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Eastern Papua
Geological Reconnaissance

by

H.L. Davies, I.E. Smith, G. Cifali, and D.J. Belford

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EASTERN PAPUA - GEOLOGICAL RECONNAISSANCE

SUMMARY

This report presents the preliminary results of a helicopter - borne geological reconnaissance of eastern Papua in March-April, 1968.

Eastern Papua is made up of three physiographic units which roughly coincide with the structural units in the area.

(1) the Suckling - Dayman block
(2) southern and eastern mountains and foothills and
(3) the northern hills and plains of which the Cape Vogel Peninsula is the main component.

The Suckling - Dayman block is a broad east-west anticline of Upper Cretaceous basic and calcic schists (greenschist and some glaucophane schist facies) with a core of less altered basalt and limestone. The formation of the schists is thought to be the result of an Eocene thrust; they have been arched up by post- lower Miocene vertical movements. The southern and eastern mountains and foothills consist of lower Miocene marine basalts with minor limestone and volcanogenic sediments; they are intruded by gabbro with minor peridotite, and by syenitic bodies. The northern hills and plains are almost entirely post-lower Miocene sediments with some Quaternary volcanics. The sediments were deposited on a lower Tertiary basement. An orogeny which began during or after the lower Miocene and is continuing today has produced spectacular vertical movements and probably some westerly or north-westerly strike-slip (left-lateral ?) movement.

Alluvial gold and platinum have been worked south of Milne Bay, and at several other points. The greatest economic potential of the area may lie in the off-shore petroleum prospects of the Cape Vogel basin.

INTRODUCTION

Between March 6th and April 8th, 1968, the Bureau of Mineral Resources carried out a helicopter supported geological reconnaissance of the Eastern Papuan mainland between Mount Suckling (149°E) and East Cape (151°E), an area of approximately 12,000 sq.km. This report presents field data, micropalaeontological determinations and preliminary thin-section petrography. Further field work is planned and a final report is scheduled for completion in October 1969.

The geological mapping of Eastern Papua is one aspect of a concerted study of the area by the Bureau of Mineral Resources. A regional gravity survey of land areas has been completed (J.S. Milsom in prep.) and this may be followed by a seaborne, gravity survey. Aeromagnetic work is being planned to extend the work already done in the western part of Papua by the Compagnie Generale de Geophysique in 1967, on behalf of the Bureau of Mineral Resources. A brief oceanographic survey has been conducted in the Milne Bay area by the Phosphate Group of the Bureau of Mineral Resources.

1. METHOD OF WORK

The reconnaissance survey was planned and directed by Davies; Smith and Cifali shared in the preparations for the survey; Smith worked closely with Davies in the field, whereas Cifali was forced to withdraw with an accidental injury after only a few days. Smith and Cifali compiled the results of the survey and will carry out the follow-up surveys and prepare the final report. D.J. Belford examined a number of specimen for microfossils and thus provided stratigraphic control of the many lithologically similar rock units, (see Appendix). Members of the T.P.N.G. resident geological staff made a valuable contribution to the field work. R.F. Heming participated for two weeks and P.D. Hohnen and P. Pieters for ten days each. C.D. Ollier, from the University of Papua-New Guinea also joined the party for ten days. V.G. Dawson was seconded to the B.M.R. from C.S.I.R.O. to act as Camp Manager/Transport Officer. Ten native assistants completed the party.

The survey was carried out from base camps at Alotau (march 6th to 15th), Raba Raba (March 15th to 27th) and Agaun (March 27th to April 7th). Most of the area is within 50 km. of one or other of these bases. The base camps were moved by shuttle flights with a Cessna 337 aircraft owned by Aerial Tours of Port Moresby. The final camp shift from Agaun to Port Moresby was made with two Pilatus Porter, two Cessna 337 and one Cessna 185 aircraft; 150 hours of helicopter flying were used during the 32 days of the survey. The helicopter was a Bell 47 G3B1 on charter from Helicopter Transport of Lae and piloted by J.C. Arthurston and B.L. Evans. Because of the good scattering of natural landing sites most of the mapping was done by means of day traverses (set down about 0630 hours, pick up 12.30 - 15.00 hours).

A leap-frog traverse method was developed in areas of good access and simple geology, such as the southern watershed between the Bonua River and Mullins Harbour. Two geologists are landed at separate localities one or two miles apart. After dropping the second geologist the helicopter returns to pick up the first, and drops him one or two miles beyond the second geologist and so on. This method will cover about 300 sq.km. of country in a 6-hour working day.

Air-photo coverage is almost complete. Civil Aviation photos are indexed in Figure 1; 1:250,000 topographic bases have been prepared by the U.S. Army map services and are distributed by Division of National Mapping. More accurate 1:50,000 topographic base maps are being prepared by National Mapping.

2. PREVIOUS WORK

An account of the geology of Papua by E.R. Stanley is probably the earliest attempt at a geological synthesis of Papua (Stanley, 1923). In 1928, Anglo Persian Oil Company geologists investigated the Mio-Pliocene sediments of the Cape Vogel Peninsula (Papp and Nason-Jones, 1928). Baker (1946) gives an account of the 1943-44 volcanic eruptions along the northern margin of the Mount Suckling - Mount Dayman mountain block; he has also published a short paper dealing with the petrography of a diorite intrusive which outcrops at East Cape (Baker, 1953). Paterson and Kicinski (1956) discuss briefly the geology of Papua in relation to the petroleum prospects of the Cape Vogel basin. During the 1950's J.E. Thompson made a number of traverses across Eastern Papua including a reconnaissance survey of Cape Vogel Peninsula with a party from the C.S.I.R.O. Division of Land Research, during which he collected specimens of clinoenstatite-bearing lavas, (Dallwitz et al., 1966). An outline of Thompson's findings in Eastern Papua appears in his synthesis of the structure of Papua - New Guinea (Thompson and Fisher, 1965). In 1961 and 1962 J.H. Latter visited the Mount Dayman area, (Latter, 1964). Davies spent two days in March 1967 in helicopter reconnaissance around Milne Bay during the B.M.R. gravity survey of the area,(Davies,1967). In January, 1968, K. Phillips and K.R. Yates of Anaconda (Australia) Inc., investigated mineralization at Oura Oura near Milne Bay and reconnoitred nearby rivers,(Phillips and Yates 1968); the company kindly passed on results of the reconnaissance to the writers.

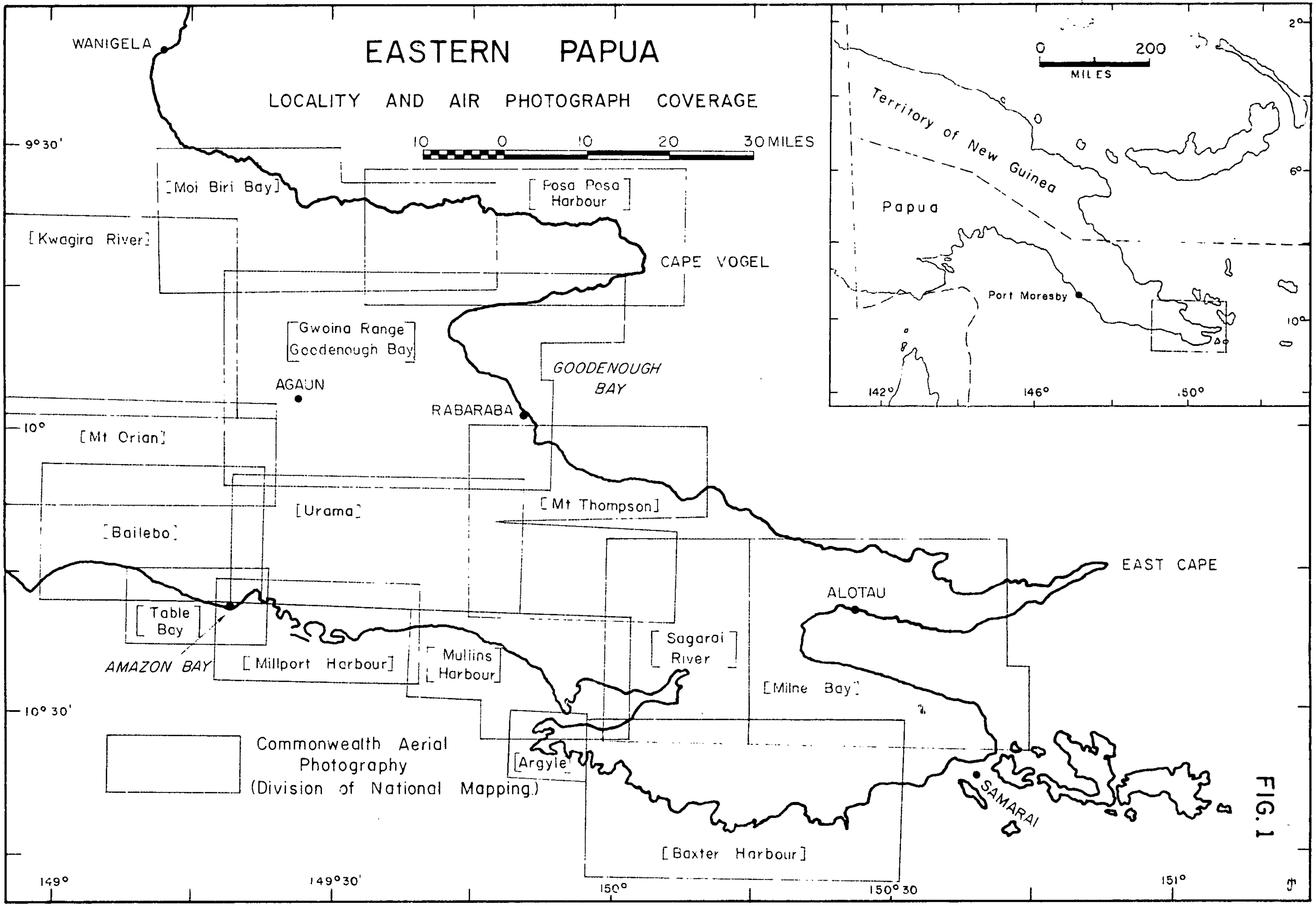

FIG. 1

To accompany Record 1968/66

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3. PHYSIOGRAPHY

Eastern Papua (Plate 1) is mountainous and heavily forested with only a few relatively flat areas, namely, the low hills of the Cape Vogel Peninsula which carry a cover of grass and savannah forest, the alluvial piedmont in the extreme north west of the area and parts of the south coast. It can be divided into three physiographic units.

(1) The Suckling - Dayman block;
(2) The southern and eastern mountains and foothills;
(3) the northern hills and plains.

The most prominent feature is the Suckling-Dayman block, an east-west trending elongated mountain block which ranges in elevation from over 3,700 metres at the western end (Mount Suckling) to approximately 1,800 metres in a relatively deperessed central portion to over 2,800 metres at the eastern end (Mounts Aniata, Dayman and Orian).

The southern mountains and foothills lie to the south and south east of the Suckling-Dayman block. The highest mountain, Mount Simpson, is a steep-sided east-west trending ridge 32 kilometres south east of Mount Dayman. Other notable peaks in the area are Mounts Thompson (1,800 metres) and Nelson (900 metres). An alluvial plain five to ten kilometres wide borders the main ranges on the southern side as far east as Mullins Harbour. Major streams include the Bonua and Tavanei Rivers draining south from the Suckling-Dayman block, the Gwariu and Nauwandowan Rivers in the Suckling-Dayman block, the Ruaba, Kutu, Wamira, and Tameo Rivers draining north from the main ranges and the Gumini, Dawa Dawa and Sagarai Rivers in the Milne Bay area.

The northern foothills and plains extend along the north coast from 149°E to Puni Puni Point (150°28'E). The unit is mainly low-lying (less than 600 metres) and includes the piedmont to the north of the Suckling-Dayman block, the grass-covered hills of the Cape Vogel Peninsula and the coastal hills between the head of Goodenough Bay and Bentley Bay. Small recent volcanic hills stand on the piedmont north of the Suckling-Dayman block.

GEOLOGY

1. LITHOLOGY AND STRATIGRAPHY

The oldest rocks in Eastern Papua are Cretaceous low-grade metamorphics, an eastern continuation of the Goropu Metamorphics, (Smith and Green, 1961). These rocks make up the Suckling-Dayman block.

To the east of the Suckling-Dayman block, the main ranges consist of basalt, limestone, and volcanogenic clastic sediments. These rocks are mostly lower Miocene, but include some Eocene on the northern side of East Cape Peninsula. They are intruded in a number of localities by post-lower Miocene ultrabasic, basic, and syenitic rocks. Pliocene or Pleistocene volcanics overlie the lower Miocene rocks on part of the south coast.

To the north of the main ranges the rocks are mainly coarse clastic sediments of post-lower Miocene age; some upfaulted ridges of upper Oligocene - lower Miocene volcanic basement are preserved in the northern part of Cape Vogel Peninsula.

UPPER CRETACEOUS(?)

Goropu Metamorphics

The Goropu Metamorphics form the uplifted Suckling-Dayman block, a broad east-west anticline of Upper Cretaceous(?) basic and calcic schists which form a "carapace" over moderately schistose Upper Cretaceous (?) basalts and limestone. Quartz-mica phillite, quartz mica schist, chlorite schist, sericite schist, and metaquartzite are described from Mount Suckling, immediately to the west of the mapped area by Smith and Green, (1961).

The schists of the eastern part of the Suckling-Dayman mountain block are tentatively divided into three units.

Gwariu metabasalts (new name):

Metabasalt which underlies the schist carapace and is exposed in the headwaters of the Gwariu River. Possible pillow textures are preserved at one locality.

Bonenao schist (new name):

Calcic schist and marble which belong to the carapace of the anticline and crop out mainly on the south eastern flank of the mountain block (Bonenao River) and immediately south of the Gwoira Range. Upper Cretaceous foraminifera have been found in specimens from the Nauwandowan River headwaters (5765 coll. P.D. Hohnen) and in the Tavanei River (3233).

Dayman schist (new name):

Greenschist facies basic schists which form the upper part of the carapace of the anticline. Some of the schists are glaucophane-bearing. They are named after Mount Dayman.

The schist carapace appears to be thicker and of a higher metamorphic grade on the northern flank of the anticline where it includes some glaucophane-bearing schists. At the eastern end of the mountain block the calcic schists (Bonenao schist) dip eastward on the Nauwandowan River and southward in the Bonenao and Tavanei River headwaters. This may represent the closure of the anticlinal structure. The schists crop out further east, south of the Gwoira Range as far as longitude $149^{\circ}40'$E; areas of the carapace are preserved on the Yau River at longitude $149^{\circ}28'$E.

The occurrence of metamorphics overlying relatively unmetamorphosed rocks in a broad anticlinal structure requires some explanation. The hypothesis that the authors favour is that the schist carapace represents the sole of a post-Cretaceous thrust, originally flat-lying but now arched by Plio-Pleistocene vertical movements. This hypothesis is compatible with current ideas on the emplacement of the Papuan Ultramafic Belt, where-by a segment of oceanic crust and upper mantle has been thrust southward over the sialic core of Papua, (Davies, 1968).

PALEOCENE

Limestone forms the prominent Castle Hill (300 metres) on Cape Vogel Peninsula. A specimen collected from this limestone by J.E. Thompson in 1964 contained upper Paleocene microfauna, (Belford, 1966). Other specimens collected on the southern slopes of Castle Hill contain lower Miocene (f1-2 stage) microfossils, (Dallwitz et al., 1966). It is likely that there are two distinct limestones on Castle Hill separated by an unconformity.

EOCENE

Touiwaira Beds (new name):

The Touiwaira Beds consist of marine basalt and related intrusives with minor fossiliferous limestone, and limey sediments which crop out on the northern watershed of East Cape Peninsula. The rocks are exposed in Touiwaira Creek (lat. 10°59'S, long. 150°25'E).

The basalt and associated coarser variants are typically composed of augite 20-40 percent, labradorite 40-50 percent, green brown interstitial material (after olivine?) 5-10 percent, and iron ore 5 percent. Well developed pillow structures are common.

The limestone and limey sediments which occur within the basalts form irregular lenses and beds which are generally severely contorted. Microfossils from a specimen of limey sediment (2045) indicate an Eocene age. This is probably the first evidence of Eocene volcanicity in Papua.

A bed of limestone overlies the basalt in the Touiwaira valley and in the adjacent valleys. It has a consistent thickness of 3 - 7 metres and a dip of 30° to the south. The hand specimen is fine grained and has an even cream colour. Microfossils contained in a number of specimens (2039, 2042-3, 2048, 2203) are all Eocene in age. The consistent dip and thickness of the limestone suggest that there has been very little folding in the area since the Eocene. The limestone is intruded by gabbro which is seen to overlie it at one locality (lat. 9°59'S, long. 150°23'E); lower Miocene basalt probably overlies the limestone elsewhere.

UPPER OLIGOCENE - LOWER MIOCENE

Dabi Volcanics (new name)

Marine basaltic pillow lavas and massive flows interbedded with minor tuff crop out in the northern part of Cape Vogel Peninsula between (long. 149°42'E,& long. 149°53'E) and in the Umurumuru Hills (lat. 9°03'S, long. 149°44'E) at the base of the peninsula; they are named from Dabi Creek. Clinoenstatite has been reported from these rocks near Dabi Creek at lat. 9°25'S, long. 149°49'E, (Dallwitz, et.al., 1966) and a specimen of the clinoestatite-bearing rock has yielded a K/Ar of 28 m.y. (op. cit.). Microfossils contained in a tuff sample (3154) collected on the current survey are older than mid Miocene. The volcanics are apparently upfaulted ridges of upper Oligocene basement.

Dawa Dawa Beds (Davies, 1967):

The Dawa Dawa Beds as defined by Davies (1967) crop out on both sides of Milne Bay and extend as far as the south coast between 150°18'E and 150°42'E longitude. The latest work has shown that they also occur west of Milne Bay as a thick sequence of marine basic volcanic rocks and their intrusive equivalents which crop out over an area of 2,000 square kilometres in the central ranges. The Dawa Dawa Beds thus include all of the lower Miocene basic volcanics and associated rocks in Papua east of 149°E. longitude.

The Dawa Dawa Beds are predominantly marine basic volcanics, associated dolerite, and basic detrital sediments with minor (less than 5%) chert, limestone, agglomerate, and limey sediment. Pillow structures are moderately common and some of the pillow basalt is well bedded. In the middle reaches of the Dawa Dawa River, there is an extensive sequence of generally thin, well bedded gently dipping flows and detrital sediments. Over much of the outcrop area, however, the basic rocks are not obviously bedded and form massive outcrops which show varying degrees of jointing, shearing, alteration, and secondary veining.

The total thickness of marine basic rocks in Eastern Papua is unknown but probably exceeds 3,000 metres. The north-western limit is not known; lower Miocene basalt probably gives way to Cretaceous basalt, somewhere between the Kutu River (9°50'S lat., 149°37'E long.) and the Bonenao schists (see page 7) south of Gwoira Range.

Microfossils in the limestone and limey sediments of the Dawa Dawa Beds are indicative of a lower Miocene age.

Suen Beds (new name):

The Suen Beds are exposed in the Suen, Sige Eueu, Modewa and Eabiha Rivers to the south east of Mullins Harbour (lat. 10°15'S, long. 150°00E), and in the Nigo Nigo and Wegulani Rivers to the north of Mullins Harbour. They consist of limestone, well bedded, graded-bedded volcanogenic sandstone and siltstone, massive sandstone and conglomerate. The sequence is cut by a swarm of augite porphyry dykes. In the Nigo Nigo and Wegulani Rivers the Suen Beds are apparently in fault contact with the lower Miocene basalt to the north. Their southern contact is buried under alluvium.

Microfossils contained in specimens of limestone from the Nigo Nigo (3120), Suen (2147), Sige Eueu (3068) and Modewa (2113) Rivers indicate a Tertiary 'e' stage age for the Suen Beds.

Juliade Beds (new name):

Limestone and chert form broad anticlines and synclines along the south coast between 149°3'E and 149°38'E. The limestone is typically white and fine grained. On Juliade Island, (lat.10°9'S, long.149°35'E) it is extremely contorted probably as a result of post-depositional slumping. Microfossils in specimens collected on Julidade Island (2297-2302) indicate a Miocene age.

POST-LOWER MIOCENE

Mount Nelson Beds (new name):

Mount Nelson Beds is the name tentatively given to basic agglomerate and conglomerate which form a thick sheet overlying the Suen Beds in the area to the south east of Mullins Harbour. The beds have been observed as outcrop on the south coast at Baxter Harbour, in the headwaters of the Suen River and as large tumbled blocks in the Sige Lele and Sige Eueu Rivers which drain the western slopes of Mount Nelson,(lat.10°20'S, long.150°14'E),after which the beds are named.

The agglomerate and conglomerate appear to have an igneous matrix with augite or aegirine-augite and labradorite phenocrysts. It is not yet clear whether these are in fact igneous rocks of unusual texture or whether they are normal agglomerate and conglomerate in which phenocrysts have developed during metasomatism associated with intrusives that occur in the area.

Mailu Beds (new name):

On Mailu Island,(Lat.10°8'S, long.149°22'E),grit, silt, and conglomerate dip at 30° to 40° degrees to the north. Components in the conglomerate include limestone, chert, basalt, and a porphyritic (dyke) rock and are typical of rock types found on the mainland. No definite age has yet been obtained for the Mailu Beds but the components in the conglomerate would indicate a post-lower Miocene age.

Momore Range Limestone (new name) :

An apparently massive limestone forms a capping, approximately 30 metres thick, along the top of the Momore Range to the south of Mullins Harbour. As yet, no age determinations are available for this limestone.

Cape Vogel Sediments :

Middle Miocene to recent sediments totalling over 3,500 metres in thickness have been mapped on Cape Vogel Peninsula by Papp and Nason-Jones, (1929), who distinguished the following divisions:

The "White Marl Group" comprises rocks which are generally creamy or white, saponaceous, thin-bedded marls. In places they are micaceous. The thickness of this unit is upwards of 240 metres and it is conformable with the overlying sediments. Papp and Nason-Jones suggest a middle Miocene age for this unit.

The "Lower Arenaceous Group" consists of thick compact sandstone beds, soft brown calcareous sandstone, grit and conglomerate, with interbedded brown marl and thin lignite bands. Fossils indicate that these sediments were laid down largely in shallow fresh water. Their thickness totals at least 2,500 metres. They have been tentatively mapped by Papp and Nason-Jones (1929) as upper Miocene.

The "Upper Arenaceous Group" conformably overlies the "Lower Arenaceous Group". It is divided into three sub-groups.

Sub-Group A: 1,200 metres of soft brown sandstone and marl, grit, and ferruginous gravelly sandstone.

Sub-Group B: Thin-bedded white, laminated, siliceous marl and occasional hard, thin, grey limestone bands, with a total thickness of 170 metres.

Sub-Group C: Grey and white sandy marl containing plant remains, poorly consolidated conglomerate, ferruginous sandstone, and gravel. They have a thickness of 130 metres.

The "Upper Arenaceous Group" has a total thickness of 1,600 metres. Fossils indicate a Mio-Pliocene age. The boundary between "Lower" and "Upper Arenaceous Groups" was arbitrarily selected by Papp and Nason-Jones mainly with regard to topographic features.

Gwoira Beds (new name):

The Gwoira Beds form a small mountain range that occupies an embayment in the schists, immediately east of the Suckling-Dayman block. Their name is derived from Mount Gwoira (900 metres a.s.l.).

The Gwoira Beds consist of strongly lithified, massive beds of conglomerate, 5 meters to 8 meters thick, alternating with thinner beds of sandstone and siltstone, resulting from predominantly rhythmic deposition, in a paralic environment. Towards the top of the section, unlithified sandstone becomes predominant.

The conglomerate contains sub-angular to well rounded, pebbles and cobbles which range from a few millimetres to 10 centimetres across; in one place, boulders as large as 1 metre across have been observed. They consist of green and purple basic schist (no calcic schist has been observed), basalt and gabbro, all represented in the ranges to the south and to the west. The matrix, a coarse angular sand, is rather scarce. Cross-bedding and channelling are common. Cross-bedding shows a thinning towards the east-south-east, but the observations are too scattered to justify generalizations.

The beds dip consistently at 30° to the south and south east, except at the western contact with the schists where the dips vary between 20° and 50°, and at the southern contact where, in the upper part of the section the beds approach the horizontal and unconformably overlie the schist surface which dips to the north at 30°.

The Gwoira Beds have been uplifted along a west-north-west-trending fault which forms their northern contact. At present about 1,050 metres of sediments are exposed in the Gwoira Range. With the Uga and Wamira Beds described below they probably represent a near shore paralic facies of the sediments on Cape Vogel and probably also of sediments that are still under the sea.

Uga Beds (new name):

The Uga Beds consist of unlithified sandstone, siltstone, and minor conglomerate which form precipitous hills near Raba Raba, (lat.16°43'S, long.149°50'E). Present relief is of the order of 300 to 500 metres.

The most startling feature of these beds is their large-scale cross-bedding. Foreset beds up to 20 metres thick have been observed in cliff sections. Dips may range as high as 25°; in places, the hills are capped by a thin cover of horizontal sediments.

The Uga Beds were probably deposited close to a shore line in Plio-Pleistocene times. They have since been uplifted and at present are being eroded extremely rapidly.

Wamira Beds (new name):

The Wamira Beds occur in the lower reaches of the Wamira River, (lat.10°05'S, long.150°05'E) and the Tameo River (lat.10°12'S, long.150°15'E) and along the north coast to the east of the Tameo River. They are similar in lithology to the Uga Beds but do not form the same rugged topography. They have been raised and tilted and locally show dips of as much as 25°. Between the mouth of the Tameo River and Puni Puni Point (lat.9°57'S, long.150°28'E), conglomerate of the Wamira Beds laps onto the basalt basement and forms conspicuous dip slopes with a northerly dip of 25°.

The sediments are capped by raised coral reef to the west of Bartle Bay and in the Tameo River valley. Some of these reefs are 300 metres above sea level. The Wamira Beds are probably Pleistocene-Recent.

Fife Bay Beds (new name):

The Fife Bay Beds include basalt, agglomerate, tuff, and intrusives of Pleistocene or Pliocene age which form islands off the south coast and extend onto the mainland between long.149°50'E and long.150°00'E. They have been gently folded.

Quaternary volcanics:

Small low-lying hills of Quaternary andesitic volcanics occur on the piedmont to the north of the Suckling-Dayman block. The most recent of these volcanics is Goropu volcano (lat.9°34'S, long.149°05'E) immediately to the west of the map area, which formed during a series of eruptions in 1943-44, (Baker,1946).

Recent deposits:

Recent coral reefs occur around East Cape, on the western side of Bentley Bay (lat.10°15'S, long.150°38'E), in the north-west corner of Milne Bay at lat.10°01'S, long.150°17'E, and at Cape Vogel.

Flat-lying deposits of Recent alluvium occur extensively along the south coast around Mullins Harbour, in the Sagarai River valley, at the head of Milne Bay, and to the north of the Suckling-Dayman block. The thickness of these deposits is not known.

INTRUSIVE ROCKS

Ultramatic bodies:

Small dunite bodies crop out in the lower part of the Gabahusuhusu Creek at lat.10°11'S, long.150°21'E, and in the Dawa Dawa River at lat.10°18'S, long.150°26'E. The dunite consists of olivine and serpentine with accessory chromite, (Davies, 1967).

In the west of the map area at lat.9°38'S, long.149°08'E there is a larger body of ultramafic rock, predominantly enstatite-olivinite, which crops out over an area of approximately 1.6 sq.km.

The dunite in Gabahusuhusu Creek is itself intruded by the surrounding syenite (see below). The relationship of the two other ultramafic bodies to the basalt which surrounds them is not known.

Mila Gabbro (new name):

The Mila Gabbro lies to the south of the Sagarai River at about lat.10°16'S, long.150°17'E. The area of outcrop is approximately 115 sq. km. A small body of gabbro north of the Sagarai River at Oura Oura (Ulo Ulo) Mine, (lat.10°02'S, long.150° 19'E) is regarded as part of the Mila Gabbro. At Oura Oura Mine the gabbro is associated with some acid intrusives.

The principal rock type in the body is a medium-grained gabbro which is intruded by minor basaltic and feldspathic dykes. A typical specimen consists of augite (30-40%), labradorite (50-55%), minor biotite (5%), orthopyroxene (5%), opaque ore (5-10%), and green interstitial material.

East Cape Gabbro (new name):

The East Cape Gabbro crops out over an area of approximately 13 sq. km.,between East Cape and long. 150°45'E. A typical specimen is dark green grey and granular on freshly broken surfaces. Weathered surfaces have a deep rusty red colour. One highly altered and sheared specimen (2184) is light green and is cut by veins of white and green material.

In thin section the rocks are seen to be composed of subhedral augite (20%) intergrown with elongate laths of labradorite - An 62-65-(50-65%), and minor orthopyroxene (5-10%), opaque minerals (5%), and green secondary interstitial material (5-10%),

An earlier worker, (Baker, 1953), describes specimens of micropegmatitic quartz diorite collected from the shore platform on the north side of East Cape and on Meimeiara Island, just offshore. This rock appears to be distinct from the gabbro described above. It was not encountered during the limited smapling of the present survey but it is likely that it is part of the smae intrusive body.

Yau Gabbro (new name):

The Yau Gabbro, named from the Yau River (lat.9°41'S, long.149°26'E) occurs over an area of approximately 25 sq.km. The Yau Gabbro is an altered quartz gabbro. The alternation appears to have been late magmatic rather than post magmatic. In hand specimens the gabbro is medium to coarse grained and has a mottled appearance with elongate mafic crystals in a white matrix. The rock consists of pyroxene plus hornblende (30%), altered plagioclase (30%), quartz (20%), opaque minerals (10%), and minor interstitial fine grained material.

The hornblende is secondary after pyroxene (augite) and many hornblende crystals contain relict cores of pyroxene. In two cases the pyroxene is only 50 percent altered to hornblende but in most cases alteration is 80 - 90 percent complete. The plagioclase is invariably altered and indeterminate, it forms graphic intergrowths with quartz.

Gabahusuhusu Syenite (new name):

The Gabahusuhusu Syenite and associated minor gabbro occupy an area of approximately 11 sq. km.,on the south side of Milne Bay between latitudes 10010'S and 10°13'E and longitudes 150°24'E and 150°27'E. The syenite is younger than the sourrounding lower Miocene Dawa Dawa Beds and the gabbro is intruded by the syenite. It is exposed in Gabahusuhusu Creek from which it is named.

In hand specimen the syenite is medium-grained with dark mafic crystals in a pinkish grey matrix. A generalised mineralogical composition is - perthitic potassic feldspar (55-80%), albite (0-15%), biotite (5-10%), aegirine-augite (10-15%), hornblende (0-15%), opaque minerals (2-5%), and zircon (1-2%). Minor nepheline has been observed in two specimens (2221,2222) of the four examined.

A generalised composition of the gabbro associated with the syenite is augite (10%), tremolite-actinolite- (after augite)- (30%), labradorite-An62-68-(40%), with minor orthopyroxene, opaque minerals, and fine-grained alteration.

Mase Syenite (new name):

The greatest development of post-lower Miocene intrusives occurs in the Mase, Magavara and Wamira Rivers. Between lat.9°50'S, long.149°52'E and lat.9°56'S, long.150°02'E, basalt of the Dawa Dawa Beds is extensively intruded by 'syenitic' porphyry dykes and stocks within an area of approximately 28 sq.km. in the upper, middle reaches of these rivers and along the coast between the Mase and Magavara Rivers. The occurrence of 'syenitic' rocks in the float of adjacent rivers indicates that these rocks occur widely in the surrounding area but the ratio of syenitic rock to country rock is much lower.

Th rocks of the Mase syenite include a variety of types with a broad 'syenitic' composition. Coarse feldspar porphyries and coarse and fine-grained syenite occur with minor amounts of more basic 'hybrid' rocks. The proportions of different minerals vary from rock to rock, but, generally, the ratic of feldspars to mafic minerals in unaltered specimens is approximately 4 : 1. Potash feldspar occurs as large (4-5 cm) zoned phenocrysts and in the groundmass of the porphyries; it is common in all of the rocks although in some specimens it has been extensively altered. Sodic plagioclase in places forms large phenocrysts but is generally confined to the groundmass and is usually subordinate to potash feldspar.

Biotite is a common minor (10% or less) constituent, and is commonly accompanied by green slightly pleochroic aegirine - augite. Melanite, the deep brown variety of andradite garnet, occurs as zoned euhedral phenocrysts in many of the rocks . Opaque minerals are a ubiquitous minor accessory; zircon also occurs as an accessory.

Nepheline occurs in some specimens although it is never more than 1 - 2 percent of the rock volume. It usually forms very small euhedral crystals.

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Imudat Syenite (new name):

A small body of syenite crops out in the Imudat River to the north west of Amazon Bay (lat. 10°18'S, long. 149°22'E). A single specimen which has been examined in thin section consists of orthoclase (12%), perthite (31%), calcic andesine (30%), colourless augite (16%), and biotite (6%), with minor nepheline (2%) (usually altered), opaque oxide (3%), apatite (0.3%), and zircon (0.3%). Minor gold mineralization is associated with the Imudat Syenite.

Dyke rocks:

A swarm of dykes with a general north easterly trend occurs in the Sige Lele and Sige Eueu Rivers to the south-south-west of Milne Bay. These dykes range in thickness from 1 to 7 metres. They are medium to dark grey and usually porphyritic with conspicuous green euhedral crystals up to 4 mm across in a fine-grained groundmass. The phenocrysts are aegirine - augite and the groundmass consists of aegirine - augite and dendritic plagioclase (calcic albite to sodic oliogoclase) with minor interstitial alteration. Biotite occurs in some specimens which differ from the other dyke rocks in being non porphyritic.

A dyke on East Cape Peninsula at lat. 10°09'S, long. 150°42'E is probably the same rock type, and so are the boulders observed in the rivers west of Mullins Harbour.

Isolated dykes, composed largely of biotite, intrude the basalt at the western end of the map area. These have not yet been examined in thin section.

2. GEOLOGICAL HISTORY AND STRUCTURE

Geological history of the area began with the extrusion of basaltic pillow lavas and the development of up to a thousand metres of probably deep-water limestone in Upper Cretaceous time.

In post Upper Cretaceous, perhaps Eocene time, the Cretaceous oceanic crust and upper mantle was thrust over itself by compression from the north. The thrust sheet was subsequently removed by gravity sliding or erosion, except for a remanent of ultramafics in the west and some basalt lavas just west of the map limits. Also in Eocene time we see the development of a pile of basalt lavas and limestone on the seafloor in the Milne Bay area.

Most of the Oligocene seems to have been a quiet period with neither sedimentation nor vulcanism, but the upper Oligocene and lower Miocene saw a renewed pulse of seafloor volcanic activity over a wide area.

Following closely on this we have the onset of the mid-Miocene orogeny which is continuing today. Features of this orogeny are (a) spectacular vertical movements, and (b) some westerly to north-westerly strike-slip faulting, probably mostly left-lateral. The vertical movements exhumed and arched up the Eocene thrust zone to form the Suckling-Dayman block. Further south and east, the lower Miocene pillow lavas were elevated through at least 3,000 metres and rapid erosion began which has since filled the Cape Vogel basin.

The only evidence for strike-slip faulting is the straight trace of many of the young faults, for example the more or less east-west lineaments which control parts of the courses of the Kutu, Magavara, Bonua, and Tavanei Rivers. A left lateral sense is suggested simply because left lateral major upper Tertiary movements have affected the Papuan Ultramafic Belt, 150 km. north-west of the map area,

The most spectacular evidence of recent vertical movements is seen along the north coast where pillow lava ridges rise steeply from a rocky coast, and Quaternary alluvium and coral are perched at heights of more than 500 metres above sea-level. We postulate a major dip-slip fault just off-shore and more or less parallel to the north coast. The trace of this fault can be seen on land at the head of Goodenough Bay where it marks the front of the Gwoira Range and continues westward along the northern front of the Suckling-Dayman block.

3. ECONOMIC GEOLOGY

Alluvial gold and platinum have been won in the area south of Milne Bay. Rocords are incomplete but total production was of the order of 15,000 to 20,000 ounces of gold and 220 ounces of platinum, (Nye and Fisher, 1954). Three mines were operating on a small scale in 1938-9 and produced a total of 881 ounces of gold in the year. Rough Ridge Mine was the most successful of the mines, producing 771 ounces from 1,301 tons of ore; other mines were the Juno and Jumbo, and the Louise. The Louise Mine was apparently located at Oura Oura (Ulo Ulo) but the location of the other mines is not known, (Davies, 1967).

Gold mineralization in the area is associated with the intrusion of syenite and gabbro. Thompson (1962) suggests that the platinum has shed from small bodies of peridotite. Gold and platinum have been mined from gravels on the Sagarai River, Gabahusuhusu Creek, and Debolina Creek (platinum only), (Davies 1967).

Minor mineralization in the form of disseminated copper and iron sulphides is associated with basic intrusions (Mila Gabbro) to the south of the Sagarai River and in the Sige Lele River.

In the Magavara River there is quite extensive sulphide mineralization associated with a zone of shearing. Disseminated pyrite occurs in both the basalt country rock (Dawa Dawa Beds), and in the syenitic rocks which intrude it. The sulphide mineralization is probably related to the intrusions of syenite rock. Alluvial gold occurs in the Imudat River and is at present being won in small quantities by local natives. The gold mineralization is probably related to the intrusion of syenitic rocks.

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Some sulphide mineralization occurs in the upper reaches of the Yau River associated with the Yau Gabbro.

A number of specimens from these localities have been analysed for nickel, cobalt, copper and iron. The results of these analyses are tabulated below. We wish to thank International Nickel for conducting these analyses -

Locality	Field No.	Type	Cu.(ppm)	Ni.(ppm)	Co.(ppm)	Fe%
Gabahusuhusu Creek	2225	Syenite	71	20	18	4.9
Sige Lele River	4076	gabbro	200	50	46	9.10
"	4077	"	310	20	42	9.1
Imudat River	2310	syenitic	114	30	32	7.9
Yau Gabbro	5139	altered gabbro	22	10	32	12.7

The petroleum prospects of the Cape Vogel basin offshore may turn out to be the greatest economic potential of the area. In 1928, Anglo Persian oil Company conducted an investigation on Cape Vogel Peninsula; exploration was discontinued because of unfavourable results, (Papp & Nason Jones 1928). At present, General Exploration Company of California holds a prospecting authority over the area, and exploration is directed at assessing the offshore oil prospects.

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APPENDIX

MICROFOSSIL DETERMINATIONS

Upper Cretaceous:

Four samples of Upper Cretaceous age were obtained from the Tufi 1:250000 sheet area. These samples, 2505,2584, 3233 and 5765, are from the Tavanei and Nauwandowan Rivers. The only definitely identifiable foraminifera are specimens of Globotruncana, although sample 5765 also contains other planktonic genera, possibly including Rugoglobigerina. Preservation is very poor, with details of the specimens obliterated by recrystallization, or with the specimens sheared and distorted. Double-keeled forms of Globotruncana predominate in the fauna, and only a general Senonian age is given.

Eocene (Upper Eocene, Tb, of Indo-Pacific area).

Samples of Eocene age occur in a small area in Touiwaira Creek, on the Samarai 1: 250000 sheet area (2039,2042,2043, 2048,2203). Foraminifera, algae, echinoid spines, bryozoa and molluscan fragments occur in the limestones. Foraminifera are Discocyclina (including a pillared form), Nummulites, Heterostegina, Gypsina, Operculina, Amphistegina ?, an indeterminable rotaline genus and other indeterminable smaller foraminifera, and rare planktonic species. There is some evidence that these are detrital or breccia limestones, formed from cemented worn pebbles; the weathered outlines of the constituent pebbles are visible in some thin sections.

Associated with these limestones is a limestone containing abundant planktonic foraminifera only; this is represented by two samples, 2045 and 2204. Sample 2045 contains a keeled specimen of Globorotalia of a type not known from beds younger than Eocene, and 2204 contains a species of Globorotalia possibly referable to the G.centralis group. Definite specific identification is not possible, and the main factor in assigning an Eocene age to these two samples is their close association with undoubted Eocene beds.

Tertiary "e" (Upper Oligocene - Lower Miocene)

Included here is a group of tuffaceous and breccia limestones containing derived faunas. Each of the samples is discussed separately.

2113. Modewa River. This is a detrital limestone consisting of small and fragmentary tests of foraminifera in a matrix of comminuted foraminifera and other organic material, mainly algae; ferro-magnesian minerals occur commonly. The foraminiferal fauna includes small tests and fragments of Lepidocyclina (including fragments of Eulepidina) Heterostegina sp., Cycloclypeus sp., rare planktonic specimens, an identerminable rotaline genus and other indeterminable smaller foraminifera. The only age which can be assigned to the sample on the basis of this fauna is "e" stage (possibly lower "e" stage). The sample possibly represents an intraformational conglomerate, with the constituent material being subjected to considerable transport or movement before consolidation.

2147. Baxter Harbour area. A tuffaceous sediment containing poorly preserved foraminifera with worn irregular outlines, or occurring only as fragments. Present are Lepidocyclina sp. (possibly Eulepidina) Miogypsina sp., Cycloclypeus sp., Planorbulinella sp., rare planktonic foraminifera (Globigerinidae), indeterminable miliolids and other indeterminable smaller foraminifera. The Planorbulinella sp., is similar to the specimens from the Cape Vogel area recorded by Paterson & Kicinski (1956) as Linderina sp. indet.; it is characterised by thickened lamellar shell material in the central part of the test, and is recorded from the "e" and lower "f" stages in Papua and New Guinea. The age of this sample is considered to be most probably upper "e" stage.

2156-2158 These three samples from a tributary of the Sagarai River are treated together; they are detrital limestones containing much tuffaceous material. 2156 contains Lepidocyclina (Eulepidina) sp., Heterostegina sp.cf.H. borneensis, Nummulites sp. (cf.fichteli), Gypsina globulus, Carpenteria (fragments) and one fragment possibly of Miogypsinoides sp. 2157 contains Miogypsinoides "bantamensis", Heterostegina sp.cf. H. borneensis, Spiroclypeus sp., Gypsina globulus, Amphistegina sp., Carpenteria (fragments), Operculina and Nummulites. Except for the Nummulites, none of the foraminifera show any obvious indication of being derived. 2158 contains abundant very poorly preserved Lepidocyclina (Eulepidina) and rare Heterostegina sp.

In assessing the age significance of the recorded fauna from these three samples, the main consideration is given to that in sample 2157. Here the most important forms are Spiroclypeus sp., Miogypsinoides "bantamensis" and to a lesser extent Heterostegina sp.cf.H. borneensis. The first two forms place this sample in the lower Te, with the Nummulites being derived from upper Oligocene (Td). In the other samples the significance of the specimens of Lepidocyclina (Eulepidina) is uncertain; specific identification is not possible, and the sub-genus ranges in the Indo-Pacific area through Td and Te. The preservation of the specimens in 2156 does not indicate which are the derived forms; all are equally worn, often with their margins eroded by igneous pebbles. The determination of Miogypsinoides would, if correct, also enable this sample to be referred to the lower Te, and this is supported by the occurrence of specimens of Heterostegina close to H. borneensis. It seems reasonable to conclude that these samples are from beds of lower Te age containing derived upper Oligocene (Td) specimens.

2293 contains Lepidocyclina spp. (Eulepidina, Nephrolepidina), Spiroclypeus, Miogypsina, Cycloclypeus, and rare planktonic species including a thick-walled form with a thin outer cortex, possibly Sphaeroidinellopsis. This is a detrital sediment, and in addition to worn limestone pebbles contains fragments of siltstone with abundant planktonic foraminifera; these are smaller than the planktonic specimens in the limestone pebbles and have a thinner wall. The foraminiferal fauna indicates a Te age, possibly upper Te, and in the absence of any direct evidence to the contrary these beds are also regarded as Te in age.

3068 contains Lepidocyclina spp. (no subgeneric determination possible), Miogypsina, Spiroclypeus, an indeterminable rotaline genus, planktonic foraminifera, rock fragments with planktonic foraminifera and other fragments with radiolaria. This is a tuffaceous, obviously detrital sediment, with volcanic material affecting sediments of Te (?upper Te) age.

3120 is also a detrital limestone formed from derived pebbles, and with the specimens of foraminifera poorly preserved and affected by secondary calcite veining. The foraminiferal fauna includes Lepidocyclina sp., (probably Eulepidina), Austrotrillina sp.cf. A.striata, Discocyclina sp., Nummulites sp., Heterostegina sp., Gypsina vesicularis and Spiroclypeus sp.cf. S.vermicularis. Only one poorly preserved specimen of Austrotrillina is present; it has a simple alveolar wall, but no definite identification is made as Adams (1968) has shown that distinction between A.striata and A.asmariensis is difficult with random sections or poorly preserved specimens. The fauna is regarded as Te, with derived Tb.

5044 is again a breccia limestone, containing Lepidocyclina (Eulepidina), Spiroclypeus, Carpenteria, Amphistegina?, Heterostegina, and one specimen of a miogypsinid, possibly Miogypsinoides, occurring as an oblique section of the initial chambers. This is also a Te fauna.

Planktonic foraminiferal limestones.

Because of the difficulty of identifying planktonic foraminifera in random thin sections, definite age determinations for limestones of this type may not be possible. The limestones considered here are of different types: some pure limestones, others tuffaceous or containing considerable ferro-magnesian content, others with specimens in a matrix consisting of comminuted foraminifera, and others with considerable secondary calcite veining.

One group contains abundant Globigerinidae, some also with Globorotaliidae and thick-walled specimens with a thin outer cortex, possibly Sphaeroidinellopsis. Because of the possible occurrence of this genus they are given a tentative Miocene age. These samples are: 2071, 2137, 2263, 2297, 2298, 2300, 2301, 3067, 3115, 4024, 5047, 5055 and 5070.

Two other samples also referred tentatively to the Miocene possibly contain Orbulina: 2197 and 5066. Other samples containing abundant planktonic foraminifera similar to those in the samples already mentioned are 2302, 3024, and 3062; they may also be Miocene.

Numerous samples contain small specimens of planktonic foraminifera, often rare, and also often poorly preserved and distorted. It is not possible to assign any more than a general Tertiary age to these samples, which are: 2073, 2089, 2121, 2131, 2136, 2146, 2161, 2177, 2262, 2580, 3023, 3025, 3223, 5036 and 5116.

Sample 2122 contains abundant small planktonic foraminifera, sponge spicules and radiolaria; sample 5043 contains abundant planktonic foraminifera and benthonic smaller foraminifera and sponge spicules. No definite age can be given to these samples; Glaessner (1952) recorded abundant sponge spicules in chert beds of Eocene age in the Port Moresby area.

Another group of samples contains small planktonic foraminifera in association with radiolaria, or radiolaria only. These are: 2281, 2283, 2303, 2308, 2326, 2413, 2573, 2610, 3069, 3070, 3074, 3132, 3222, 5035 and 5063. Again no definite age determination can be made. Radiolaria are common in various rock types in the Eocene of the Port Moresby area (Glaessner, 1952).

Five samples, 2088, 2417, 5069, 5110, and 5112 contain indeterminable smaller foraminifera and foraminiferal fragments, associated in different samples with molluscan fragments, bryozoa or echinoid spines. The age of these samples is not known.

Two samples, 2299 and 5040, contain foraminifera, algae, corals and bryozoa. Foraminifera are Alveolinella, Baculogypsina, Amphistegina, Pseudorotalia, Cellanthus, and Sorites?; these are regarded as samples of raised Recent deposits.

Sample 3085 yielded abundant free specimens of planktonic foraminifera and benthonic smaller foraminifera. Species occurring are: Globorotalia crassula Cushman and Stewart, Globigerinoides quadrilobatus quadrilobatus (d'Orbigny), G.bollii Blow, G.conglobatus (Brady), G. ruber (d'Orbigny), Globigerina bulloides d'Orbigny, Globigerinita glutinata (Egger), Orbulina universa d'Orbigny, Neogloboquadrina humerosa (Takayanagi & Saito) Bolivinita quadrilatera (Schwager), Pseudorotalia gaimardi (d'Orbigny), Ammonia beccarii (Linne), Bulimina marginata d'Orbigny, "Eponides" margaritiferus (Brady), Planorbulinella sp., Melonis affinis (Reuss), Brizalina patula, Belford, Globocassidulina subglobosa(Brady), and Siphogenerina costata Schlumberger. This sample is referred to the lower Pliocene, to zones N.19 - N.20 of Banner & Blow (1965).

Sample 5122 contains only abundant specimens of "Eponides" praecinctus (Karrer); this species has been recorded from lower Miocene to Pliocene in Papua-New Guinea, and no definte age can be given to this sample.

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