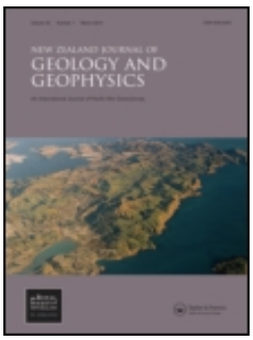

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UPPER TRIASSIC TO MIDDLE JURASSIC STRATIGRAPHY OF SOUTH-WEST KAWHIA, NEW ZEALAND

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ABSTRACT

The Mesozoic sequence at south-west Kawhia constitutes part of the western flank of the Kawhia Syncline. It is composed of sedimentary rocks of the Newcastle and Rengarenga Groups and extends in age from Upper Triassic to Middle Jurassic.

Within the Newcastle Group, eight new formations and one informal unit are described which total at least 2360 metres in thickness and extend in age from Otamitan to Ururoan (Upper Triassic to Lower Jurassic). They are (from oldest): **Anakawakawa beds, Arawi Shellbed, Ngutunui Formation, Arataura Formation, Rewarewa Formation, Arawhero Formation, Otamaehu Formation, Ururoa Shellbed,** and **Ururoa Formation.**

Rocks of Temaikan (Middle Jurassic) age, exposed in the vicinity of Albatross Point, form a synclinal block which is in fault contact with the Upper Triassic rocks to the east. The Temaikan sequence is divided into four new formations within the Rengarenga Group: **Waioioi Formation** (oldest), **Tokatapu Sandstone, Te Angina Formation,** and **Kaiate Formation.** A general correlation is possible between the sequence at Albatross Point and the type sequence of the Rengarenga Group on Te Maika Peninsula.

INTRODUCTION

The area under discussion is situated on the south-west Kawhia coast and includes the shoreline from north of Ururoa, on the west side of Te Maika Peninsula, west to Albatross Point and south to the Taharoa sand dunes (Fig. 1). The north-west shore of Lake Taharoa forms the southern boundary of the area, whilst the base of the Middle Jurassic Rengarenga Group (Fleming & Kear 1960) forms an eastern stratigraphic boundary.

The area is dominated topographically by a prominent ridge which forms an arc extending from Te Maika Peninsula to Albatross Point. The highest point on this ridge, Orangiwhao (304 m), is located approximately midway between Albatross Point and Te Maika Peninsula and approximately 700 m south of the coast. Differential weathering of sandstones and siltstones has resulted in some structural control of topography, and dip slopes have developed in several places; a particularly fine example can be seen on the east side of Albatross Point.

To the south, the land is generally low-lying, and areas of swamp adjoin Lake Taharoa, which is 2·8 km long, and is the largest of a series of lakes ponded behind advancing Holocene dunes of titanomagnetite-rich sand.

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Much of the coastline is extremely rugged, with high cliffs and many off-shore reefs and stacks, although most of the coast can be traversed at low tide.

The aims of this work were to continue into the lower Jurassic and Upper Triassic strata of the Kawhia district, the lithostratigraphic studies carried out in the younger Jurassic rocks of the area by Fleming & Kear (1960) and to correlate the rocks of the Albatross Point area with those of Te Maika Peninsula.

In this study, most emphasis is placed on the coastal section, which provides an almost continuous exposure; the continuity of the Mesozoic section is broken only towards its base by intrusive stocks of Tertiary Orangiwhao Andesite.

PREVIOUS WORK

In 1859 the Kawhia area was visited by Hochstetter who crossed the harbour to the south side and examined the exposed sequence. He may have visited Te Maika Peninsula, but did not mention it in his description (Hochstetter 1864).

The first detailed account of the geology of the south-west Kawhia area was given by McKay (1884) who examined the section from Te Maika Peninsula to somewhere in the vicinity of Te Arawi, but did not examine the beds west of Te Arawi. He divided the sequence into Bastion, Otapiri, and Wairoa Series, which were units previously established for the Hokonui Hills, and collected fossils including *Clavigera, Monotis,* and *Pseudaucella.* He also noted the structural disturbance caused by the emplacement of the Orangiwhao Andesite.

Trechmann (1918) discussed the Upper Triassic (Norian, Rhaetian) rocks of south-west Kawhia in his account of the Triassic rocks of New Zealand. He recorded several new fossil discoveries, including *Arcestes* cf. *rhaeticus.* He later (1923) referred again to the area but added little to the earlier report of McKay, except to note the presence of conglomerates and the unfossiliferous nature of the beds in the vicinity of Albatross Point.

Henderson & Grange (1926) described the south-west Kawhia area in their account of the geology of the Huntly–Kawhia Subdivision. They merely divided the sequence into Triassic and Lower Jurassic, taking a conglomerate at Arawhero Point (N73/283072*; Fig. 1) to mark the Triassic–Jurassic boundary. They classed the beds west of Te Arawi as Upper Triassic even though no fossils were found in them.

Williamson (1932) established local series names for the Triassic and Jurassic rocks of the Kawhia Syncline in a preliminary report prior to publication of a major regional study of the Te Kuiti Subdivision (Marwick 1946). These series were based on two sections: one at Kawhia extending from Te Arawi to Waiharakeke Stream inlet (to the east of Fig. 1), and the other to the south at Marakopa. Williamson also recorded the first Otamitan ("Whakahau Series") fossils to be found in the Kawhia district.

*Grid reference based on the national thousand-yard grid of the 1 : 63 360 topographical map series (NZMS 1), Sheet N73 Kawhia, 1st ed.

Marwick (1951) proposed series and stage subdivisions of New Zealand Triassic and Jurassic rocks for which he retained some of Williamson's series names. He based all his Jurassic subdivisions on the Kawhia area. In 1953 he more fully described the stage divisions, their distribution, correlation, and faunas, but stated that no attempt had been made to define stage boundaries precisely, for this required further detailed work. Marwick noted that the conglomerate bed at Arawhero, which had been taken by Henderson & Grange (1926) and Williamson (1932) as marking the base of the Jurassic, was likely to be well up in the Aratauran Stage.

Mason (1952) gave an account of the geology of the Albatross Point area which had previously received little attention. He recorded the occurrence of marine fossils which indicated a Temaikan age.

Campbell (1956) discussed the Otapirian Stage and its fauna in the Kawhia area, and compared it with the type section of the stage and its correlatives elsewhere. He also discussed the Otapirian–Aratauran boundary, which he tentatively placed some 260 m north of Arataura Point.

Fleming & Kear (1960) gave a detailed account of the Middle and Upper Jurassic stratigraphy in the Kawhia area. Four groups comprising 16 formations were established to cover the 4267 m of the Middle and Upper Jurassic rocks exposed around Kawhia Harbour. In addition, they also briefly described the Liassic sequence down to the conglomerate at Arawhero.

In a stratigraphic summary of the Ngaruawahia Subdivision, Kear & Schofield (1964) used the group names originally applied to the Middle and Upper Jurassic section at Kawhia (Fleming & Kear 1960), and introduced the Newcastle Group to include the remainder of the Mesozoic section below the Rengarenga Group.

Stevens (1965) discussed the stratigraphy and correlation of the Kawhia sequence in his study of New Zealand Jurassic and Cretaceous belemnites.

Speden (1970) described three new Jurassic inoceramid species, including two Ururoan species from south-west Kawhia, and he also discussed the problems of stage boundary placement in the Kawhia section.

The petrography of the Jurassic conglomerates in the Kawhia area has been studied by Bartrum (1935), and Macdonald (1954) who described a wide range of igneous, metamorphic, and sedimentary rock types from pebbles in the conglomerates.

STRUCTURE

In the south-west Kawhia area, the Mesozoic rocks can be conveniently separated into two blocks, the **Te Maika–Taharoa Block** and **Albatross Point Block,** which are in fault contact, and differ in both structure and age.

Te Maika–Taharoa Block

This block includes at least 2630 m of Upper Triassic and Liassic strata which are exposed on the coast from north of Ururoa (N73/294087), to immediately east of Wairere (N73/248060), and to the south around

the north-west shore of Lake Taharoa (Fig. 1). This sequence forms part of the western flank of the Toe Syncline (Fleming & Kear 1960), the axis of which is situated 9 km east of Te Maika. Most of this coastal sequence strikes in a northerly direction with easterly dips which increase from 38° near Ururoa to 59° south-west of Arataura (N73/268062). Between Wairere and Ngutunui Stream (N73/266058), considerable local structural disruption has occurred because of the intrusion of large stocks of Tertiary Orangiwhao Andesite. Approaching the most easterly exposure of the andesite, the strike of the Mesozoic rocks swings to the north-west, the dip increases, and the beds become vertical or slightly overturned. Further west at Ngutupuku Creek (N73/262059), beds containing *Monotis* dip to the west at 21° but steepen rapidly to the west to be near-vertical only 300 m away. Several other isolated exposures of Mesozoic strata, separated by large areas of Orangiwhao Andesite, lie to the south-east and south-west of Te Arawi. These exposures showed no consistent structural trend.

Albatross Point Block

In this block, at least 600 m of Temaikan strata are folded into an assymetrical syncline, named the **Albatross Syncline**, which plunges to the north at approximately 20°. The axis of this fold passes through Kaiate Bay, to the east of Albatross Point. The western limb of the syncline strikes at 160° and dips eastward at 35° except at its most southerly exposure near Paparoa (N73/223040), where the strike swings to the north and the dip decreases to 15°. Beds of the eastern limb are less regular in both strike and dip than their equivalents of the western limb, with most strikes ranging beween 028° and 062° and dips ranging from 19° to 35°. Some local structural disturbance is also evident in the sequence near the andesite stock at Waipuna.

Wairere Fault

The existence of a large fault separating the two structural blocks was first suggested by Mason (1952) as a result of the recognition of Temaikan strata west of Wairere. The Albatross Point area had been mapped previously by Henderson & Grange (1926) as a continuation of the Triassic sequence seen further to the east. Although the fault, named the **Wairere Fault**, is nowhere clearly exposed, its position has been located with reasonable accuracy because the lithologies on each side of the fault are sufficiently distinctive to be recognisable even where deeply weathered. To the west of the fault, the lithology is coarse, carbonaceous sandstone, whereas on the eastern side, it is siltstone. Between Wairere and the crest of the main ridge to the south (N73/244058) the fault appears to trend in a north-east direction, but this may change to a north-north-east trend further south since the fault probably passes to the east of an isolated outcrop of Ururoan strata (N73/228029) situated on the coast 4·5 km south of Albatross Point. The position of this outcrop is most easily explained if the outcrop is structurally related to the Albatross Point Block. The apparent change in trend of the Wairere Fault could also be due to an eastward dip on the fault plane, but neither the attitude of the

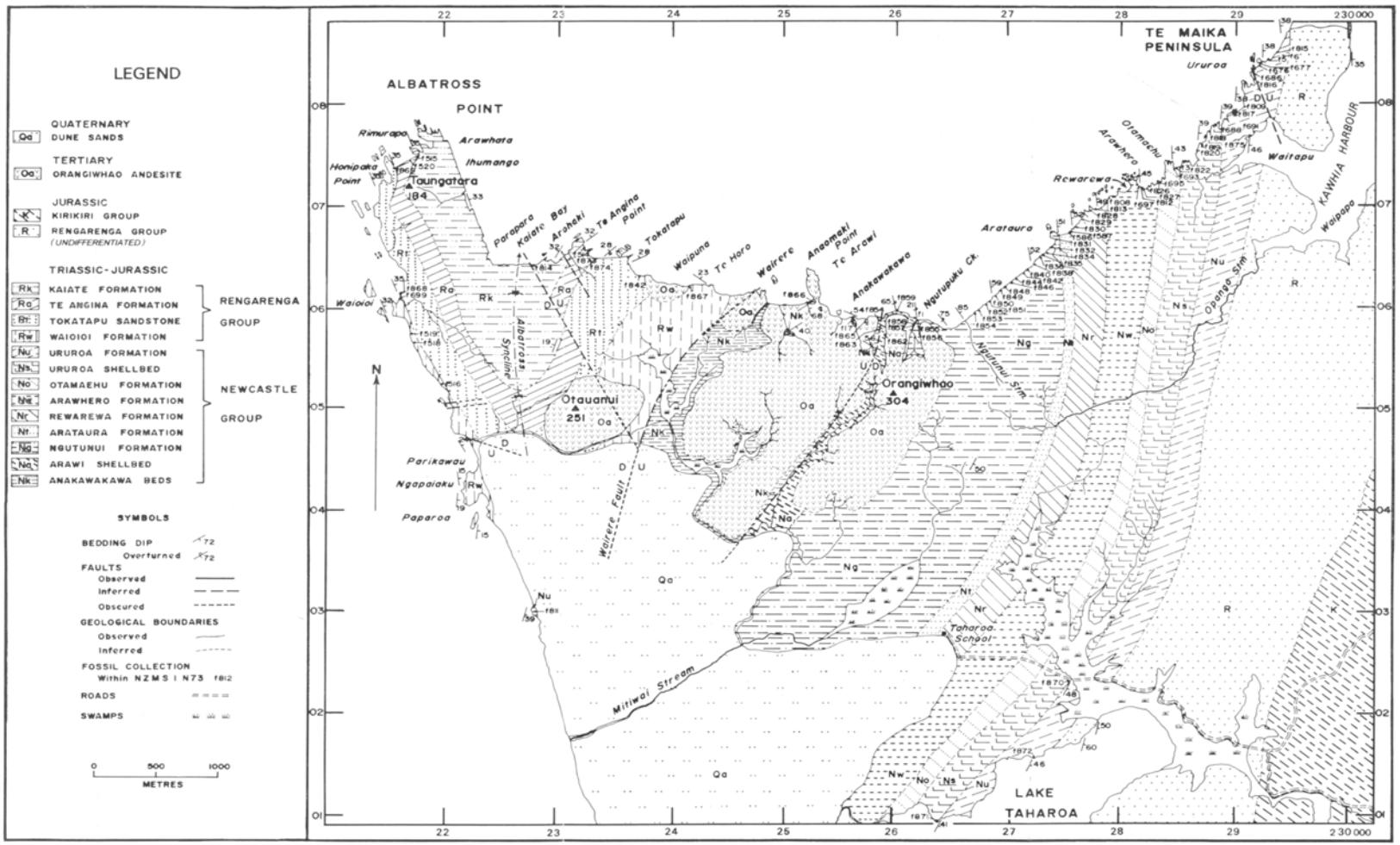

FIG. 1—Geological map of the south-west Kawhia area. Grid lines are from NZMS 1 Sheet N73.

fault plane, nor the component of movement on it, could be determined. The effect of the Wairere Fault is to displace at least 2600 m of Upper Triassic and Liassic strata and bring rocks of Temaikan age, such as are seen on the eastern side of Te Maika Peninsula, into contact with Upper Triassic (Otamitan) beds.

STRATIGRAPHY

Previous Lithostratigraphic Terminology

Fleming & Kear (1960) introduced formation and group names for the Middle–Upper Jurassic sequence at Kawhia; the lowest of their groups (Rengarenga Group) can be used to accommodate the sequence of Middle Jurassic rocks exposed at Albatross Point, although it has not proved possible to correlate to formation level.

In the Ngaruawahia Subdivision, Kear & Schofield (1964) have used the term Newcastle Group for the sequence on the eastern flank of the Kawhia Syncline below the Rengarenga Group. The Newcastle Group, which ranges in age from Oretian–Otamitan to Ururoan, is composed of four formations, in which greywacke sandstone and siltstone are the main lithologies. These lithologies are essentially the same as those of the Upper Triassic–Lower Jurassic sequence at south-west Kawhia, but the sequence varies in detail so that it is not possible to recognise the succession of formations mapped by Kear & Schofield in the Ngaruawahia Subdivision. In addition, the particularly good exposure presented by the Kawhia section has enabled more detailed mapping to be carried out than would otherwise be possible.

It has been decided not to use the name Marakopa Formation in the adopted nomenclature despite the fact that Kear & Schofield (1964) have used this name in the Ngaruawahia Subdivision. This name was first used by Williamson (1932) as a series name to include 1000 ft (305 m) of greywacke, argillite, and *Monotis* shellbeds in the south-west Marakopa Survey District. Since Williamson's original units have never been properly defined, it is considered inadvisable to use the name in this account.

Consequently, the procedure adopted here is to retain the group names which have been used elsewhere but to describe new formations which can be mapped in the south-west Kawhia section (see Figs 2, 11).

NEWCASTLE GROUP

This group name was established by Kear & Schofield (1964) to include all the sequence of Mesozoic greywacke sandstones and siltstones exposed below the Rengarenga Group in the Ngaruawahia Subdivision.

Because of the general similarity of lithologies, the group name can be applied at Kawhia where the Newcastle Group is at least 2238 m thick; it includes eight new formations together with some poorly exposed beds at the base of the sequence to which formational status is not given (Fig. 2).

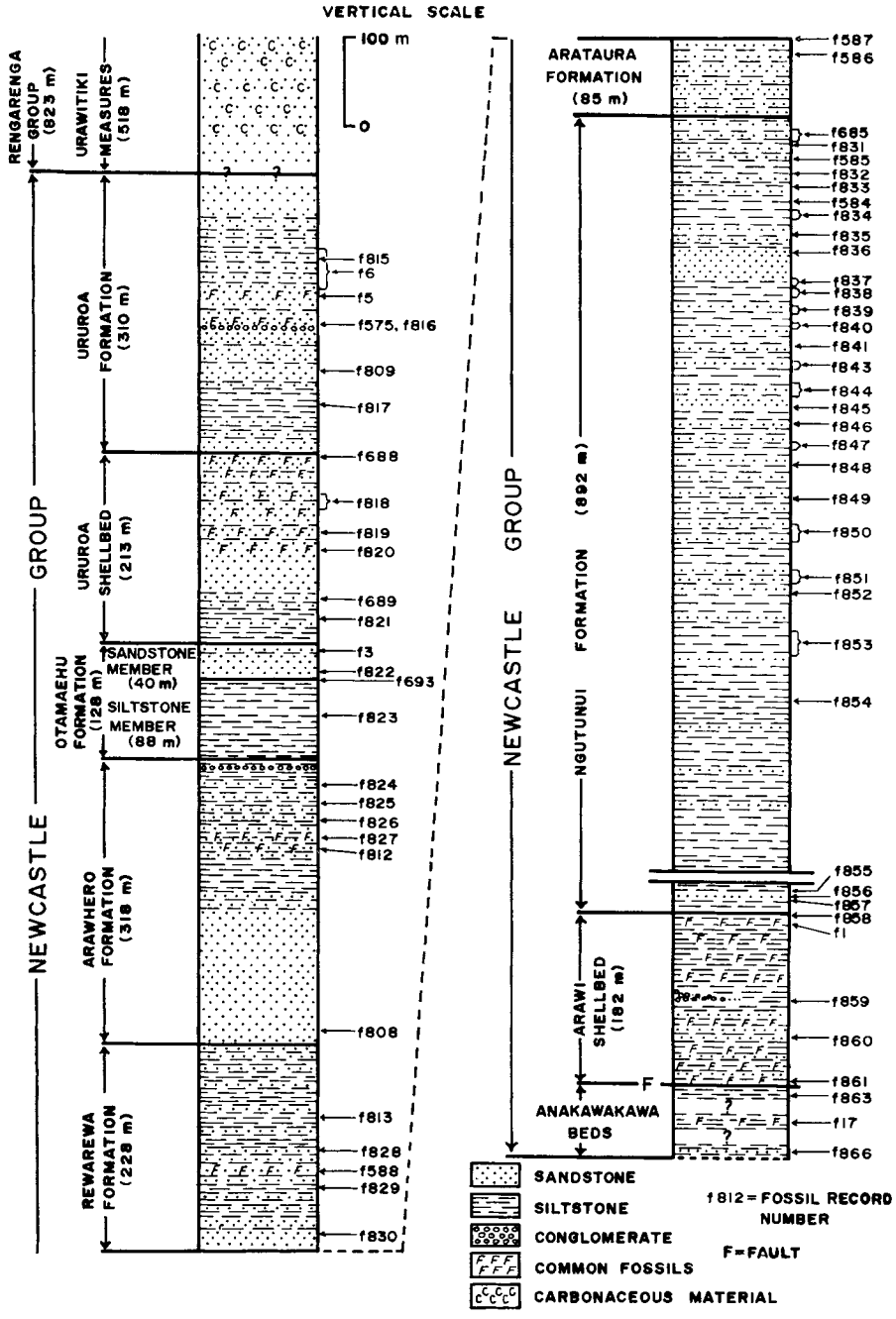

FIG. 2—Stratigraphic column for the Newcastle Group in the south-west Kawhia area.

ANAKAWAKAWA BEDS

Anakawakawa is a local name for a small bay east of Te Arawi, into which two small streams flow (N73/256059; Fig. 1).

The term "**Anakawakawa beds**" is used in an informal sense for all the sedimentary rocks underlying the Arawi Shellbed. They are not afforded formal status because they constitute a poorly exposed discontinuous sequence of indefinite thickness. The beds lie as wedges and isolated blocks between stocks of Orangiwhao Andesite, and it is uncertain how, if at all, the various blocks are related to each other.

The Anakawakawa beds consist of hard, grey siltstones which are highly veined and sheared in some outcrops, especially west of Te Arawi. The beds are in fault contact with the younger Arawi Shellbed in a valley west of Ngutupuku Creek (N73/258058), and their stratigraphic position beneath the Arawi Shellbed has been determined only by paleontological means. In this valley, the attitude of the Anakawakawa beds, where they can be mapped, suggests that at least 100 m of these beds may be present, but because of the paucity of exposure this could not be verified. The maximum observable thickness of these beds in one continuous outcrop is only 9 m, at Anakawakawa.

Paleontology

Williamson (1932) recorded the occurrence of *Manticula problematica* (Zittel) 357 m east of Te Arawi, but Marwick (1953) reclassified the fossil as *Oretia* n.sp. from the same locality (N73/f17*). The writer has also collected *Manticula problematica* from this locality, as well as *Manticula* and other forms from several new localities within the Anakawakawa beds. The total known fauna is: *Athyris wreyi* (Suess); rhynchonelloid sp.; *Halobia hochstetteri* Mojsisovics; *Manticula problematica* (Zittel); *Oretia* n.sp.; gastropod indet.; *Proclydonautilus mandevillei* (Marshall); *?Rhacophyllites* sp.

Correlation

The recovery of the Otamitan primary index fossil *Manticula problematica*, as well as the secondary index forms, *Halobia hochstetteri* and *Proclydonautilus*, clearly indicates the presence of Otamitan strata in the south-west Kawhia sequence. The Anakawakawa beds all seem to be of Otamitan age, because key fossils representative of the Otamitan Stage have been recovered from nearly all exposures; the only exceptions are several small and poorly exposed inland outcrops and also the extreme western (and possibly oldest) outcrops of the beds in the valley which runs down to the coast, east of Wairere (N73/248060).

*N73/f17 = Fossil locality number recorded in the New Zealand Fossil Record File under NZMS 1 Sheet N73 Kawhia. Full details of fossil identification for each locality, together with detailed stratigraphic descriptions, are listed by Martin (1967).

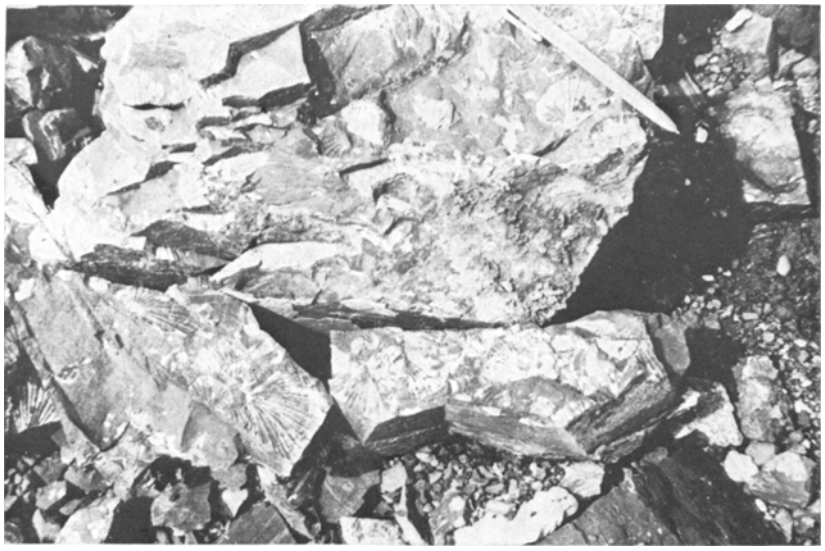

FIG. 3—Siltstones of the Arawi Shellbed showing abundant *Monotis* shells.

ARAWI SHELLBED

Name and Type Section

The name Arawi has been adopted for this shellbed because the formation constitutes beds often linked in the literature with the locality Te Arawi (e.g., McKay 1884; Trechmann 1918).

The Arawi Shellbed crops out over a distance of 300 m on the coast from Ngutupuku Creek west to the small bay 480 m east of Te Arawi (N73/258058). The 182 m of strata exposed along this stretch of coast constitute the type section of the Arawi Shellbed. At its lower contact, the Arawi Shellbed is faulted against the underlying Anakawakawa beds. It dips in a generally westerly direction, usually at a high angle, and most of the formation is near-vertical and apparently overturned.

Content and Distribution

The characteristic lithology of the formation is a silty shellbed which consists of closely packed *Monotis* shells lying parallel to the bedding, within a matrix of grey siltstone (Fig. 3). Some beds, with minimal silty matrix, are bioclastic limestones. Sandstones form only a minor part of the Arawi Shellbed. The only distinctive coarse-grained bed in the sequence is a massive, feldspathic grit bed located 85 m below the top of the formation. This bed is 4 m thick and contains shell fragments and siltstone inclusions. Throughout the formation, occasional thin (2–10 cm), zeolitised tuff beds are interbedded with the shellbeds.

Although the Arawi Shellbed is exposed more or less continuously around the coast, there are places where fallen boulders of andesite practically obscure the outcrop near sea level, but the shellbed can usually be traced on the cliff and steep hill slopes above the shore.

The Arawi Shellbed can be traced to the south as intermittent deeply weathered outcrops, which are often largely obscured by fallen andesite boulders. These outcrops are seen in the valley immediately west of Orangiwhao as small, restricted exposures, which extend from the main ridge down the valley to the south-west towards the Taharoa dunes.

Paleontology

The occurrence of *Monotis* was first noted by McKay (1884). He collected this fossil, which he recorded as *Monotis salinaria*, from a locality 600 m east of Te Arawi, immediately west of the mouth of Ngutupuku Creek (GS 525*). Trechmann (1918) also recorded the occurrence of *Monotis*, as *Pseudomonotis ochotica*, apparently from the same locality. *Monotis richmondiana* has subsequently been recorded from boulders further west towards Te Arawi (N73/f709), and the writer has since collected *Monotis* from a number of localities within the Arawi Shellbed. The fauna identified is: terebratuloid sp.; *Monotis calvata* Marwick†; *Monotis* n.sp. aff. *calvata* Marwick; *Monotis* cf. *routhieri* Avias; *Monotis* aff. *gigantea* Avias; *Monotis richmondiana* Zittel; *Monotis* spp. indet.; bivalve gen. et sp. indet.

Correlation

Marwick (1953) and Campbell (1959) named *Monotis richmondiana* as the key fossil of the Warepan Stage. It has been pointed out (Grant-Mackie 1959), however, that *Monotis richmondiana* has been a widely employed name, and has often been used to include a number of differing forms within the genus *Monotis*. Thus the "*Monotis richmondiana*" of N73/f709 probably includes a number of variant forms similar to those collected by the writer. J. A. Grant-Mackie (pers. comm.) also points out that, in his re-collection of the locality of N73/f709, *Monotis richmondiana* itself is not present. The occurrence of the genus *Monotis* throughout the Arawi Shellbed means that a Warepan age can be assigned to this formation.

NGUTUNUI FORMATION

Name and Type Section

The formation takes its name from a small stream which flows on to the beach 1 km south of Arataura and 420 m east of Ngutupuku Creek. Strata which constitute the type section of the Ngutunui Formation are exposed to the north-east and south-west of Ngutunui Stream from Arataura to

*The prefix "GS" refers to the New Zealand Geological Survey Catalogue of Macrofossil Collections.

†*Monotis* species identified by J. A. Grant-Mackie.

FIG. 4—A typical exposure of the Ngutunui Formation consisting of fossiliferous siltstone–fine sandstone interbedded with thin coarse sandstones.

Ngutupuku Creek (Fig. 4). The continuity of the lower portion of the sequence is broken by an intrusive andesite stock which has also caused some structural disturbance within the sedimentary sequence.

At its lower contact in Ngutupuku Creek, the basal part of the Ngutunui Formation forms part of an overturned sequence which extends west from Ngutupuku Creek and includes the Arawi Shellbed. The lowest beds of the Ngutunui Formation conformably underlie the topmost beds of the Arawi Shellbed exposed on the west bank of Ngutupuku Creek. Here, 37 m of the Ngutunui Formation are exposed.

At its upper boundary, the Ngutunui Formation passes conformably but abruptly into the Arataura Formation on the north side of Arataura.

Content and Distribution

The Ngutunui Formation, which totals 892 m in thickness, is composed largely of massive, grey siltstones and fine sandstones which alternate with thinner coarse to very coarse grey-green sandstones, and occasional thin, light-coloured, zeolitised tuff beds.

In contrast to the upper half of the formation, the lithology of the lower half tends to be consistently finer; siltstone predominates and interbedded sandstones are rarer.

Because of lack of exposures further inland, the formation could not be traced beyond the type section.

Paleontology

The upper half of the Ngutunui Formation is almost continuously fossiliferous; there are especially rich faunas of brachiopods, although they are restricted in numbers of species. In the lower half of the formation, fossils become increasingly rare, although a sparse fauna was recovered from the basal beds.

McKay (1884) recorded the occurrence of *Clavigera*, several species of *Rhynchonella*, and a large *Spiriferina* from strata south of Arataura. Trechmann (1918) recorded *Arcestes* cf. *rhaeticus* Clark apparently from the upper part of the Ngutunui Formation, and, from a little lower down, *Mentzelia* cf. *ampla* Bittner and *Mentzelia kawhiana* Trechmann. N73/f74 (GS 1025, 524) includes these earlier general collections up to those of Henderson & Grange (1926).

The total faunal list for the formation is as follows: Conulariida; *Clavigera bisulcata* Hector; *Clavigera cuneiformis* (Hector); *Mentzelia kawhiana* Trechmann; *Mentzelia* cf. *ampla* Bittner; *Rastelligera gypaeetus** (Trechmann); Rhynchonellacea; Terebratulacea; *Otapiria dissimilis* (Cox); *Kalentera marwicki* Grant-Mackie; *Palaeoneilo* aff. *otamitensis* Trechmann; *Chlamys* sp.; cf. *Camptochlamys wunschae* (Marwick); ?*Anodontophora* sp.; cf. *Anodontophora* sp.; *Myophoria* sp.; *Pleuromya* sp.; Gastropoda indet.; *Arcestes* cf. *rhaeticus* Clark; ammonoid indet.; *Isocrinus* sp.

Correlation

A typical upper Otapirian fauna is represented in the assemblage of *Otapiria dissimilis, Clavigera bisulcata*, and *Mentzelia kawhiana* (Campbell 1956). Most of the rhynchonelloid brachiopods collected were the "*Rhynchonella*" sp. of Campbell (1956) (="*Rhynchonella*" sp. B of Grant-Mackie 1959). This species appears to be a good middle and upper Otapirian marker; it occurs at the type locality of the stage in the Hokonui Hills, Southland, as well as at Awakino and Kawhia.

Marwick (1953) recorded *Otapiria marshalli*, collected by R. A. S. Browne, from immediately south of Arataura, but stated that the identification was open to doubt, since it had been made before *Otapiria dissimilis* was recognised as a separate species, and the specimen could not be located for re-examination. Subsequent collections in the same area have yielded only *Otapiria dissimilis* so that the record of *Otapiria marshalli* is being disregarded for want of more conclusive evidence. No other key Lower Jurassic fossils have been recovered from the formation. Thus the Ngutunui Formation does not appear to extend into the Jurassic.

*The spelling of *R. gypaeetus* follows Campbell (1968). The original spelling was gypaëtus. The rules of zoological nomenclature do not allow the umlaut to remain, and the additional "e" signifies its removal (J. D. Campbell pers. comm.).

FIG. 5—Beds of the Arataura Formation exposed on the shore platform north of Arataura.

Because the Otapirian index fossil *Rastelligera diomedia* has not been recorded from this sequence, it is not possible to locate the position of the Warepan–Otapirian boundary with certainty. The first member of the upper Otapirian fauna to appear is *Clavigera bisulcata* at N73/f854, which is 240 m above the base of the formation. This species is not satisfactory as an Otapirian index fossil because it is known from the Warepan elsewhere. Consequently the base of the Otapirian Stage at Kawhia is probably best defined on the first appearance of *Rastelligera gypaeetus* which occurs at 428 m above the base of the Ngutunui Formation (N73/f850). This is 76 m below the first appearance of *Mentzelia kawhiana* which is the second member of the upper Otapirian fauna to appear. Using this definition, the Ngutunui Formation can be assigned a Warepan–Otapirian age.

ARATAURA FORMATION

Name and Type Section

Arataura is one of the better known geographical names on the south-west Kawhia coast, where it refers to a distinctive point (N73/274068) with a high stack immediately off shore, a little over 2 km south-west of Ururoa.

The outcrop of the Arataura Formation extends north-east from the north side of Arataura Point for a distance of approximately 115 m along the coast (Fig. 5). It has an abrupt contact with the Ngutunui Formation, which it conformably overlies, whereas the contact with the overlying Rewa-

rewa Formation is gradational over 12 m. Just below the top of the formation there is a slight disconformity, marking a surface on which some slump movement was initiated. This slumping has caused slight disruption of bedding in the overlying 120 m of strata.

Content and Distribution

Although only 85 m thick, the Arataura Formation is quite different from the formations above and below it. It is very thinly bedded with beds greater than 30 cm in thickness rare, and most not exceeding 15 cm. The formation is characterised by lithologic heterogeneity with lithologies ranging from siltstone to coarse, very coarse, and gritty sandstone.

The formation is exposed most clearly on the cliffs and low-tide platform but was recognisable in only a few places on the hills above the cliff.

Paleontology

Campbell (1956) records *Otapiria dissimilis* (Cox) from two localities 90 m (N73/f586) and 110 m (N73/f587) north of the north face of Arataura. These descriptions, together with the lithologic descriptions, would place the two localities in the Arataura Formation and not in the overlying Rewarewa Formation as is suggested by Campbell's map. The writer has also collected specimens of *Otapiria* from the Arataura Formation. These are poorly preserved but appear to be *Otapiria dissimilis.* A specimen of *Pseudolimea fida* Marwick was also obtained from near the top of this formation.

The fauna of the Arataura Formation is as follows: Rhynchonellacea; *Otapiria dissimilis* (Cox); *Pseudolimea fida* Marwick; cephalopod fragment indet.

Correlation

Marwick (1953) maps rocks of the Arataura Formation, as well as the topmost beds of the Ngutunui Formation, as being of Aratauran age. This was apparently based on the doubtful record of *Otapiria marshalli* from south of Arataura. Campbell (1956) tentatively placed the Otapirian–Aratauran boundary considerably higher up in the sequence, in what is now termed the Rewarewa Formation, based on the discovery of *Otapiria dissimilis* north of Arataura. The occurrence of *Pseudolimea fida* in the upper part of the Arataura Formation suggests that the formation may lie across the Otapirian–Aratauran boundary. This correlation is adopted here, with *Pseudolimea fida* taken as the Aratauran Stage index fossil in the absence of other suitable ones such as *Otapiria marshalli* and *Psiloceras.*

REWAREWA FORMATION

Name and Type Section

Rewarewa is the name given to the bay situated approximately 750 m north-east of Arataura (N73/280072).

The Rewarewa Formation conformably overlies the Arataura Formation in the bay immediately north of Arataura; from the contact the type section forms a continuous cliff exposure over a distance of 400 m to just south of

FIG. 6—Massive, friable siltstones with interbedded thin sandstones of the Rewarewa Formation.

Rewarewa (N73/279070). The formation is 228 m thick with gradational boundaries at top and bottom (Fig. 6).

The lower beds of the Rewarewa Formation have been involved in slight slumping but the resulting structural disturbance has not been sufficiently great to prevent recognition of a continuous stratigraphic sequence.

Content and Distribution

The formation consists of massive, grey, friable siltstone–fine sandstone, which is interbedded with rarer coarse, green, gritty sandstone. Occasional thin (2–10 cm), light grey, zeolitised tuff beds are also interbedded with the massive siltstone–fine sandstone. Towards the base of the formation the coarse, green sandstone beds become more abundant.

The formation could not be traced inland because of the paucity of exposures, although strata probably of the same formation were seen in a weathered outcrop to the south on the Taharoa track.

Paleontology

With the exception of a few rare shellbed horizons, the Rewarewa Formation is only sparsely fossiliferous, and most of the specimens recovered are poorly preserved. The fauna contrast sharply with that of the Ngutunui Formation where large spiriferid brachiopods are dominant. In the Rewarewa Formation, small undescribed rhynchonelloids and terebratuloids are the dominant types; the fauna of the formation is as follows: Rhynchonellacea; Terebratulacea; *Pseudolimea fida* Marwick; *?Astarte* (s.l.) sp.; *?Chlamys* sp.; Pectinacea gen. et sp. indet.; cf. *Ataphrus* sp.; *Primarietites* cf. *rotiforme* (Sowerby).

Correlation

The specimen of *Primarietites* from N73/f813, identified by G. R. Stevens, allows a definite correlation with the Sinemurian (upper Aratauran).

Pseudolimea fida is the only other species of obvious stratigraphic significance, and confirms a Liassic age; lack of any Ururoan elements in the fauna indicates that the Rewarewa Formation is wholly of Aratauran age.

ARAWHERO FORMATION

Name and Type Section

The formation takes its name from a small point situated in the bay between Otamaehu and Rewarewa. The outcrop of the type section extends over 1620 m of coast from south of Rewarewa (N73/278070) to Arawhero (N73/283072). The lower contact with the Rewarewa Formation is gradational while the upper contact, situated a short distance above a 20-cm conglomerate band (the "basal Jurassic conglomerate" of Henderson & Grange 1926), marks an abrupt change from coarse sediments to siltstones of the overlying Otamaehu Formation.

Content and Distribution

The Arawhero Formation is 318 m thick and consists of alternating sandstones and siltstones (Fig. 7). A 20-cm conglomerate bed containing rounded igneous and sedimentary pebbles and cobbles up to 15 cm in diameter is situated 1 m below the top of the formation. The siltstones are hard, grey, and finely laminated and predominate over medium–coarse, grey-green sandstones in the upper half of the formation. Towards the base of the formation the lithology coarsens; the siltstones grade up to fine-grained laminated sandstones which alternate with massive, grey-green medium and coarse sandstones. The formation was seen only at the type locality; no exposures were observed inland.

Paleontology

The formation is richly fossiliferous only in one restricted part—through approximately 21 m of strata which crop out approximately 100 m north of Rewarewa, where both the fine and the coarse lithologies yielded good collections. Occasional thin shellbed horizons also occur in this part of the sequence. A new, very finely-ribbed species of *Otapiria* was recovered in considerable numbers from a siltstone in this part of the sequence. Elsewhere, fossils are sparse and generally poorly preserved. The fauna of the Arawhero Formation is as follows: Rhynchonellacea; Terebratulacea; *Entolium fossatum* Marwick; *Pseudolimea fida* Marwick; *Pleuromya* cf. *milleformis* Marwick; *Pleuromya* sp; *Otapiria* n. sp.; *Kalentera mackayi* Marwick; cf. *Sphaeriola* sp.; *?Chlamys* sp.; *?Parainoceramus martini* Speden; gastropod gen. et sp. indet.; ammonite gen. et sp. indet.

Correlation

The Arawhero Formation lies within the type section designated by Marwick (1953) for the Aratauran Stage, and the lack of any characteristic Ururoan species such as *Pseudaucella marshalli* indicates that the formation does not extend into the Ururoan.

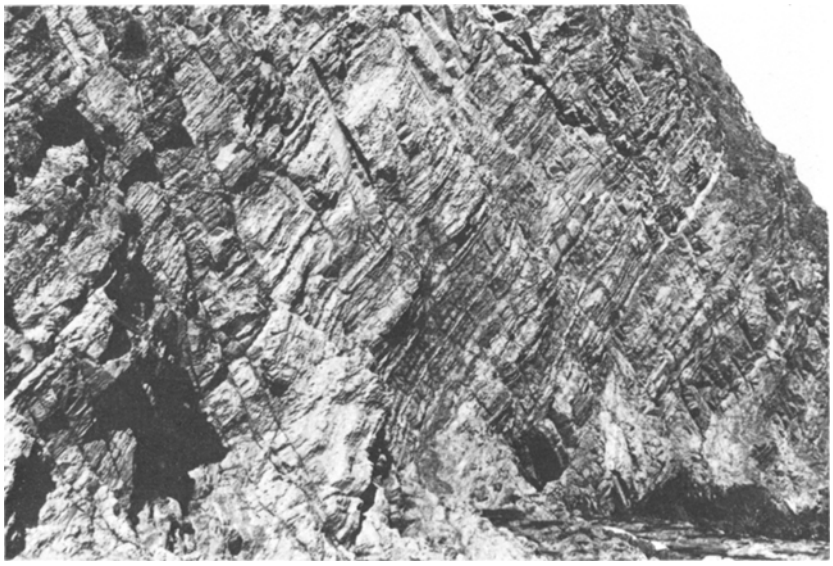

FIG. 7—Alternating laminated siltstones and fine-medium sandstones in the type section of the Arawhero Formation exposed north of Rewarewa. Distance from left to right is approx. 40 m.

Entolium fossatum and *Kalentera mackayi*, which had previously been of Arataurian age only by correlation, are now recorded from the type Arataurian.

OTAMAEHU FORMATION

Name and Type Section

The formation takes its name from a coastal promontory (N73/284073) situated 1·2 km south of Ururoa. It is 128 m thick and the type section crops out over 240 m of coast, from immediately north of Arawhero to 60 m north-east of Otamaehu Point.

Content and Distribution

The lower 88 m of the formation consist of hard, grey, finely-laminated siltstones and occasional thin sandstones (Fig. 8). This unit is named the **Otamaehu siltstone member** and is distinguishable from the overlying **Otamaehu sandstone member** which consists of fine–coarse, well-bedded, grey-green sandstones and rarer siltstones. This sandstone member is 40 m thick and represents a sandy intercalation between the laminated siltstones of the Otamaehu siltstone member below, and the overlying massive siltstones of the Ururoa Shellbed.

Lack of exposures meant that the formation could not be traced inland from the type section.

FIG. 8—Finely laminated siltstones of the Otamaehu siltstone member exposed to the south of Otamaehu.

Paleontology

The Otamaehu siltstone member is only sparsely fossiliferous, and the fossils are usually associated with the rare sandy intercalations in the siltstone sequence. The Otamaehu sandstone member, with several richly fossiliferous horizons, yielded a better fauna. The fauna of the total formation is as follows: "*Rhynchonella*" cf. *bartrumi* Marwick; rhynchonelloid spp.; terebratuloid sp.; *Pseudaucella marshalli* (Trechmann); *?Pseudolimea* sp.; *?Otapiria* sp.; cf. *Pleuromya* sp.; gastropod gen. et sp. indet.; crinoid ossicles.

Correlation

The location of N73/f3, which lists the occurrence of *Pseudaucella marshalli*, is given as 122 m above the 20-cm conglomerate at Arawhero. This places the locality near the top of the sandstone member. The writer has also collected bivalves, most likely *Pseudaucella marshalli*, from the top of the formation. No other key index fossils were recovered from the formation. The upper beds of the Otamaehu sandstone member must therefore be part of the type Ururoan Stage sequence because of the occurrence of *Pseudaucella marshalli* in the top 6 m of strata. The formation appears, therefore, to straddle the Aratauran–Ururoan boundary; it is mostly of Aratauran age and only the upper beds of the Otamaehu sandstone member are Ururoan.

URURUA SHELLBED

Name and Type Section

Ururoa Point is probably one of the best known geographical features of the south-west Kawhia coast. It forms a rocky headland with several small stacks at the south end of a long beach, approximately 2 km south of the entrance to Kawhia Harbour.

The type section of the Ururoa Shellbed extends along the west coast of Te Maika Peninsula, from 300 m south-south-west of Ururoa, to 60 m north-east of Otamaehu. The formation is 213 m thick and is characterised, particularly in its upper half, by shellbeds made up almost entirely of the bivalve *Pseudaucella marshalli.*

The lower contact represents an abrupt change from rather thinly bedded sandstones of the Otamaehu Formation into massive siltstones of the Ururoa Shellbed. The abrupt disappearance of *Pseudaucella* from the sequence marks the upper boundary of the formation, which is conformably overlain by sparsely fossiliferous basal beds of the Ururoa Formation.

Content and Distribution

The typical lithology of the Ururoa Shellbed is grey-brown, fine sandstone which is packed with *Pseudaucella* shells. The shelly sandstone is interbedded with rarer siltstones and occasional medium–coarse sandstones (Fig. 9). Towards the base of the formation, the lithology fines slightly to become massive, grey siltstone, and *Pseudaucella* shells become less abundant.

The topmost beds of the Ururoa Shellbed crop out at two localities on the shore of Lake Taharoa (N73/264011 and N73/276025), and also in the creek running north-east into Waitapu Bay and in Opango Creek which flows into Waipapa Inlet.

Paleontology

Pseudaucella marshalli has been extensively collected by virtue of its great abundance, and was first recorded from the area by McKay (1884) as *Astarte(?)*. However, a number of other less prominent species have been recorded from the formation along with *Pseudaucella.*

I. G. Speden (pers. comm.) states that the *?Meleagrinella* n.sp. is possibly a new genus and is common, along with and above *Pseudaucella*, in Southland. It has also been recorded from Awakino by Grant-Mackie (1959) as *?Placunopsis* sp. A.

The fauna of the Ururoa Shellbed is as follows: Rhynchonellacea sp.; *?Palaeonucula* sp.; *?Palaeoneilo* sp.; *?Parallelodon* sp.; *?Entolium* sp.; *Pseudolimea fida* Marwick; *Pseudaucella marshalli* (Trechmann); *?Meleagrinella* n.sp.; cf. *Hokonuia* sp.; *Pleuromya* or *Homomya* sp.; *?Cardinia* sp.; gastropod gen. et sp. indet.; ammonite sp.; crinoid ossicles.

N73/f34 is a general number for the earlier collections of McKay (1884), Henderson & Grange (1926), and Ferrar in 1932 (GS 523, 1191, and 1949, respectively).

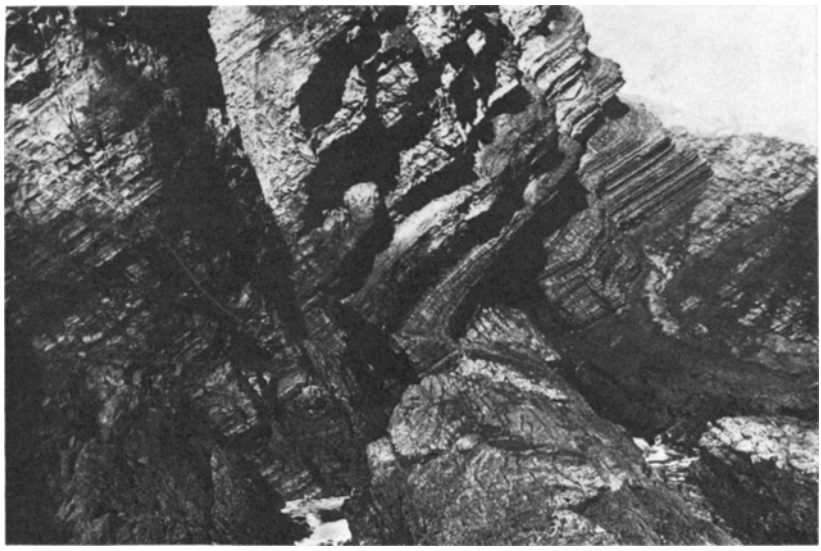

FIG. 9—Part of the type section of the Ururoa Shellbed showing a sequence of well-bedded, alternating fossiliferous sandstones and siltstones. Distance to point in upper right is approx. 30 m.

Correlation

The Ururoa Shellbed lies within the Ururoan Stage type section designated by Marwick (1953), which is based on the incoming of *Pseudaucella marshalli*. With the exception of 6 m of *Pseudaucella*-bearing strata in the underlying Otamaehu sandstone member, the Ururoa Shellbed is equivalent to the range-zone of *Pseudaucella*.

URUROA FORMATION

Type Section

The Ururoa Formation is 310 m thick and crops out to the north and south of Ururoa over approximately 1·2 km of coast.

The contact with the underlying Ururoa Shellbed is marked by the last appearance of *Pseudaucella* shellbeds approximately 300 m south-southwest of Ururoa. The contact with the overlying Rengarenga Group (Fleming & Kear 1960) is obscured by sand dunes in the bay approximately 400 m north of Ururoa.

Content and Distribution

The lithology of the Ururoa Formation is generally similar to that of the Ururoa Shellbed, although siltstones are rather more common in the former than in the latter. A conspicuous conglomerate, 1 m thick, crops out at Ururoa, and a little further north is the well-known "*Dactylioceras*

FIG. 10—Alternating sandstones and siltstones of the Ururoa Formation exposed to the north of Ururoa. The location of the highly fossiliferous "*Dactylioceras* bed" is indicated by the arrow.

bed" (N73/293084) (Fig. 10), which is 174 m above the base of the formation. The topmost exposure of the Ururoa Formation (N73/294087) shows evidence of the shallowing of the shallowing which preceded the deposition of the Rengarenga Group; the outcrop consists entirely of massive, cavernously weathering, medium sandstone, in contrast to the alternating sandstone and siltstone sequence seen in the marine beds immediately north of Ururoa. Deeply weathered beds of the Ururoa Formation also crop out at the head of Waitapu Bay (N73/292077).

Four and one-half kilometres south of Albatross Point is an outcrop (N73/228029) of Ururoan strata which can be correlated both lithologically and paleontologically with the middle of the Ururoa Formation. The sequence at this locality consists of 24 m of interbedded siltstones and sandstones, but also includes a 1 m conglomerate with the thin fossiliferous green sandstone overlying it, exactly as seen at Ururoa. The conglomerate also resembles the bed at Ururoa in containing well-rounded, but poorly sorted, pebbles and cobbles loosely packed in a gritty matrix. The pebbles and cobbles, like those of the Ururoa conglomerate, are mostly of igneous rocks, but sedimentary and metamorphic rocks are also present.

Fauna similar to those collected at Ururoa were recorded from the green sandstone overlying the conglomerate, although this was not the only fossiliferous bed in the sequence.

In the light of this lithologic and paleontologic evidence, it appears possible to correlate the Ururoan strata south of Albatross Point with strata exposed at Ururoa.

Paleontology

A wide range of fauna, listed below, has been recorded from the Ururoa Formation; they are mainly from the middle of the formation, because the topmost and basal beds are largely unfossiliferous. The fauna is: lageniid foraminifera (2 spp.); "*Rhynchonella*" *bartrumi* Marwick; "*R*" cf. *hoheneggeri* Suess; "*R.*" cf. *lacunosa* Quenstedt; Rhynchonellacea; "*Spiriferina*" cf. *radiata* Hector; "*S*" cf. *ongleyi* Marwick; Spiriferinidae; Terebratulacea; *?Palaeonucula* sp.; *Grammatodon* sp.; *Parallelodon* sp.; *Inoceramus ururoaensis* Speden; *Parainoceramus martini* Speden; *Isognomon* sp.; *?Meleagrinella* n.sp.; *Oxytoma* sp.; *Chlamys* (*Camptochlamys*) *wunschae* Marwick; *C.* (*Camptochlamys*) cf. *wunschae* Marwick; *Chlamys* sp.; *?Entolium* sp.; *?Placunopsis* sp.; *Lima* sp.; *Pseudolimea fida* Marwick; *Pseudolimea* sp.; *Pleuromya urnula* Marwick; *Pleuromya* sp.; *?Astarte* sp.; cf. *Cirsostylus* sp.; indet. gastropod spp.; *Dactylioceras* cf. *anguinum* (Reinecke); *D.* aff. *commune* (Sowerby); *D.* aff. *timorense* (Boehme); *Dactylioceras* spp. juv.; *Dactylioceras* sp.; *Harpoceras* cf. *falcifer* (Sowerby); ammonite sp.; *?Ausseites* sp. or *Cylindroteuthis* sp.; *Rotularia* sp.; annelid tubes; crinoid ossicles.

Many workers have collected from the "*Dactylioceras* bed"; probably the first was McKay (1884) who recorded ". . . one or two beds of a more calcareous nature in which fossils are fairly plentiful, yielding ammonites and brachiopods, *Spiriferina rostrata* and several undescribed forms of *Rhynchonella* . . .", apparently from strata above the *Pseudaucella* beds, but below the non-marine strata on Te Maika Peninsula.

Trechmann (1923) does not appear to have collected from the bed, for, although he mentions the existence of ammonite beds, he may have been referring to beds of the Opapaka Sandstone because he does not record *Dactylioceras* in his collections.

Correlation

The Ururoa Formation lies within the limits of the Ururoan Stage type section as originally defined by Marwick (1953), and consequently a Ururoan age is assigned to the formation.

RENGARENGA GROUP

The Rengarenga Group was proposed by Fleming & Kear (1960) to accommodate some 823 m of terrestrial and shallow water strata which crop out from Te Maika Peninsula east to Totara Point (N73/307076). Similar terrestrial and shallow water beds are exposed west of Te Arawi in the Albatross Syncline, of which Albatross Point forms the western flank. These beds have been shown (Mason 1952) to be of Temaikan age, at least in part.

The general sequence at Albatross Point is similar to that of the Rengarenga Group on Te Maika Peninsula, but detailed differences between the two sequences are considerable. Consequently it has not proved possible to apply the already established formations of the Rengarenga Group to

the Albatross Point sequence. Instead, new formations are established for this sequence, which are still included in the Rengarenga Group because they are mainly non-marine sediments similar to those in the type sequence of the Group.

Four new formations within the Rengarenga Group are proposed (Fig. 11). They total approximately 610 m in thickness and are exposed on both flanks of the Albatross Syncline. With one exception the type sections are taken from the eastern flank of the syncline, for, although the western sequence is more complete, the inaccessible nature of much of the coast prevented examination of some of the strata.

WAIOIOI FORMATION

Name and Type Section

The formation is named after a small island (N73/213062) situated 138 m off the west coast of Albatross Point, 1·2 km south of Honipaka Point.

The type section, which forms part of the western flank of the Albatross Syncline, crops out on the west coast of Albatross Point from opposite Waioioi Island south-south-east to Paparoa (N73/224039). The coast largely follows the direction of strike and although the formation crops out over 2 km of coast, only 178 m of strata are exposed. The base of the formation is nowhere visible and the lowest beds of the formation are exposed to the west on Waioioi Island and other off-shore stacks which could not be inspected. The upper contact with the Tokatapu Sandstone is abrupt and conformable.

Content and Distribution

The Waioioi Formation contains lithologies which range from shale to conglomerate (Fig. 12). The upper 55 m consists of massive, coarse sandstone containing thin conglomerate lenses which rhythmically alternates with finer lithologies including carbonaceous sandstone, siltstone, shale, and thin (5–20 cm) coal seams. The remainder of the formation is mainly carbonaceous sandstone which ranges from massive, coarse-grained to well-bedded fine sandstone, some of which is cross-bedded. Lenticular conglomerate is interbedded with the sandstone.

Despite the apparent shallow-water (or even terrestrial) environment of deposition of the Waioioi Formation, no unconformities or disconformities were seen within it, and sedimentation was evidently continuous.

On the eastern limb of the Albatross Syncline, 38 m of strata exposed near Te Horo (N73/243062) are tentatively correlated with the Waioioi Formation. The sequence consists of medium–coarse sandstones with interbedded grits, coal seams, and carbonaceous shales yielding leaf impressions. This correlation is only tentative, however, since the sequence exposed in the vicinity of Te Horo is separated from the rest of the eastern flank sequence by a large andesite stock near Waipuna. This means that the stratigraphic position of these beds with respect to the rest of the eastern flank sequence cannot be determined with certainty.

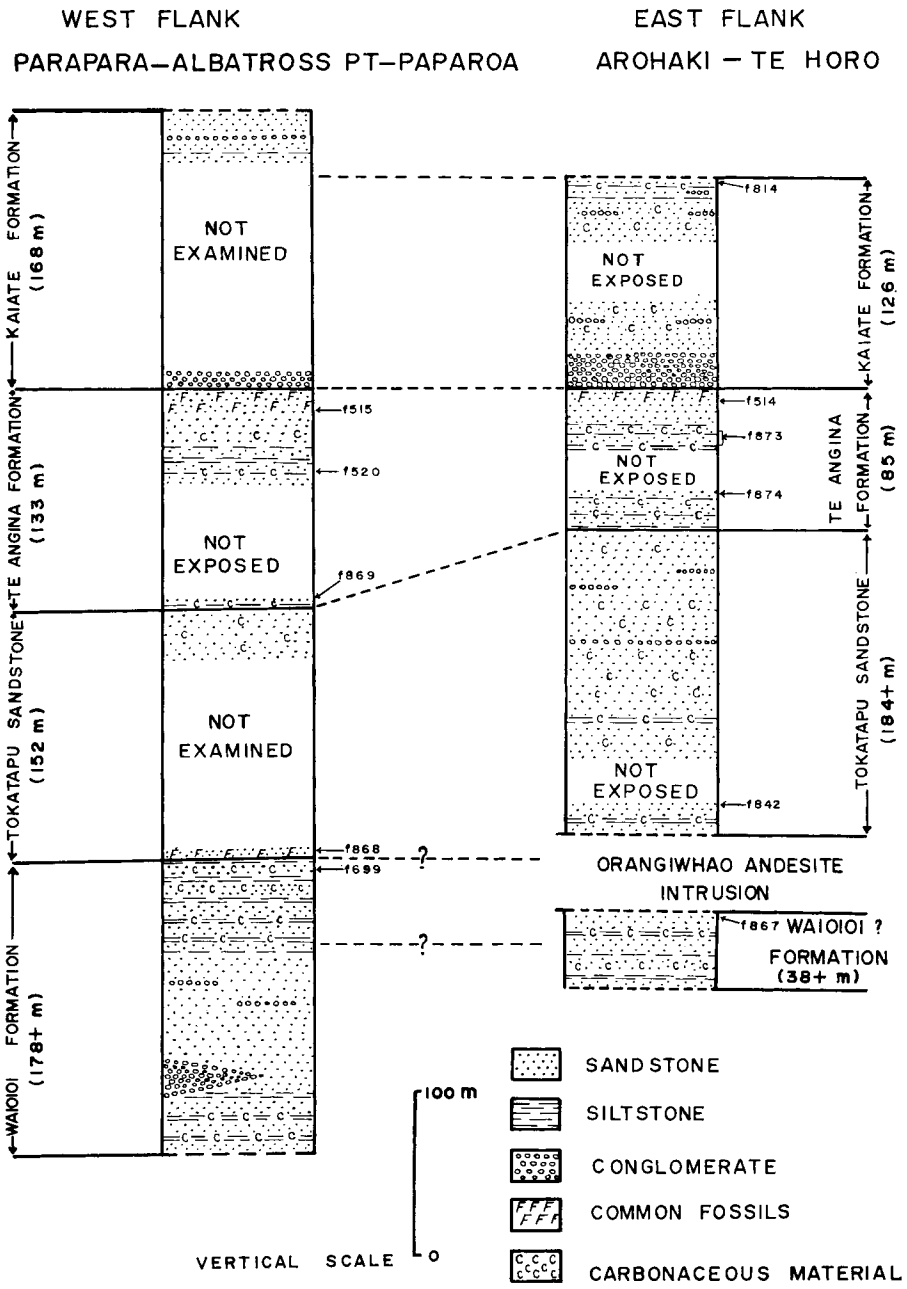

FIG. 11—Stratigraphic columns for the Rengarenga Group in the Albatross Point area.

FIG. 12—Topmost beds of the Waioioi Formation exposed on the west side of Albatross Point. The sequence here includes a wide range of lithologies from conglomerates to thin coal beds.

Paleontology

No fauna was collected from the Waioioi Formation by the writer, although plant remains were found at several localities. Two collections recorded by Mason (1952) from beach boulders (N73/f518, f519) are tentatively included in the floral list for the Waioioi Formation, which is as follows: *Cladophlebis australis* (Morris); *Cladophlebis denticulata* (Brongniart) (f518, f519); *Taeniopteris spatulata* (McClelland) (f518); *Elatocladus* sp. (f519).

Correlation

The flora of the Waioioi Formation do not enable a close correlation of the formation to be made at stage level, since they consist of Middle–Upper Jurassic species that have long time ranges (Edwards 1934). A probable Temaikan age can be assigned to the formation by correlation with the Rengarenga Group on Te Maika Peninsula, which has a known stratigraphic position in the main sequence. In addition, Temaikan fossils have been collected from immediately above the Waioioi Formation.

TOKATAPU SANDSTONE

Name and Type Section

Tokatapu is a promontory (N73/236065) situated 1·6 km west of Te Arawi and 300 m east of Te Angina Point.

FIG. 13—Tokatapu Sandstone. Massive coarse sandstones exposed on the eastern limb of the Albatross Syncline near Tokatapu.

The type section of the Tokatapu Sandstone is on the eastern flank of the Albatross Syncline, and extends from 270 m west to 330 m south-east of Tokatapu Point.

The lower contact with the Waioioi Formation is not seen at the type section because the outcrop is truncated by a stock of Orangiwhao Andesite. The lower contact can be seen on the western flank of the syncline opposite Waioioi, where it is conformable upon the Waioioi Formation. The upper contact is abrupt and conformable and is visible on both flanks of the syncline.

Content and Distribution

The Tokatapu Sandstone is 184 m thick at the type section and consists of massive, coarse to gritty sandstones which often contain wood fragments and occasionally show poorly developed cross-stratification. Rarer carbonaceous horizons, and thin conglomerate bands and lenses are also found (Fig. 13).

The entire sequence of the Tokatapu Sandstone is exposed on the west side of Albatross Point, but because of the inaccessible nature of the coast, only the top 29 m and the basal 2 m of the formation could be inspected. Here the formation is probably 152 m thick.

Paleontology

The writer collected specimens of *Tancredia allani* Marwick and a possible *Meleagrinella* sp. from boulders which had come from beds 2 m

above the base of the Tokatapu Sandstone near Waioioi. Mason (1952) records *Meleagrinella* sp., *Astarte* sp., and *Tancredia* sp. from beach boulders south of Waioioi (N73/f516, f517). These boulders probably came from the Tokatapu Sandstone.

In the type section on the eastern flank, plant fossils were recovered from a locality near the base of the sequence (N73/237063).

The biota of the Tokatapu Sandstone is as follows: *Tancredia allani* Marwick; *Meleagrinella* sp.; ?*Astarte* sp.; *Cladophlebis australis* Morris; *Coniopteris* sp.; *Elatocladus* sp.

Correlation

Although it has not been found at the type section of the stage, the presence of *Tancredia allani* allows correlation of the basal beds of the formation with the Temaikan Stage. The whole formation can in fact be confidently dated as Temaikan since other Temaikan fossils have been collected from the overlying Te Angina Formation.

TE ANGINA FORMATION

Name and Type Section

Te Angina is a distinctive promontory (N73/232066) located 1·9 km west of Te Arawi.

The type section of the Te Angina Formation extends from the west side of Te Angina Point to 180 m west of Tokatapu.

The lower contact with the Tokatapu Sandstone and the upper contact with the Kaiate Formation are both conformable.

Content and Distribution

The Te Angina Formation is 85 m thick at the type locality, and consists mostly of sandstones which are massive, fine–medium grained near the top of the formation (Fig. 14), but rapidly become coarser lower in the sequence and alternate with carbonaceous siltstones, shales, and thin (8–15 cm) coal seams.

On the western flank of the Albatross Syncline, the Te Angina Formation is exposed at the end of Albatross Point over 240 m of coast east from Honipaka Point (N73/215074). Here the formation appears to be substantially thicker than at the type section. It is 133 m thick, of which 70 m in the lower part of the formation is obscured by fallen debris, although the base of the formation is visible. There is somewhat clearer distinction apparent in the Albatross Point section between the upper, fossiliferous sandstones and the underlying interbedded sandstones and carbonaceous beds, whereas at the type section, the boundary between them is gradational.

Paleontology

The Te Angina Formation is quite richly fossiliferous in its uppermost beds which contain marine bivalves, whereas plant fossils were obtained from lower down in the formation. The fauna and flora of the Te Angina

FIG. 14—Fossiliferous sandstones near the top of the Te Angina Formation on the east side of Te Angina Point.

Formation are as follows: *Meleagrinella* cf. *echinata* (Smith); *Inoceramus brownei* Marwick; *Cladophlebis australis* (Morris); *Cladophlebis denticulata* (Brongniart); *Elatocladus* sp.

Inoceramus brownei was originally identified by Marwick (*in* Mason 1952) as *Gervillea* n.sp.

Correlation

The occurrence of *Meleagrinella* cf. *echinata* and *Inoceramus brownei* in the topmost beds permits confident correlation of the Te Angina Formation with the Temaikan Stage.

KAIATE FORMATION

Name and Type Section

The formation takes its name from Kaiate Bay which is situated between Albatross and Te Angina Points.

The Kaiate Formation is the topmost formation of the Rengarenga Group in the Albatross Point area, where it forms the axis of the syncline, with beds cropping out immediately east and west of Kaiate Bay (Fig. 15). Because of the inaccessible nature of most of the western limb sequence which is exposed at the northern end of Albatross Point, the sequence of the eastern limb has been taken as the type section. However, the topmost beds of the western limb are also included in the type section because they are not visible on the eastern limb owing to Quaternary sand cover.

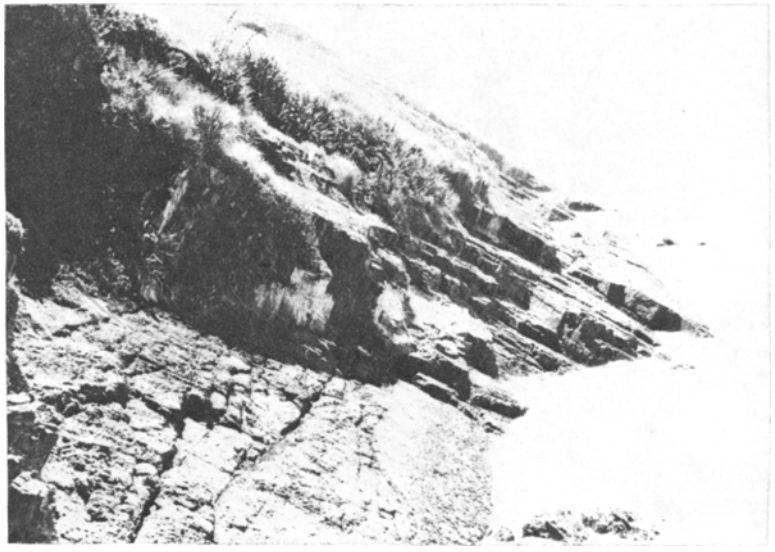

FIG. 15—Well-bedded sandstones of the Kaiate Formation forming a prominent dip slope on the east side of Albatross Point.

Consequently, the type section has been taken as extending from the east side of Te Angina Point, where the Kaiate formation conformably overlies the Te Angina Formation, across Kaiate Bay, where the outcrop is obscured by sand dunes, to the west limb of the syncline to include the topmost beds, of which only 30 m could be examined.

The total thickness of the formation exposed on the western limb is 168 m, most of which could not be examined. The sequence on the east limb totals 126 m, including a gap of 37 m where strata are obscured by recent sands in a bay east of Arohaki (N73/228064).

Content and Distribution

The basal unit of the Kaiate Formation is a massive conglomerate, 20 m thick, composed of closely packed, rounded pebbles of mainly igneous rock. Above the conglomerate, the formation consists of massive, medium–coarse sandstone with thin pebbly conglomerate and well-bedded, cross-stratified sandstone, interbedded with occasional thin, carbonaceous shales, siltstones, and coal seams up to 0·3 m thick.

An exposure of the basal conglomerate and an overlying, cross-stratified sandstone was seen on a track approximately 1 km south of Te Angina Point. The location of this exposure suggests the existence of a fault as shown in Fig. 1.

Correlation

No fossils were recorded from the Kaiate Formation, so direct correlation of the formation with the appropriate stage is not possible. Nevertheless, a probable Temaikan age can be assigned to the formation on stratigraphic grounds and by general lithologic correlation with the upper non-marine strata (Wharetanu Measures) of the Rengarenga Group on Te Maika Peninsula.

Correlation with the Te Maika Peninsula Sequence

Although differences exist between the Rengarenga Group sequences on Te Maika Peninsula and Albatross Point, correlation between them may still be possible in a general way. The sequence at Albatross Point contains two fossiliferous marine incursions, whereas on Te Maika Peninsula, only one fossiliferous marine incursion (Opapaka Sandstone) is apparently present. If the Opapaka Sandstone is correlated with the fossiliferous beds at the top of the Te Angina Formation, there is little or no correlation between other parts of the two sequences. In particular, there is no equivalent, immediately above the Opapaka Sandstone, of the distinctive conglomerate at the base of the Kaiate Formation. However, Fleming & Kear (1960, p. 23) record a 30-m conglomerate in the upper part of the Wharetanu Measures, 190 m above the Opapaka Sandstone. If this conglomerate is correlated with the base of the Kaiate Formation, then the Opapaka Sandstone may well correlate with the base of the Tokatapu Sandstone. If so, the Wharetanu Measures would be equivalent to the Kaiate Formation, Te Angina Formation, and most of the Tokatapu Sandstone. A comparison of the lithologies of these formations tends to support this correlation although the sequence at Albatross Point may be somewhat thicker than at Te Maika. The thickness from the base of the Tokatapu Sandstone to the top of the Kaiate Formation is 437+ m whereas the sequence from the base of the Opapaka Sandstone to the top of the Wharetanu Measures totals only 300 m. If this correlation is correct, the Waioioi Formation would be equivalent to the upper part of the Urawitiki Measures, which are 518 m thick in their type section.

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