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Geology of the Ngahape Area, Eastern Wairarapa

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Abstract

THE Ngahape area, in Sheet District N162 eastern Wairarapa, contains complexly folded and faulted Lower Cretaceous to Lower Eocene strata unconformably overlain by less deformed Middle Miocene strata. Molluscan faunas of Wangaloan (Paleocene) and Bortonian (Upper Eocene) age have been found in boulders but could not be found in place. Sills, flows, and agglomerates of basic igneous rocks are interbedded in the Cretaceous and early Tertiary strata. A circular teschenite intrusion in the Brocken Range is possibly the plug of an eroded volcano.

Structure, illustrated by a small-scale regional map of the eastern Wairarapa, is dominated by north-north-east-striking faults and folds. Limestone appears to be displaced sinistrally about 30 miles by one of the faults, the inferred sense of displacement, being sinistral, is opposite to that of the active wrench faults of the western Wairarapa.

INTRODUCTION

THE following is a short geological account of an area of about 60 square miles in the coastal ranges of the Wairarapa that is entirely within the N162 Sheet District (Fig. 4, locality map). The area includes most of the Kaiwhata River valley, and the small settlement of Ngahape lies near its centre. Reasonably good access is given by the road to Ngahape and the road, commonly known as the Kaiwhata Track, that crosses the Kaiwhata River near its mouth. About half the area is open farmland, and about half is covered by thick scrub. Outcrops are reasonably good in the streams but are poor elsewhere.

A field sheet on a scale of about 4in to a mile was constructed from air photographs by radial line plotting and was adjusted by fitting it to the grid lines of the one-mile-to-an-inch map NZMS 1, Sheet N162. Grid references are shown in the text by a six-figure block of numbers. Fossil locality numbers, prefixed by "f" in the text and on the map, refer to those of the Sheet N162 Fossil Forms. A list of the most important fossil localities, with their key fossils, ages, collectors, identifiers, and grid references, are given in Table I.

A total of four weeks was spent mapping the area.

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TABLE I.—List of key fossil localities.

Stage Symbol	N162 Sheet f number	Collection Number	N162 Grid Reference	In place	Collected by	Identified by	KEY FOSSILS (I. = Inoceramus)
Mh-?p	726	GS6312	373398	n	HWW	CAF	Ostrea lapillicola (0.1)
D	728	GS6314	408413	n	HWW et al	RAC	Spores and pollens, "Wangaloan" macrofossils
Ab	733	GS6319	403407	n	CAF	CAF	Monalaria concinna, Glycymeris subglobosa
R	792	V998	373353	y	HBvdH	HWW	I. nukeus
R ?	795	V1000	368342	y	HBvdH	HWW	I. ? opetius
R	796	V1001	370344	y	HBvdH	HWW	I. nukeus
Mh-?p	804	V666	379408	n	PV	RAH	Baculites rectus & Phyllopachyceras forbesianum
Mp	806	V1005	415444	a	PV	HWW	I. australis
Cm	807	V1006	350418	n	PV	IGS	I. sp., Aucellina cf. euglypha
Mp	809	V1008	418438	a	PV	HWW	I. pacificus
Cm	810	V1403	349413	n	PV	IGS	Aucellina euglypha
Cm	820	V657	388408	n	VUW	HWW & RAH	I. urius, Hamites (Hamites) sp. nov.
Mp	821	V658	386409	y	VUW	HWW	I. pacificus
Sa	822	V659	344392	y	JE	PV	Foraminifera
Sa	823	V660	351389	y	JE	PV	Foraminifera
Sa	824	V661	353386	y	JE	PV	Foraminifera
Ra	826	V663	376352	y	RAC	HWW	I. rangatira
S	833	V674	369389	y	PW		Mollusca
D	835	V676	349387	y	RB	PV	Foraminifera
Rm	861	V1204	410428	n	VUW	HWW	I. bicorrugatus
Mh-?p	878	V1381	395431	n	PW	IGS	Ostrea lapillicola
R	879	V1382	374356	y	PW	HWW	I. nukeus
?Mh	880	V1383	417460	a	PW	CAF	Trigonia sp., Thyasira sp.
Mp	881	V1384	377361	y	PW	HWW	I. pacificus
Cn	882	V1385	363373	y	PW	HWW	I. hakarius
C	883	V1386	399445	y	PW		I. sp.

TABLE I.—(*cont.*)

Stage Symbol	N162 Sheet f number	Collection Number	N162 Grid Reference	In place	Collected by	Identified by	KEY FOSSILS
Cn-Rm	884	V1387	379417	?	PW	GRS	I. sp., Dimitobelus superstes (Hector)
R	885	V1388	373358	y	PW	HWW	I. nukeus
Cn	886	V1389	410431	n	PW	HWW	I. Tawhanus, Trigonia sp.
Cn	890	V1393	382361	y	PW	HWW	I. cf. hakarius, ammonite
Cm	891	V1394	401448	n	PW	IGS	I. sp., Aucellina euglypha
Rm	892	V1395	421431	a	PW	HWW	I. bicorrugatus
Cn	893	V1396	382355	n	PW	HWW	I. hakarius
Cn	897	V1400	378343	y	PW	HWW	I. hakarius
Mh	899	V1402	375407	n	RAH	HWW & IGS	I. ? matatorus, Ostrea lapillicola
Cn ?	900	V1183	408457	n	PV	HWW	I. ? hakarius
Mp-h	981	V2157	413457	n	RAH	RAH	Phyllopachyceras forbesianum, Tetragonites simplex, Kossmaticeras (Natalites) sulcatum
Mp?-h	983	V2158	371398	n	TH	RAH	Neograhamites n. sp.
Mh-D+	985	F17588	411418	y	NdeBH	NdeBH	Foraminifera
D+	989	F17589	407412	y	NdeBH	NdeBH	Foraminifera
Mh-Dm	991	F17590	399407	y	NdeBH	NdeBH	Foraminifera

"Collection number" prefixes

GS = Geological Survey macro-fossils
V = Victoria University
F = Geological Survey foraminifera

"In place" column

n = not in place
y = in place
a = almost in place

CAF = C.A. Fleming
GRS = G.R. Stevens
HBvdH = H.B. van den Heuvel
HWW = H.W. Wellman
IGS = I.G. Speden
JE = J. Eade
NdeBH = N. de B. Hornibrook
PV = P. Vella
PW = P. Wellman
RAC = R.A. Cooper
RB = R. Brathwaite
TH = Mr. Thomas
VUW = Victoria University of Wellington

Previous Accounts of the Geology

Only the igneous rocks, which are more common that elsewhere in the Wairarapa, have been described previously in any detail. They are mostly of Upper Cretaceous age and consist of flows and sills in the eastern part of the area and a plug in the Brocken Range to the west. Brief descriptions were given by Crawford (1861), A. McKay (1884), and W. A. McKay (1889), and a more detailed description by Brown and Hutton in 1943.

Of paleontological interest is a boulder (Hornibrook and Harrington, 1957), from the middle reaches of Kaiwhata Stream, with the only diagnostic molluscan fossils of Wangaloan age so far found in the North Island of New Zealand. The Wangaloan Stage was based by Finlay and Marwick in 1940 on the shallow-water marine molluscan fauna of Wangaloa in north Otago, and considered to be of earliest Tertiary age. Later work showed the Wangaloan fauna to be a restricted one, and to be probably of the same age as one of the more widespread and deeper-water Dannevirke stages. Because of the probable stage overlap, Hornibrook and Harrington in 1957 recommended that the Wangaloan be no longer used as a New Zealand stage, but its exact relation to the Dannevirke stages remained uncertain. In 1960 Couper described plant microfossils from the Kaiwhata Stream boulder and considered them to be about Teurian in age, the Teurian now being regarded as the lowest stage of the Dannevirke series.

A Cretaceous section at Kaiwhata Stream immediately to the east of Ngahape Settlement is easily accessible; it was described by Brown, in 1943, and by H. W. Wellman, in his general account of the New Zealand Cretaceous, in 1959. It is of interest because upper Cretaceous conglomerates contain boulders with shelf faunas of lower- and mid-Cretaceous age that are not known elsewhere in the Wairarapa.

Stratigraphy

The stratigraphic divisions adopted here are based on known and probable ages of the rocks in terms of the New Zealand stage and series divisions (Finlay and Marwick, 1940, 1947; Hornibrook and Harrington, 1957; Wellman, 1959; and Hall, 1963). Some divisions are defined by fossils and some by lithology, but

STRATIGRAPHIC SEQUENCE IN THE CENTRAL PART OF WAIRARAPA COAST

MAP SYMBOL	NEW ZEALAND SERIES	AGE
T	Taranaki Series	Upper Miocene
S	Southland Series	Middle Miocene
P	Pareora Series	Lower Miocene
D	Dannevirke Series	Lower Eocene & Paleocene
M	Mata Series	Senonian & Maestrichtian
R	Raukumara Series	Turonian & Senonian
C	Clarence Series	Albian to Cenomanian
Uk	Taitai Series (Korangan Stage)	Aptian
Um	Taitai Series (Mokoiwian Stage)	? Neocomian

Fig. 1.—Map legend and stratigraphic sequences for Figure 2.

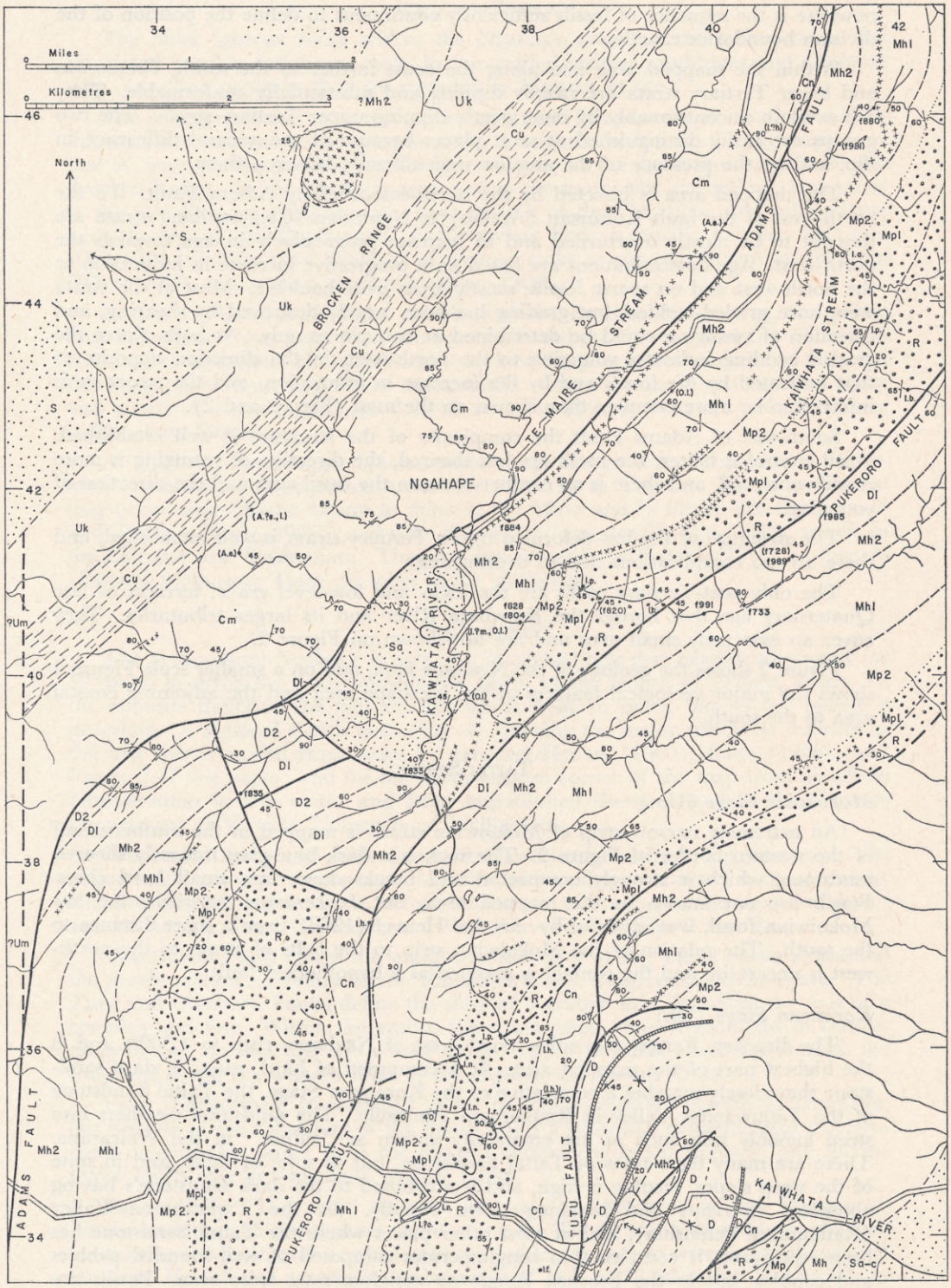

FIG. 2.—Map showing solid geology of the Ngahape area, Eastern Wairarapa.

nowhere is the sequence of fossils sufficiently continuous to define the position of the division boundaries exactly.

Within the mapped area and along the coast farther to the south, Cretaceous and lower Tertiary strata are steeply dipping and substantially conformable. They are overlain unconformably by more gently dipping upper Tertiary strata. The two groups are easily distinguished at most places because of the general difference in dip, and by the presence of the angular unconformity between them.

The mapped area is bisected by the north-east-trending Adams Fault. To the north-west of the fault Korangan (Aptian) to Ngaterian (Cenomanian) strata are thought to be mostly overturned and to increase progressively in age towards the north-west. Age determinations are based on a progressive increase in induration to the north-west and on sparse fossils, mostly from loose boulders. Most of the strata were once graded-bedded, but grading has been largely destroyed by shearing, and direction of younging could be determined at two places only. At both places the graded bedding indicates younging to the north-west, in the direction opposite to that indicated by the fossils and by the increase in induration, and the structure is inferred to be more complex than shown on the map (Figs. 1 and 2).

South-east of Adams Fault the complexity of the structure is well established. Fossil control is better, the rocks are less sheared, the direction of younging is more readily observed, and there is no conflict between the fossil ages and the direction of younging.

The structure of the less-deformed upper Tertiary strata is well established, and there are no complications due to overturning.

The only post-Tertiary rocks are the high- and low-level gravel terraces of late Quaternary age that border the Kaiwhata River and its larger tributaries. They cover an extremely small area and are not shown on Figure 2.

Figure 2 shows the geology of the Ngahape area, and on a smaller scale Figure 4 shows the major geological features of the Ngahape area and the adjoining coastal area to the south.

TAITAI SERIES

Mokoiwian Stage (Um)

An extremely narrow strip of Mokoiwian strata is mapped in the southern half of the western border of Figure 2. The rock is a dark blue-grey intensely sheared mudstone, which is strongly compacted and breaks down into small hard chips. Fossils are not known in the mapped area, but *Inoceramus warakius,* the key Mokoiwian fossil, was reported by van den Heuvel (1960) from a short distance to the south. The relation of the Mokoiwian strip to the belts of strata to the north-west is uncertain, and the contact is mapped as a hypothetical fault.

Korangan Stage (Uk)

The Brocken Range, two miles north-west of Ngahape, rises to 1,500ft and is the highest part of the mapped area. It is composed of hard, massive, dark sandstone that closely matches a correlative of the Korangan Stage, the Taitai Sandstone of the Tapuwaeroa Valley in Raukumara Peninsula. The sandstone weathers into steep knobbly hills such as are commonly known as "taipos" in the Wairarapa. There are many bare areas of Taitai Sandstone, but in spite of these, and in spite of the steep slopes, fertility is high, and is attributed to the dark sandstone's having abundant nutrients and breaking down rapidly. In the Tapuwaeroa Valley (Raukumara Peninsula), and at most other places where the Taitai Sandstone has been recognised, it contains thin conglomerates composed of well-rounded pebbles and cobbles, but in the Brocken Range no conglomerates were seen. Fossils are generally absent from Taitai Sandstone, and none was seen in the Brocken Range.

The Taitai Sandstone of the Brocken Range is confined to a strip about a half-a-mile wide. To the east it is thought to pass up to the Urutawan Stage, to the south-west it is unconformably overlain by Southland strata, and to the north-west it seems to be faulted against uppermost Cretaceous strata.

CLARENCE SERIES

Urutawan Stage

The Urutawan Stage directly overlies the Taitai Series, is the oldest of the three stages of the Clarence Series, and is the one least well defined by fossils away from its type locality. The strata here mapped as Urutawan are unfossiliferous, strongly sheared, graded-bedded sandstones and siltstones, some 2,000ft thick, and lie to the south-east of the dark massive Taitai Sandstone mapped as Korangan. The Urutawan age has been assumed because of the stratigraphic position between the Taitai Sandstone and fossiliferous Motuan strata.

Motuan Stage

A continuous belt in the northern part of the area, to the north-west of Ngahape, is mapped as Motuan. The key fossil *Aucellina euglypha* and a large flat but non-diagnostic *Inoceramus* were found in loose concretions in the streams. Some specimens of the *Inoceramus* were found in place.

The rocks are strongly sheared and consist of graded-bedded siltstones and sandstones with a few massive sandstones that form prominent strike ridges. Occasional conglomerate bands up to 20ft thick are composed of cobbles up to 8in long and well rounded pebbles of greywacke, basic volcanics, and unfossiliferous concretions.

Basic volcanics, shown by crosses on Figure 2, crop out as a strip 350ft wide between Adams Fault and Te Maire Stream. They consist of greenish pillow lava with lenses of red chert and chlorite, and are closely associated with red and dove-grey argillite that is thought to be tuffaceous. Some of the argillite is finely bedded and some contains lenses of *Inoceramus* fragments. Small areas of slumped rocks that appear to be slightly bentonitic are associated with the pillow lavas and red argillites.

Ngaterian Stage

Strata in the northern part of the area, near the head of Kaiwhata Stream, which are the probable source of concretions with the key species *Inoceramus hakarius*, are mapped as Ngaterian. They dip steeply to the west and are considered to be slightly overturned. They consist of graded-bedded and strongly sheared sandstone and siltstone and do not differ appreciably from the rocks of the Motuan belt immediately to the north-west.

In the southern part of the mapped area three fault-bounded strips are mapped as Ngaterian. The eastern strip was mapped as Ngaterian by van den Heuvel (1960) by lithological correlation with fossiliferous strata farther to the south. The western and middle strips contain diagnostic Ngaterian fossils and conformably underlie Raukumara strata. The middle strip contains the best Ngaterian section, and is about 1,500ft thick. A basal 500ft of graded-bedded, hard, grey sandstone and dark-grey siltstone is overlain by 1,000ft of thin dark sandstones and dark blue-grey siltstone with abundant *I. hakarius*, rare indeterminate ammonites, and rare brachiopods. Flute casts at the northern end of the middle strip (382360) indicate that the direction of turbidity-current transport was 100°, and thus suggest that in the mid-Cretaceous land lay to the west.

RAUKUMARA SERIES

The Raukumara Series is mapped as a single unit. Its three stages are comparatively thin and are not fossiliferous enough or lithologically distinctive enough to be mapped separately.

There are two discontinuous belts of Raukumara strata, one on each side of the Pukeroro Fault, each belt being interrupted along its length by one or more faults. The only complete section is through the south-west end of the south-eastern belt, where the Raukumara Series overlies fossiliferous Ngaterian, underlies Piripauan, and contains in their correct order the key species of *Inoceramus* for the upper and lower of the three Raukumara stages. At Kaiwhata Stream, the best section through the north-western belt, the upper and middle stages of the Raukumara Series are defined by their key fossils and underlie fossiliferous Piripauan, but the lowest stage is faulted out by the Pukeroro Fault.

The Raukumara Series is about 1,500ft thick and consists of graded-bedded, light-grey, finely layered quartzose sandstones and laminated jarositic grey siltstones, in rhythms from two to six feet thick, and irregularly spaced bands of massive conglomerate from three to 20ft thick. The conglomerate bands appear to form the bases of the rhythms. They are mostly composed of well-rounded pebbles and cobbles that are almost entirely greywacke, set in a sandy matrix. A few of the conglomerate bands contain mudflakes that have weathered red, and are thus conspicuous rocks. Fossil fragments, small concretion with *Inoceramus* fragments, and unfossiliferous concretionary boulders are not uncommon in the conglomerate.

Loose boulders of siltstone, sandstone, and conglomerate, mostly concretionary, and up to 10ft long, litter the streams where they flow through the conglomerates. Some of the concretionary boulders contain well-preserved fossils. From their position in the streams it is certain that the fossiliferous boulders are derived from the conglomerates, but although fossiliferous pebbles and unfossiliferous boulders have been found in the conglomerates, probably because of their comparative rarity no fossiliferous boulders have yet been found in them.

The sediments of the concretionary boulders are mostly well sorted, and the fossils, as distinct from those of the interbedded sediments, are varied. Sediments and fossils both indicate that the concretionary boulders are of shelf facies.

Several kinds of concretionary boulders are represented, but by far the commonest consists of bands of conglomerate with well-rounded and well-sorted greywacke pebbles interbedded with bands of well-sorted medium sand. Most of the boulders of this kind contain abundant *Megatrigonia glyptica* and *Inoceramus* fragments, and a few contain in addition rare gastropods and rare belemnites. The *Megatrigonia* has the greatest interest, being described by Finlay and Marwick (1948) in what was one of the first references to the fossils of the Ngahape area. It is unfortunate that although the fossils are well preserved their matrix clings to them and they cannot be extracted cleanly.

The conglomerates are interbedded with graded-bedded sandstones and siltstones, and the conglomerates and sandstones appear to be turbidites. Consequently the concretionary boulders, together with the well-rounded greywacke pebbles, have probably been transported into deeper water from the shelf.

The fossils are mostly of Motuan and Ngaterian age, appreciably older than the conglomerate itself, and represent shelf faunas that are not known in place in the North Island, but are widely distributed in boulders in similar conglomerates of about the same age at several other places in the North Island (Wellman, 1959).

MATA SERIES

Piripauan Stage (Mp1 and Mp2)

The strata mapped as Piripauan consist of about 1,300ft of graded-bedded, light-coloured, and finely-bedded quartzose sandstones and jarositic grey siltstones that are divided into a lower 500ft (Mp1), with conglomerate bands similar to those of the Raukumara Series, and an upper 800ft (Mp2), without conglomerate bands but with sills and flows of alkaline basalt, which are shown by crosses in

Figure 2. The Piripauan key fossils—*Inoceramus australis* and *I. pacificus*—are rare and known only in the lower part, the exact age of the upper part being thus uncertain.

Haumurian Stage (Mh1 and Mh2)

The strata mapped as Haumurian are about 2,000ft thick and, like Piripauan, consist of two lithologically distinct parts that are mapped separately.

The lower half (Mh1) consists of grey siltstone with indistinct partings at intervals of 2 to 6in and is mostly jarositic and slightly flinty. In contrast with the underlying Piripauan strata, sandstones are rare and thin.

The upper half (Mh2) consists of massive to poorly bedded blue-grey siltstone, with layers and dykes of greensand. Flattened siliceous tubes about 3mm wide and up to 15mm long are common in the upper part of the Haumurian and in the overlying Teurian. Variously described as an annelid or as a foraminifer it is widely distributed in New Zealand in strata of youngest Cretaceous and oldest Tertiary age.

Igneous rocks, mostly pillow lavas and agglomerates, occur extensively, and are shown by crosses in Figure 2. They are commonest near the middle of the lower half and near the top of the upper half of the Haumurian.

Fossils are uncommon, have been collected mostly from loose boulders, and contain—for New Zealand—an unusually high proportion of ammonites. The most common diagnostic fossil is *Ostrea lapillicola.*

The bulk of the strata mapped as Haumurian form well-defined belts to the south-east of Adams Fault, and its age is partly controlled by fossils. An area that is mapped as Haumurian solely on indifferent lithological correlation lies in the extreme north-west and surrounds the igneous plug on the north-western side of the Brocken Range. Here the bulk of the rocks consists of soft quartzose sandstone and siltstone, but a single outcrop at the north-western edge of the plug shows 10ft of light grey mudstone overlain by 10ft of conglomerate composed of a similar mudstone. Hard rocks that form knobby hills like those of the Taitai Sandstone lie along the eastern margin of the plug. They are lighter coloured than the Taitai Sandstone and are interpreted as being quartzose sandstone that has been hardened by contact metamorphism. To the east of a rill on the south-east side of the plug the contact between the "contact" rocks and the igneous rock of the plug is a well-exposed and somewhat irregular, steeply dipping, slickensided surface that can be traced fairly continuously for several hundred feet. The slickensides are probably an intrusive phenomenon, but they plunge at only 30°, are not parallel for the whole length of the outcrop, and are not well understood.

Dannevirke Series (D, D1, and D2)

Mapping is largely by lithological correlation with more fossiliferous strata elsewhere, and, as at Pahaoa River to the south (Eade, 1966), the Dannevirke Strata to the west of the Tutu Fault differ lithologically from those to the east of the fault.

West of Tutu Fault the Dannevirke Series is about 1,000ft thick and consists of two distinct parts. The lower part (D1), 800ft thick, is composed of about 400ft of massive jarositic dark-brown siltstones and numerous greensand dykes, and is overlain by 400ft of poorly bedded grey siltstone and minor sandstones. The upper part (D2), about 700ft thick, is composed of alternating laminae $\frac{1}{4}$ to $\frac{1}{2}$in thick of graded-bedded purplish-grey siltstone and light grey sandstone. Two samples (f835 and f989) from the lower part have yielded diagnostic Teurian Foraminifera, the Teurian being the lowest of the four Dannevirke stages.

East of Tutu Fault the Dannevirke Series is poorly exposed, is about 1,300ft thick, and was described by van den Heuvel in 1960. It consists mostly of well-

bedded grey siltstone, grey, moderately soft sandstones, and thick beds of greensand. It also contains distinctive beds of well-bedded fine-grained white limestone, the two thickest being 20ft and 40ft thick. The limestones appear to be separated by 20ft of graded-bedded greensand and red bentonitic siltstone. Slump folds similar to those to the south (Eade, 1966) occur in the limestone and more rarely in the associated rocks. No macrofossils were seen and no microfossils were collected by the author to the south-east of the Tutu Fault, but Eade (1966) has reported diagnostic Dannevirke Series Foraminifera from the strata at Pahaoa River.

Wangaloan and Bortonian

By an extraordinary coincidence a boulder with Wangaloan macrofossils (f728) and another boulder with Bortonian macrofossils (f733) were collected at different times within less than half-a-mile of each other from the middle reaches of Kaiwhata Stream some two miles upstream from the road on the south-east side of Puketoro Fault. Other than the fossils from the two boulders, Wangaloan macrofossils are known only from the type and nearby localities in the South Island, and Bortonian macrofossils are known only from the South Island and from Northland. In spite of careful search the writer could find no additional boulders in Kaiwhata Stream.

The Wangaloan fauna is now thought to be of an age equivalent to the deeper-water Teurian Stage of the Dannevirke Series and to be Paleocene in age. The Wangaloan boulder was thus probably derived from the belt of rocks mapped as "D1" within the outcrop area in which the boulder was found, but only a single fragment of a macrofossil and no trace whatever of fossiliferous concretions have been found in these rocks.

The Bortonian boulder contained the Bortonian key species *Monolaria concinna* and *Glycymeris subglobosa*. The Bortonian is upper Eocene, younger than the youngest rocks below the regional unconformity, and older than the oldest rocks above.

The simplest way of explaining the presence of the boulder is to infer that it is derived from a hypothetical sliver of Bortonian shelf-facies rocks infaulted along the Puketoro Fault.

Southland Series

At Ngahape an outlier of Southland Series at least 3,300ft thick unconformably overlies Mata Series, dips west at 40°, and is faulted against Dannevirke and Clarence Series. Massive sandstone 100ft thick, with a thin basal conglomerate, is overlain by 2,000ft of graded-bedded sandstone and siltstone and minor conglomerates, which in turn are overlain by 1,200ft of massive siltstone with a few bands of graded-bedded sandstone. Poorly preserved macrofossils are common in concretions within the lower 2,000ft. Better preserved macrofossils (f833) were collected from a four-inch-thick limestone lens in the massive standstone near the base of the section. Foraminiferal samples (f822, f823, and f824) indicate that the entire sequence is Altonian, the lowest stage of the Southland Series.

In the extreme north-western part of the mapped area (Fig. 2) similar strata, probably Altonian to Clifdenian in age, border the western side of the Brocken Range. They unconformably overlie the Korangan rocks of the Brocken Range and the probably Haumurian rocks that surround the plug of igneous rock immediately west of the range.

In the extreme south-east corner of the mapped area Southland strata rest unconformably on the Haumurian Stage (van den Heuvel, 1960). They are a part of a strip of Southland Series extending north-east along the east coast from Kaiwhata River for 10 miles beyond the mapped area to Whareama River.

IGNEOUS ROCKS

The older igneous rocks within the Ngahape area are the pillow lavas and associated possibly tuffaceous rocks in the graded-bedded sandstones and siltstones with *Aucellina euglypha* that are regarded as Motuan in age.

The younger igneous rocks are more varied, and from systematic changes in their thickness are inferred to have come from a volcanic centre in the Ngahape area that is, now possibly marked by the igneous plug at the north-western side of the Brocken Range. In the Ngahape area, and to the south, sills and pillow lavas occur in the mid-Piripauan agglomerate, near the top of the Piripauan, and pillow lavas near the top of the Haumurian. Each igneous body is usually between 25ft and 100ft thick, and the total thickness of igneous rocks in any one section ranges from 50ft to 700ft and is most commonly about 150ft.

Hutton (1943) described the petrology of the Brocken Range plug, the pillow lava immediately upstream from the road in Kaiwhata Stream, and the sill half-a-mile farther upstream. He identified the rock of the plug as teschenite, and regarded the plug, pillow lava, and sill as comagmatic. Attractive hand specimens of agate and quartz-after-calcite that are derived from the igneous rocks are not uncommon in Kaiwhata Stream.

At Ngahape the younger igneous rocks range in age from Piripauan to uppermost Haumurian. In adjoining areas they range up to Teurian. To the south-east they occur near Mount Adams as flows in the Mata and as sills in the Raukumara and Teurian (Eade, 1966), and near Flat Point (van den Heuvel, 1960) as sills in the Clarence and Raukumara. They are also reported by Hutton (1943) to intrude Clarence rocks near Tinui, 10 miles to the north-east.

STRUCTURE

The area around Ngahape is part of a structural belt that extends south-east for 30 miles, to reach the coast immediately north of the mouth of Pahaoa River. In the opposite direction the belt extends for at least 10 miles, but its full extent is uncertain. A regional sketch map (Fig. 4) showing the major structural features of the belt was compiled from maps by van den Heuvel (1960), Eade (1966), and Figure 2 of this paper; and for the north-western corner of the map from air-photo interpretation by the writer and from unpublished theses lodged in the Geology Department of Victoria University of Wellington.

Subparallel faults and folds that strike north-east dominate the structure. The major faults are more continuous than the folds and have already been named by van den Heuvel and by Eade. From north-west to south-east the most important are the Adams, Tutu, Glenburn, and Flat Point Faults (Figs. 2 and 4).

The Adams Fault marks the south-east boundary of the Taitai Series strata and the north-western boundary of the Raukumara and Dannevirke Series strata. The Tutu and Glenburn Faults define the sides of a graben that lies along the axis of a complex anticline. Within the graben the strata range from Raukumara to Dannevirke in age; outside they are mostly older. The Flat Point Fault lies close to the coast and forms the western limit of the exposed Cretaceous strata.

Fault displacement is described above as though entirely dip-slip in character, but because of the continuity of the major faults a strike-slip component of displacement considerably larger than the dip-slip component is not unlikely, and all the major faults may be essentially wrench faults.

Eade (1966: 115) noted that the lithology and thickness of the Dannevirke Limestone remained constant on approaching the Tutu Fault then suddenly changed on crossing the fault, and he attributed the sudden change to wrench (transcurrent) faulting. He inferred a wrench displacement of at least 12 miles, but was unable to give a preferred sense of strike-slip displacement—sinistral or dextral.

MAP SYMBOL	AGE AND LITHOLOGY OF SEDIMENTS	THICKNESS FEET
	MIOCENE	
S & Sa	Southland Series; and Southland Series, Altonian Stage Massive grey siltstone, and graded bedded sandstone and siltstone. Angular unconformity and conglomerate at base.	3,300
	LOWER EOCENE AND PALEOCENE	
D2	Dannevirke Series, upper part Graded bedded sandstone and siltstone in $\frac{1}{4}$ to $\frac{1}{2}$ in layers.	700
D1	Dannevirke Series, lower part Blue, grey, and dark-brown siltstone, greensands.	c. 800
D	Dannevirke Series, undifferentiated (W of Tutu Fault only) Grey siltstones, soft grey sandstones, thick greensand, and (mapped separately) well-bedded fine-grained limestones.	c. 1,300
	UPPER CRETACEOUS	
Mh2	Mata Series, Haumurian Stage, upper part Massive to poorly bedded blue-grey siltstone with greensand layers and a few greensand dykes. Agglomerates and pillow lavas (crosses).	1,000
Mh1	Mata Series, Haumurian Stage, lower part Gray, flinty, jarositic siltstone in 2 to 6 in layers. Agglomerates and pillow lavas (crosses).	1,000
Mp2	Mata Series, Piripauan Stage, upper part Graded-bedded siltstone and quartzose sandstone. Pillow lavas and sills (crosses).	700
Mp1	Mata Series, Piripauan Stage, lower part Graded-bedded siltstone and quartzose sandstone, with many bands of redeposited conglomerate.	600
R	Raukumara Series: Arowhanan, Mangaotanean, and Teratan stages Graded-bedded siltstone and quartzose sandstone with many bands of redeposited conglomerate.	1,500
Cn	Clarence Series, Ngaterian Stage Graded bedded dark sandstone and siltstone.	1,000
	LOWER CRETACEOUS	
Cn	Clarence Series, Motuan Stage (fossils rare) Sheared, graded, bedded sandstone and siltstone, bands of massive sandstone. Pillow lava (crosses).	c. 6,000
Cu	Clarence Series, ?Urutawan Stage (no fossils) Strongly sheared sandstone and siltstone.	2,000
Uk	Taitai Series, ?Korangan Stage (no fossils) Massive dark sandstone, sheared sandstone and siltstone.	c. 4,500 +
Um	Taitai Series, Mokoiwian Stage (no fossils) Sheared dark siltstone.	1,000 +

Key fossils: 0.1 = Ostrea lapillicola. A.e = Aucellina euglypha.
Inoceramus species are indicated by "I" followed by the initial letter of the specific name.
Direction of younging, at the few places where determined, is indicated by an arrow on the dip symbol.
Sheet N162 fossil locality numbers are indicated by f726 etc.

FIG. 3.—Map symbols and stratigraphic sequence for Figure 4.

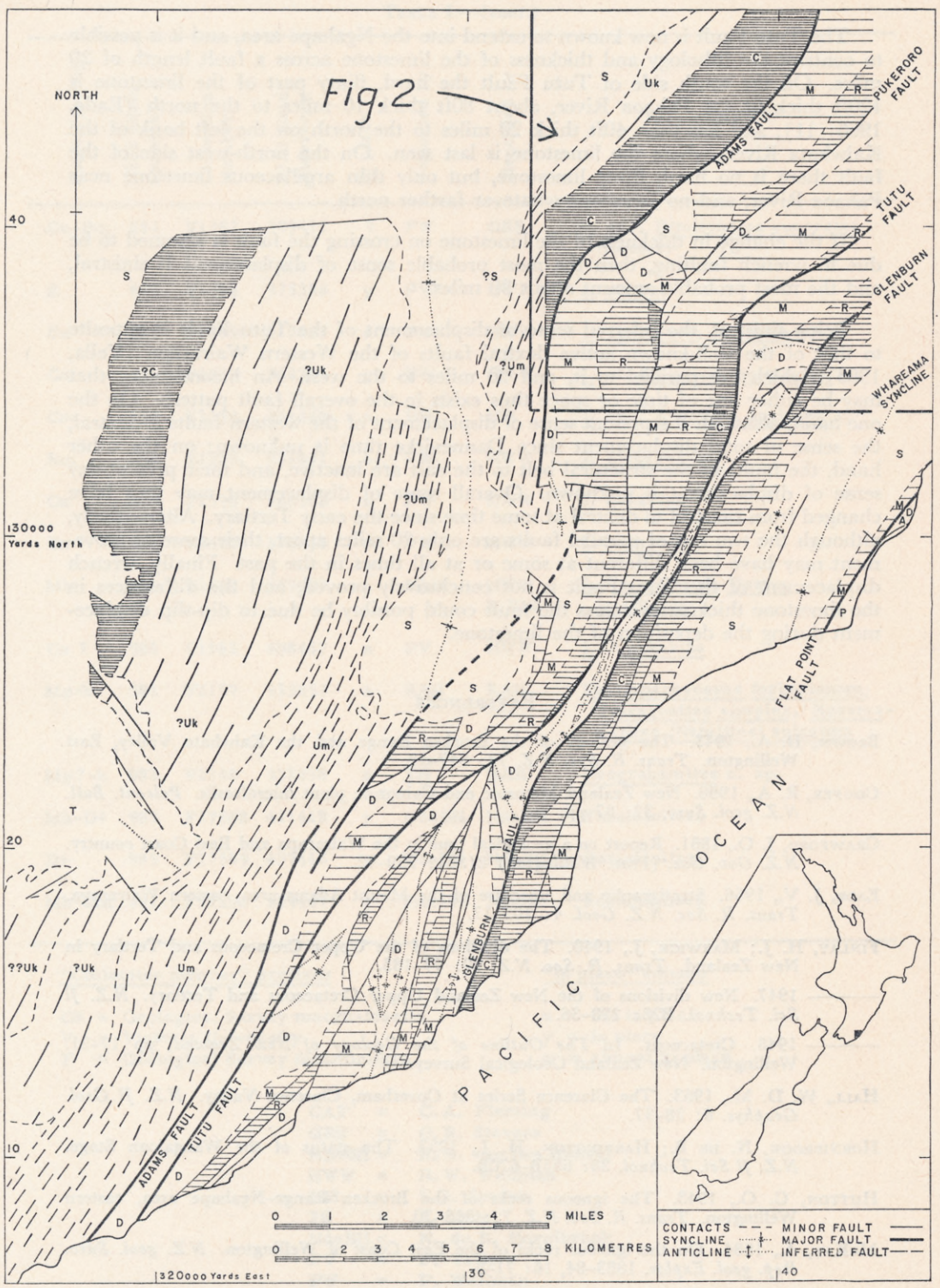

FIG. 4.—Locality map and geological map of central part of Wairarapa coast. The Ngahape area of Figure 2 is represented by the north-eastern part.

The Tutu Fault is now known to extend into the Ngahape area, and it is possible to contrast the lithology and thickness of the limestone across a fault length of 20 miles. On the south side of Tutu Fault the hard, flinty part of the limestone is 120ft thick at the Pahaoa River, about 80ft thick 10 miles to the north (Eade, 1966: 11), and less than 40ft thick 20 miles to the north on the left bank of the Kaiwhata River, where the limestone is last seen. On the north-west side of the fault there is no hard, flinty limestone, but only thin argillaceous limestone near Pahaoa River, and no limestone whatever farther north.

If the change in thickness of the limestone on crossing the fault is assumed to be due to wrench faulting, then the most probable sense of displacement is sinistral, and the most probable amount about 30 miles.

Being sinistral, the inferred sense of displacement of the Tutu Fault is opposite to that of the well-known active dextral faults of the Western Wairarapa (Vella, 1963), which are parallel to it, and 20 miles to the west. An inconsistency that may be either one of time or space thus exists in the overall fault pattern. On the one hand, although the present sense of displacement of the western faults is dextral, the sense of total displacement since Dannevirke time is unknown; on the other hand, the faults of the structural belt to the east are inactive, and their present-day sense of displacement is unknown. Overall sense of displacement may thus have changed from sinistral to dextral at some time since the early Tertiary. Alternatively, although the two sets of parallel faults are only 20 miles apart, their sense of movement may have been different at some or at all times in the past. Finally, wrench displacement of the Tutu Fault is not conclusively proved, and the differences in the limestone thicknesses across the fault could possibly be due to dip-slip displacement during the deposition of the limestone.

REFERENCES

BROWN, D. A., 1943. The geology of the Brocken Range and the Kaiwhata Valley, East Wellington. *Trans. R. Soc. N.Z.* 72: 347–52.

COUPER, R. A., 1960. New Zealand Mesozoic and Cainozoic plant microfossils. *Paleont. Bull. N.Z. geol. Surv.* 32: 87 pp.

CRAWFORD, J. O., 1861. Report on a geological tour in the Wairarapa and East Coast country. *N.Z. Gov. Gaz. (Prov. Wellington)* 8(35): 239–42.

EADE, J. V., 1966. Stratigraphy and structure of the Mount Adams area, eastern Wairarapa. *Trans. R. Soc. N.Z. Geol.* 4: 103–17.

FINLAY, H. J.; MARWICK, J., 1940. The divisions of the Upper Cretaceous and Tertiary in New Zealand. *Trans. R. Soc. N.Z.* 70: 77–135.

——— 1947. New divisions of the New Zealand Upper Cretaceous and Tertiary. *N.Z. Jl Sci. Technol.* B28: 228–36.

——— 1948. Cretaceous. In *The Outline of the Geology of New Zealand,* pp 17–21. Wellington. New Zealand Geological Survey.

HALL, W. D. M., 1963. The Clarence Series at Coverham, Clarence Valley. *N.Z. Jl Geol. Geophys.* 6: 28–37.

HORNIBROOK, N. DE B.; HARRINGTON, H. J., 1957. The status of the Wangaloan Stage. *N.Z. Jl Sci. Technol.* 38: 655B–670B.

HUTTON, C. O., 1943. The igneous rocks of the Brocken Range–Ngahape area, eastern Wellington. *Trans. R. Soc. N.Z.* 72: 353–70.

MCKAY, A., 1884. On the igneous rocks of the East Coast of Wellington. *N.Z. geol. Surv. Rep. geol. Explor.* 1883–84, 16: 71–5.

MCKAY, W. A., 1899. Report on geology of East Coast from the Kaiwhata River to Glenburn, East Coast of Wellington. *Append. J. House Repres. N.Z.* C–9: 36–43.

VAN DEN HEUVEL, H. B., 1960. The geology of the Flat Point area, Eastern Wairarapa. *N.Z. Jl Geol. Geophys.* 3: 309–20.

VELLA, P., 1963. Upper Pleistocene succession in the inland part of Wairarapa Valley, New Zealand. *Trans. R. Soc. N.Z. Geol.* 2: 63–78.

WELLMAN, H. W., 1959. Divisions of the New Zealand Cretaceous. *Trans. R. Soc. N.Z.* 87: 99–163.

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