静岡大学地球科学研究報告 20（1994年3月）91頁～113頁
Geosci. Repts. Shizuoka Univ., 20 (Mar., 1994), 91-113

Stratigraphy of the Neogene marine sequence to the east of Dannevirke, southern Hawke's Bay, New Zealand

Noboru FUJII[1], Tetsuyuki YAMAMOTO[2] and Nobuaki NIITSUMA[3]

Abstract A field survey documented the lithostratigraphy and sampled for biostratigraphic, paleomagnetic and isotopic analyses of sedimentary sections to the east of Dannevirke, Southern Hawke's Bay, New Zealand. The studied marine sequence was deposited in the forearc basin along the Hikurangi Trench from the late Miocene to the latest Pliocene. The marine sequence is divided into Moastone, Mapiri, Mangatoro, Pukerua, Te Aute, Okarae, Kumeroa, and Mangatarata Formations in ascending order. The sedimentary sequence is cut into spindle shape blocks by faults with right lateral movements. Oxygen and carbon isotopes of foraminiferal tests indicate that the sedimentary environment was shallow, with relatively higher near-bottom than surface primary production. A distinct tectonic event occurred in the latest Pliocene, 2.2 Ma, reflected in an angular unconformity at the base of the Kumeroa Formation and deformation of the formation immediately after its deposition. The event rearranged the forearc basin and terminated the deposition within it. The event was associated with volcanic activity.

Key words: New Zealand, southern Hawke's Bay, Neogene forearc basin, collision, Alpine Fault, magnetostratigraphy, biostratigraphy, oxygen and carbon isotopes

INTRODUCTION

New Zealand, which comprises two main islands, is situated on the boundary between the Indian-Australian Plate and Pacific Plate. It is associated with the Kermadec Trench system to the north, and with the Macquarie system to the south. The islands were part of the Gondwana Margin, but have been an accretionary complex since the Triassic (Spörli & Ballance 1989; Aita & Spörli 1992; Pettinga 1982), thus they are covered with forearc and backarc marine sediments and island arc volcanics related to subduction tectonics. The Alpine Fault and associated faults cut them with a northeast strike and act as a transform plate boundary (Fig. 1).

The Chatham Rise is colliding with the South Island, and the Hikurangi Trench is bending westward and closing (e.g., Allis 1986). The collisional process is recorded in the sedimentary sequence deposited on the forearc basin, and the sediments are exposed on eastern part of the North Island as result of the collisional process. Southern Hawke's Bay province provides good exposures of the Neogene marine sequences of the forearc basin (e.g., Suggate 1978). The area between east of Takapau and east of Dannevirke was selected for this study (Fig. 1). The purpose of this study is to describe the geology of the sedimentary sequences and the collisional process, based on stratigraphic work in the field and biostratigraphic and paleomagnetic investigations on the sediments.

The studied area has been mapped by the New Zealand Geological Survey and oil companies, and Lillie (1953) published his stratigraphic work with a compilation of previously published and unpublished data. There was some confusion about the stratigraphic position of the intercalated limestones, especially the "Te-Aute limestone", and Beu *et al.* (1980) re-examined the limestones based on molluscan biostratigraphy.

Magneto-bio-stratigraphic datum planes have been established and compiled for the Neogene sedimentary sequences of New Zealand and core samples from the Deep Sea Drilling

---

[1] Mitsui Mining & Smelting Co., Ltd., 2-1-1 Nihonbashi-Muromachi, Chuo-ku, Tokyo, 103 Japan.
[2] NEC Information Service Ltd., 1-4-28 Mita, Minato-ku, Tokyo, 108 Japan.
[3] Institute of Geosciences, Shizuoka University, 836 Oya, Shizuoka, 422 Japan.

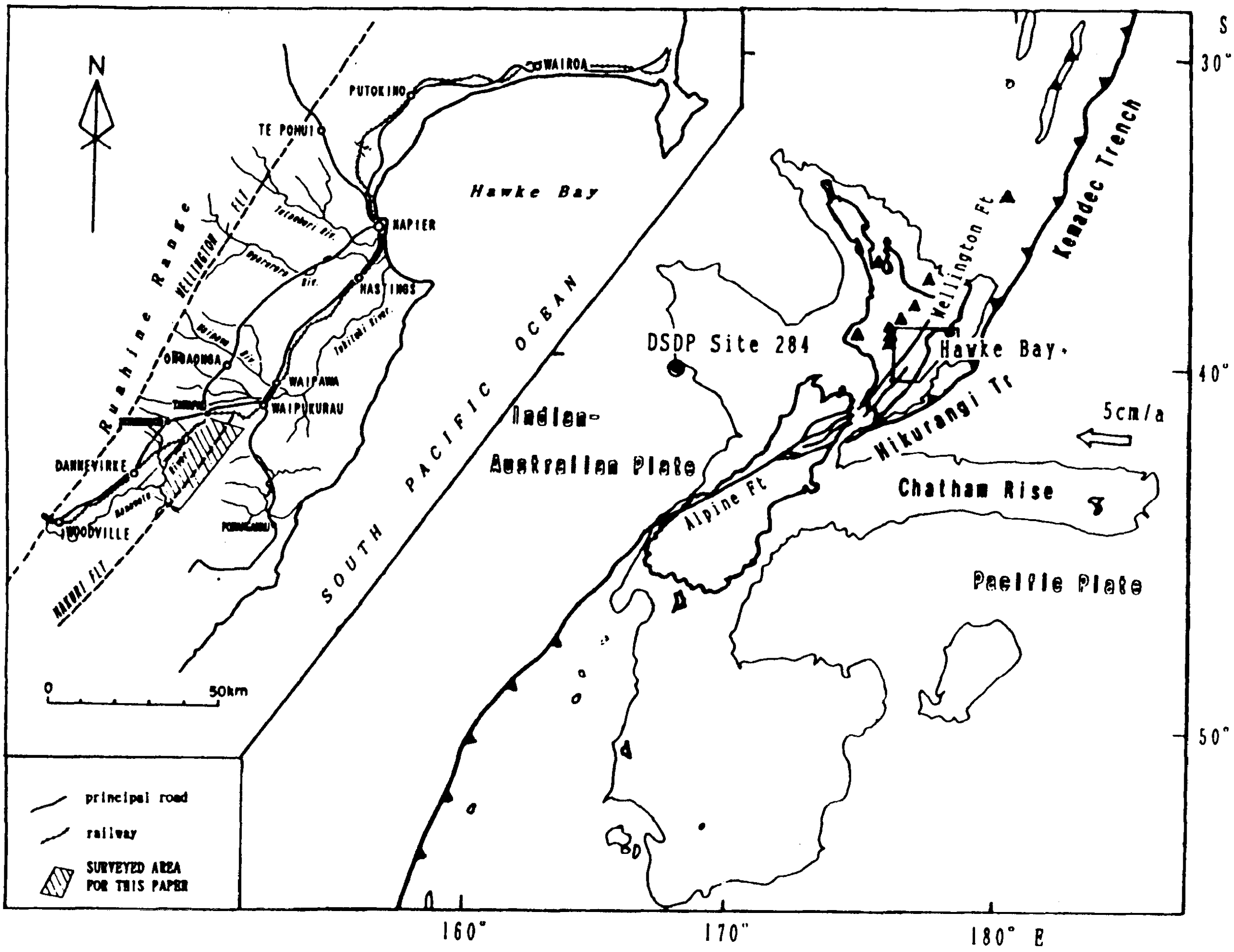


Fig. 1 Index map of the study area.

Project (Edwards 1987). This study applied the newly established datum planes directly to the stratigraphic sequence and documents the processes of subduction and collision quantitatively.

The authors carried out the field survey and sampling in the Dannevirke district during the summers of 1981-1982, 1983-1984 and 1985, more than 260 days, and the total number of the collected samples for magneto-biostratigraphic and isotopic studies are 126 from successive stratigraphic sequences and 81 from sporadic exposures.

Topographic maps on the scale 1:25000, which were used for the field work, were drawn with enlargement of the 1:63360 map from the Lands and Survey Department, and stream lines were retraced using air photographs.

STRATIGRAPHY

The Neogene marine sequence of the forearc basin in this area is composed of soft massive siltstone, sandstone, and alternating sandstone and siltstone. This sequence contains several sedimen-tary cycles and is classified into eight formations based on these cycles: the Moastone, Mapiri, Mangatoro, Pukerua, Te Aute, Okarae, Kumeroa and Mangatarata Formations, in ascending order (Figs. 2 and 3). Coquina limestone beds, which consist mainly of indurated shell fragments, are intercalated in the basal part of the sedimentary cycles. The limestone beds form a dip-slope on the topography, which is traced easily in the field. Most of the formations were deposited conform-ably upon each other, but the base of the Kumeroa Formation overlies unconformably the other formations. The basement of the Neogene marine sediments is

"Greywacke" and Paleogene rocks, mostly a pre-Neogene accretionary complex.

The sedimentary sequence is cut by northeast-trending faults and divided into spindle-shaped blocks. The bedding planes generally dip northwestward in the faulted blocks, and south-east dipping is developed along the western margin in some faulted blocks.

In this paper, the authors use the previously established stratigraphic names of Lillie (1953) as far as possible, and use new names only for the units which are newly distinguished lithologically (Fig. 4).

1. "Greywacke" and Paleogene Rocks

The term "Greywacke" has been used broadly to describe the entire indurated accretionary complex presumed to be older than Cretaceous age. In this district, the authors use the term for the rocks which constitute the basement of the Neogene marine sequence.

"Greywacke" is exposed in six areas along the eastern margins of faulted blocks in this district (Fig. 2). The "Greywacke" consists of ill-sorted massive hard dark-grey sandstone characterized by rusty weathering and sheared slickenside. The rocks are easily distinguished from Neogene marine sediments which unconformably cover them.

"Greywacke" is overlain unconformably with "Paleogene" (including early Miocene) dark-grey rocks banded with pebbles in the Mangapurakau Stream outcrop. Most of the "Greywacke" and the "Paleogene rocks" are covered unconformably by the Mapiri Formation in the north, and by the Mangatoro Formation in the central and southern parts.

"Paleogene" dark-grey siltstones with occasional glauconitic sandstone is exposed along the eastern margin of this district, and the contact with the Neogene marine sequence is a fault (Fig. 2).

2. Moastone Formation (new name)

Type Locality: Along the Pamanuka Stream, a tributary of the Mangapuaka Stream.

Distribution: the Moastone Formation is exposed along the northeastern margin of this district, and the central part along the Mangapuaka Stream and Pamanuka Stream.

Classification: The Moastone Formation is equivalent to the lower part of the "Mapiri Formation" used by Lillie (1953). The name **Moastone Formation** was first used by Fujii (1983ms) to distinguish lithological facies in the "Mapiri Formation".

Lithology: The Moastone Formation consists mainly of smooth dark-grey sandy siltstone. Occasional round and lenticular calcareous concretions up to 3 m in diameter, and molluscan shells are commonly contained (Photo 1). The surface of the outcrops are usually weathered white to light-grey.

Near the base of the formation, massive siltstone grades downward to sandstone with hard shelly limestone beds (50 cm maximum thickness), the lowest of which contains pebbles of hard sandstone. The formation unconformably rests upon Paleogene rocks. Sand pipes projecting into the Paleogene rocks are commonly found at the lowest boundary of the limestone.

Thickness: The formation ranges in thickness from 200 to 600 m. It thickens to the north and attains its maximum thickness at the head of Ngahape Stream.

Relation: The formation is mostly overlain conformably by the Mapiri Formation and uncon-formably by the Mangatoro Formation, and covers Paleogene rocks and "Greywacke" with basal limestone beds.

3. Mapiri Formation

Type Locality: Mapiri Point in the Wairoa Subdivision (Ongley 1930), northern Hawke's Bay. Typical exposures are developed at the head of Whatatuna Stream in the middle to eastern part of the study area.

Distribution: The Mapiri Formation crops out in the southeast of Takapau, southeast of the Turiri Range and along the Mangapuaka Stream.

Classification: The name **Mapiri Formation** was given by Ongley (1930) at Mapiri Point. In the Dannevirke Subdivision, Lillie (1953) used the term "Mapiri" for the rocks approximately equivalent to the strata of the Tongaporutuan Stage. The "Mapiri Formation" adopted by Lillie can be divided into a lower massive siltstone facies and an upper alternation facies. The term "Mapiri" used in this paper is equivalent to the upper part of the "Mapiri Formation" of Lillie (1953).

Lithology: The Mapiri Formation consists chiefly of an alternation of pumiceous creamy grey siltstone and fine-grained sandstone associated with fine-grained tuff beds (Photo 2).

In the southeast of Takapau, the formation is distributed along the west side of the "Greywacke". Laminated fine sandstone with bands of conglomerate ranging in thickness from 20 cm to 100 cm occur at basal part of the formation. Fragments of molluscs, lenticular calcareous concretions (20 cm maximum thickness), and very coarse-grained glauconitic sandstone are also associated with the basal part. These rocks rest directly on "Greywacke" and grade up into siltstone alternated with fine-grained sandstone and tuff beds. The maximum thickness of the sandstone in the alternation thins northward from 100 cm to 5

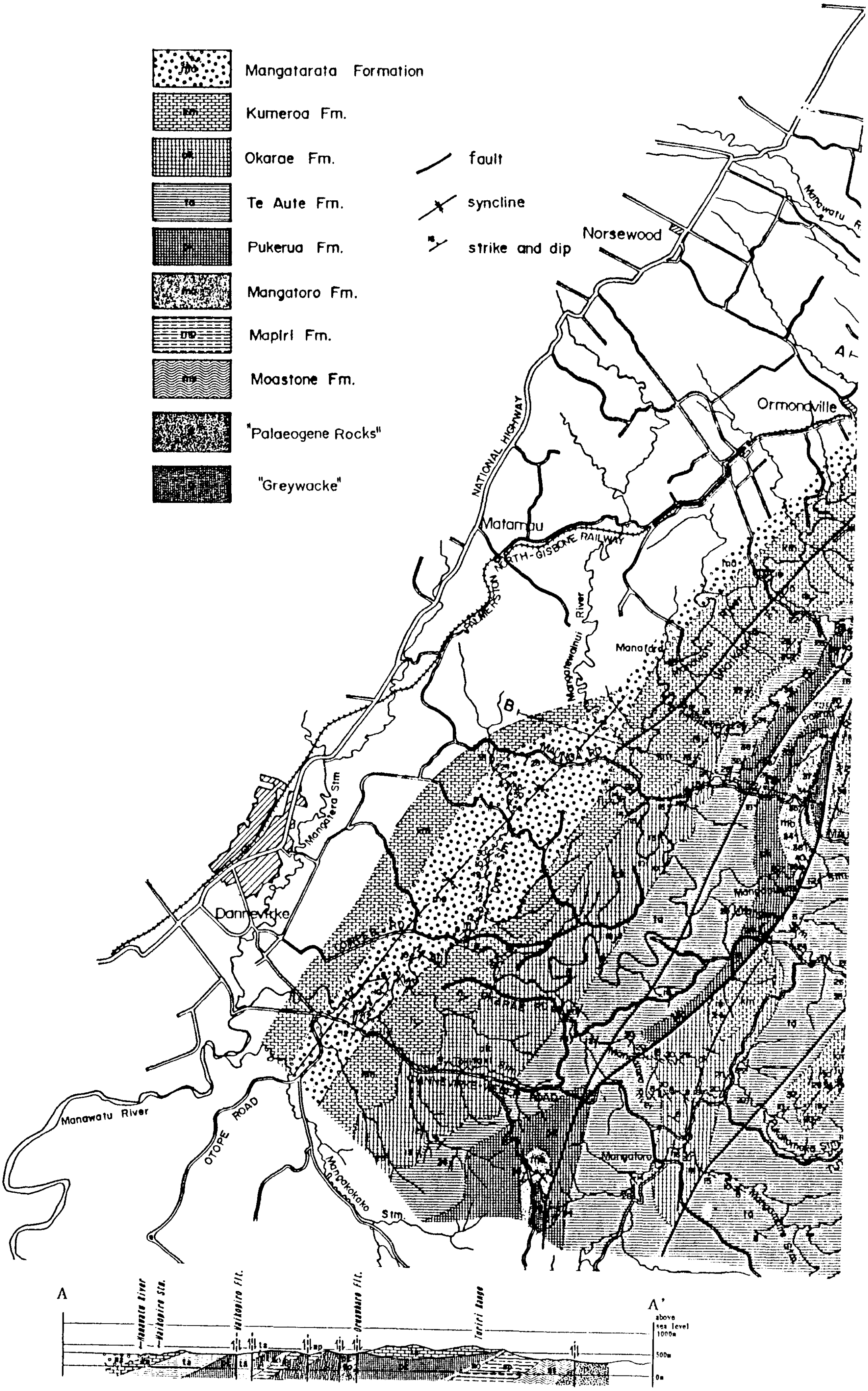
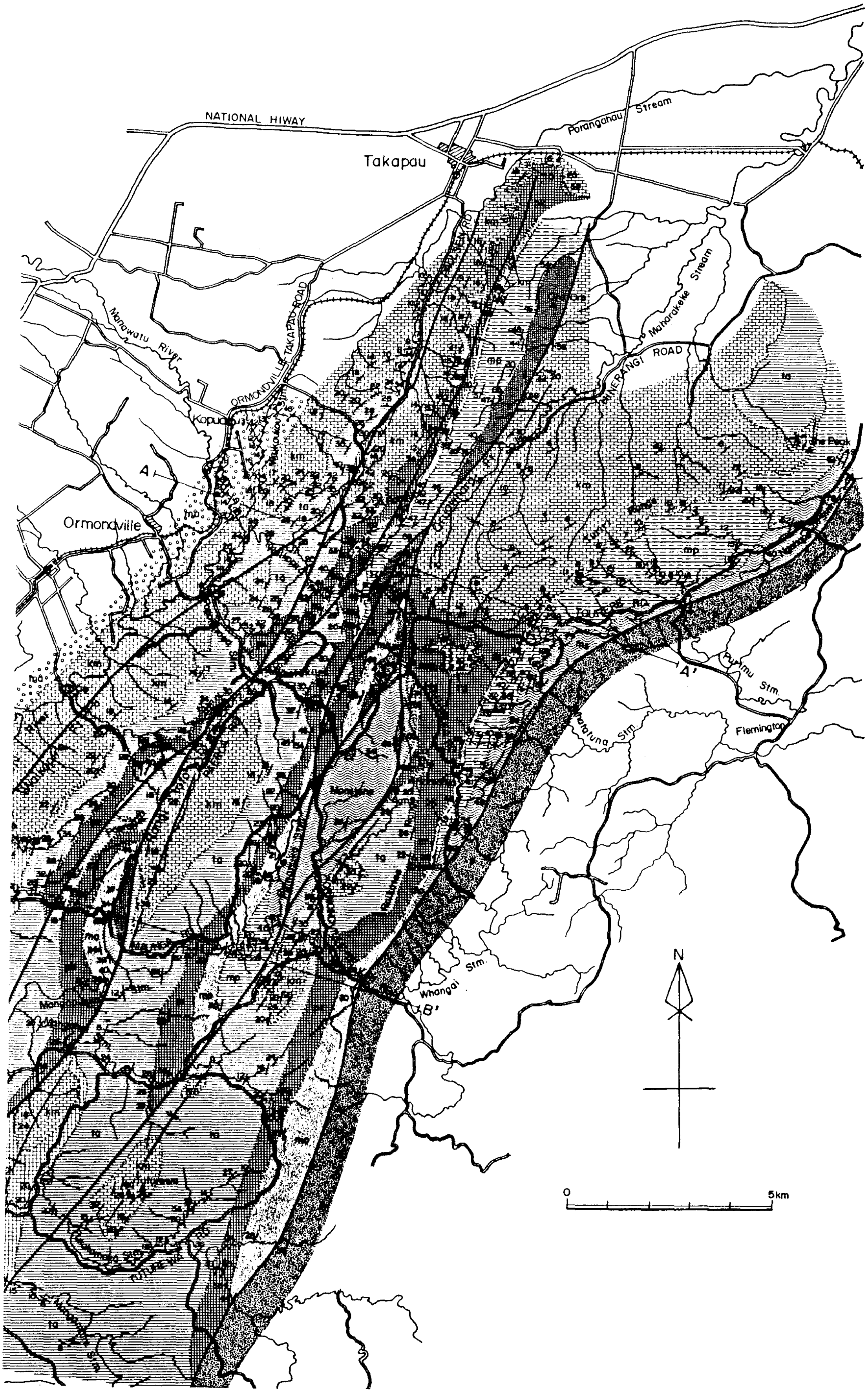
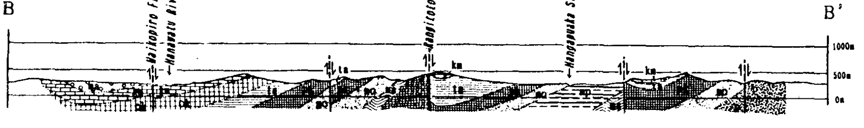


Fig. 2 Geologic map of Neogene sedimentary sequence to the east of Dannevirke, southern Hawke's Bay, New Zealand. Fm: formation


NATIONAL HIWAY
Takapau
Porangahau Stream
Manawatu River
ORMONDVILLE TAKAPAU ROAD
Maharakeke Stream
WIMBLEDON ROAD
Kopua
A
Ormondville
A'
Puhimu Stm.
Flemington
Whangai Stm.
B'
The Peak
ta
km
mp
N
0
5km


B
B'
Waikopiro Flt.
Manawatu River
Rangitoto Flt.
Mangapuaka Stm.
ta
km
1000m
500m
0m

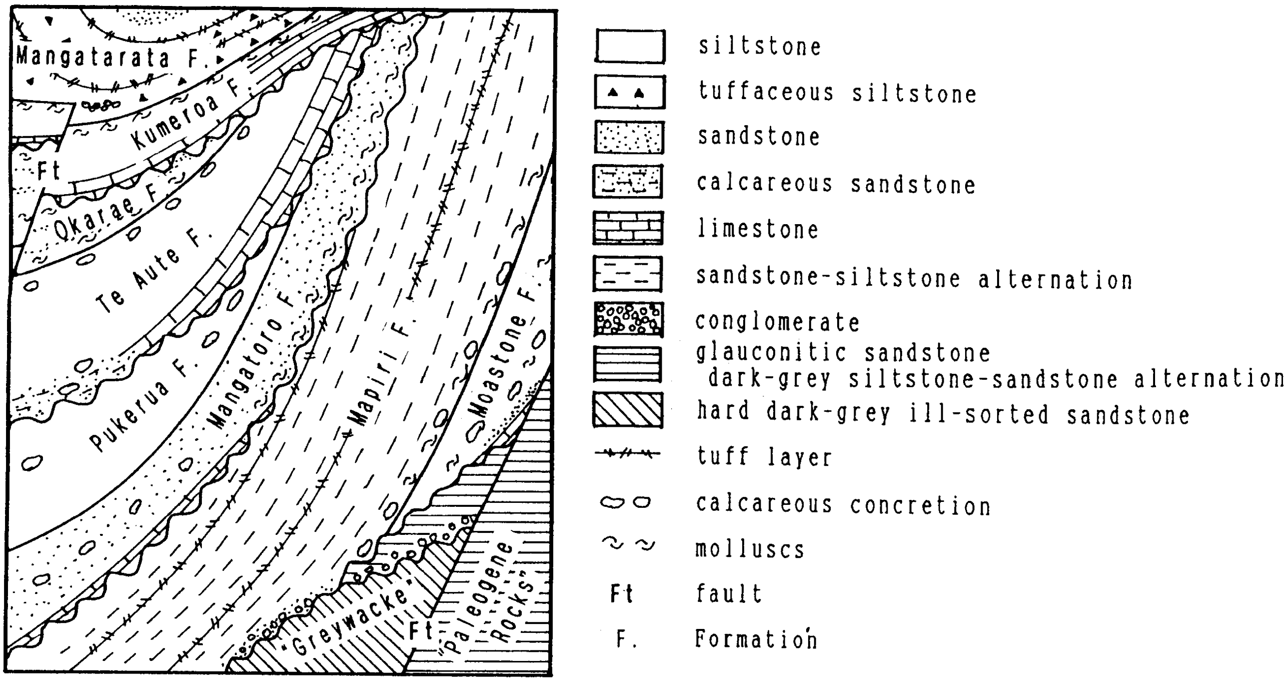


Fig. 3 Schematic cross section of Neogene sedimentary sequence to the east of Dannevirke, southern Hawke's Bay, New Zealand.

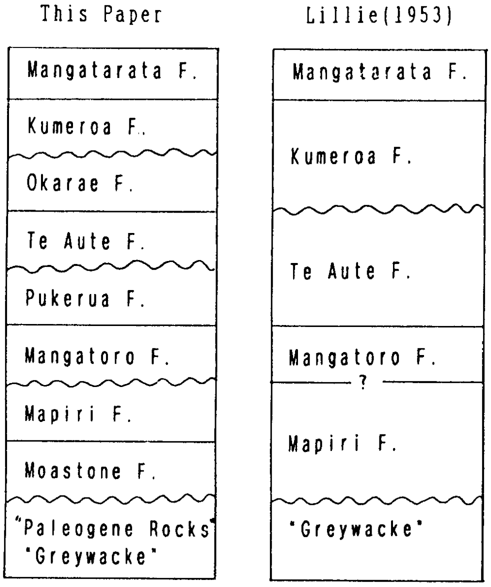


Fig. 4 Comparison of table of stratigraphic divisions between this paper and Lillie (1953). F.: Formation.

cm.

In the southeast of the Turiri Range, the Mapiri Formation consists of alternating sandstone and siltstone, and contains white tuff beds. The siltstone of the alternation is creamy grey medium-grained siltstone ranging in thickness from 20 cm to 100 cm. The maximum thickness of the sandstone of the alternation is 50 cm. The thickness of the tuff beds ranges from 5 cm to 200 cm. Grading is present in both the sandstone and tuff beds.

At Mangapuaka Stream, the Mapiri Formation consists mainly of very fine-grained sandstone and sandstone-siltstone alternations. Fragments of molluscs and lenticular calcareous concretions (20 cm in maximum thickness) are contained at the base.

Thickness: The formation thickens northward and attains a maximum thickness of 800 m to the southeast of Takapau.

Relation: The basal conglomerate of the Mapiri Formation rests unconformably on the "Greywacke" in the southeast of Takapau, and its basal facies changes into the massive dark-grey sandy siltstone of the Moastone Formation in the east of the Turiri Range and along the Mangapuaka Stream.

The Mapiri Formation is overlain unconformably by the Mangatoro and Kumeroa Formations. Angular unconformities are observed along the Turiri Range and at the head of the Whatauna Stream.

4. Mangatoro Formation

Type Locality: Opoiti Survey District of Wairoa Subdivision in northern Hawke's Bay. Typical exposures are developed along the tributary of Mangapuaka Stream to the south of Paeroa Mount and the Waikopiro Stream to the south of Rangitoto Mount in the study area.

Classification: The name Mangatoro was first used

by Lillie (1953) in the Dannevirke Subdivision to rename the Opoiti Formation as defined by Ongley (1930).
Distribution: The formation is exposed, striking in a northeasterly direction, along the west side of the Mapiri Formation, Moastone Formation and "Greywacke".
Lithology: The Mangatoro Formation consists of light-grey fine-grained sandstone with occasional lenticular calcareous concretions and thin lignite layers (Photo 3). The base of the formation is marked by bands of shelly limestone or shell beds ranging in thickness from 5 cm to 200 cm. The basal limestone and shell beds contain pebbles and granules of "Greywacke".
Thickness: The Mangatoro Formation ranges in thickness from 30 m to 80 m in the northern area, and a maximum thickness of 500 m is attained in outcrop at the Mangapuaka Stream in the southern part of the study area.
Relation: The formation unconformably overlies the Moastone Formation, Mapiri Formation, "Pa-leog ene rocks" and "Greywacke". Discordance of bedding between the Mangatoro Formation and the Mapiri Formation can be clearly observed at the head of the Whatatuna Stream and the Turiri Range.

5. Pukerua Formation (new name)

Type Locality: Tributary of the Mangapurakau Stream at Pukerua, Turiri Range.
Classification: The Pukerua Formation is approximately equivalent to the lower part of the "Te Aute Formation" of Lillie (1953). The name was defined by Fujii (1985ms) based on the presence of an unconformity and lithological change in the middle part of the "Te Aute Formation", where it is equivalent to the base of the "Te Aute limestone" of Lillie (1953). In this paper, the Pukerua Formation and the Te Aute Formation are used for the lower and upper parts of the "Te Aute Formation" of Lillie (1953), respectively.
Distribution: The formation is exposed, striking northeast, along the east side of the Te Aute Formation.
Lithology: The Pukerua Formation consists of well-sorted smooth light-grey massive micaceous siltstone (Photo 4). The siltstone in rare instances contains small fragments of pumice and calcareous concretions. The concretions are boulder-sized and consist of light-grey siltstone. Molluscs are few. Parallel lamination of a very fine-grained sandstone layer occurs near the basal part of the formation, below which the siltstone becomes micaceous sandy siltstone; the latter grades downward into the massive fine sandstone of the Mangatoro Formation. The basal parallel lamination is developed typically in the eastern part of Mangapurakau Stream.
Thickness: The formation has a maximum thickness of 420 m at its type locality, Pukerua, in the northeastern part of the study area.
Relation: The Pukerua Formation overlies conformably the Mangatoro Formation. The basal limestone of the Te Aute Formation, the "Te Aute limestone", contains basal pebbles and calcareous boulders, and rests unconformably on the Pukerua Formation.

6. Te Aute Formation

Type Locality: Te Aute Hill to the northeast of the study area. Typical exposures within the study area are developed along the Papaiahoea and Waikopiro Streams.
Classification: The Te Aute limestone was first described by McKay (1877) for the limestone of the Te Aute Hills to the northeast of this district. Lillie (1953) used "Te Aute Formation" including Te Aute limestone beds, first mapped by McKay (1877) within the district. Lillie (1953) mapped the "Te Aute Formation" to coincide with beds containing the fauna of the Waitotaran Stage, in so far as possible. Following Fujii (1983ms), this paper divides the "Te Aute Formation" of Lillie (1953) into a lower Pukerua Formation and an upper Te Aute Formation. Beu *et al.* (1980) subdivided the basal limestone of the "Te Aute limestone" of Lillie (1953) into the Whetakura limestone and the Te Aute limestone because of their ages. Most of the basal limestone beds of the Te Aute Formation in this district are Whetakura limestone, and the Te Aute limestone of Beu *et al.* (1980) is exposed in the north of the Turiri Range.
Distribution: The formation is present mainly in the western and southern part of this district. In the northeastern part, only the basal limestone crops out beneath the Kumeroa Formation.
Lithology: The Te Aute Formation consists mainly of calcareous sandstone (Photo 5), sandy coquina limestone, and sandy massive siltstone. Calcareous sandstone and limestone are developed in the basal part. The calcareous sandstone contains shells, shell fragments, and numerous calcareous concretions. Lenticular or platy calcareous concretions range in thickness from 5 cm to 30 cm. The concretions and shells partly combine to form a sandy coquina limestone, the Whetakura limestone, which form a weathering-resistant feature in the local landscape (Photo 6). The base of the limestone contains hard sandstone pebbles and cobbles, and occasional boulder-sized calcareous concretions of siltstone. The boundary is clear between the base and Pukerua Formation. Many sandpipes with lengths of 10 cm to 30 cm protrude into the massive siltstone of the Pukerua For-