy to sharp lower contacts and sharp to gradational upper contacts throughout. Occasional *Atrina pectinata zealandica*. 360-450 m thick. Tangahoe Mudstone contains in basal sections - MAUNGATITI SANDSTONE MEMBER (Tms). Prominent, fine-grained, well-sorted, micaceous, blue-grey to orange-brown, redeposited sandstone unit with a wavy to sharp lower contact and a sharp to gradational upper contact. Contains rounded to angular mudstone rip-up clasts in basal 2 m. Thickness increases from 4 m in the Mangamingi and Tangahoe Valleys to 20 m in hills surrounding the Patea Dam. At the Patea Dam a 3 m thick by 40 m wide channel intersects the Maungatiti Sandstone Member and is infilled with poorly-sorted, coarse-grained, basement type cobble to pebble conglomerate with disarticulated and fragmentary bioclastic material.

UNDIFFERENTIATED WHENUAKURA SUBGROUP (Wh). Cyclothemic shallow marine sediments comprising bivalve mollusc dominated shellbeds, fine-grained, well-sorted, massive and bedded, blue-grey to orange-brown, micaceous, siliciclastic sandstone and mudstone. 270 m thick.

Quaternary (Castlecliffian to Haweran) deposits

Marine terraces (NGARINO TERRACE (pn); BRUNSWICK TERRACE (pb); ARARATA TERRACE (pa); RANGITATAU TERRACE (pt); BALL TERRACE (pl)) comprising a wave cut platform (typically bored by *Barnea similis*) and terrace surface, separated by both marine and non-marine deposits, which include: fine-grained, well-sorted, micaceous sand (both marine and dune sands); silt; shellbeds; gravel or conglomerate; laharic breccia or laharic conglomerate; concretions or nodules; lignite or tephric lignite; rhyolitic tephra or ash beds; andesitic tuff, tephra or ash beds; pumice lapilli; and peat. Terraces are bounded on their inner and outer edges by fossil sea cliffs, which have a strandline at their basal intersection with the wave cut platform. Terrace stratigraphy is incorporated from Pillans (1990).

River terrace deposits (Qt1, Qt2, Qt3, lQt). Poorly sorted gravel, sand, mud, peat, lignite, andesitic and rhyolitic tephra, laharic andesite conglomerate or breccia.

Undifferentiated alluvial deposits (lQa). Poorly sorted gravel, sand, mud, peat, lignite, andesitic and rhyolitic tephra, laharic andesite conglomerate or breccia.

Mass movement deposits (Qls). Poorly-sorted incoherent deposits resulting from slump, block fall and landslide events.

Undifferentiated Egmont, Pouakai and Kaitake Volcano ring plain deposits (Qel). laharic andesite conglomerate and breccia with minor peat, tephra, tuff, lignite, terrestrial sand, silt and mud. Incorporates OPUNAKE, STRATFORD, LEPPERTON, MAITAHI and ELTHAM LAHARS of Hay (1967).

Structure and faulting

The mapping area sits astride the southward-plunging Whangamomona Anticline, which has deformed the Late Neogene succession, producing a regional dip on its western flank of 2 to 4 degrees to the southwest. The anticline axis strikes through the lower reaches of Lake Rotorangi, near the Patea Dam, and intersects the south Taranaki coast immediately north of Mangaroa Stream. Northeast-southwest trending normal faults are relatively common and offset Matemateaonga Formation strata with throws of 2-50 m. Most faults have little or no surface expression. Rather, they are identified by offset on shellbed marker horizons. This combined with the similar thickness of the cyclothems compounds the correlation problem. Some of the more significant faults in the mapping area include the Aorere Fault, Mangamingi Fault, Strathmore Saddle Fault, Tarerepo Fault and the Mana Fault.

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