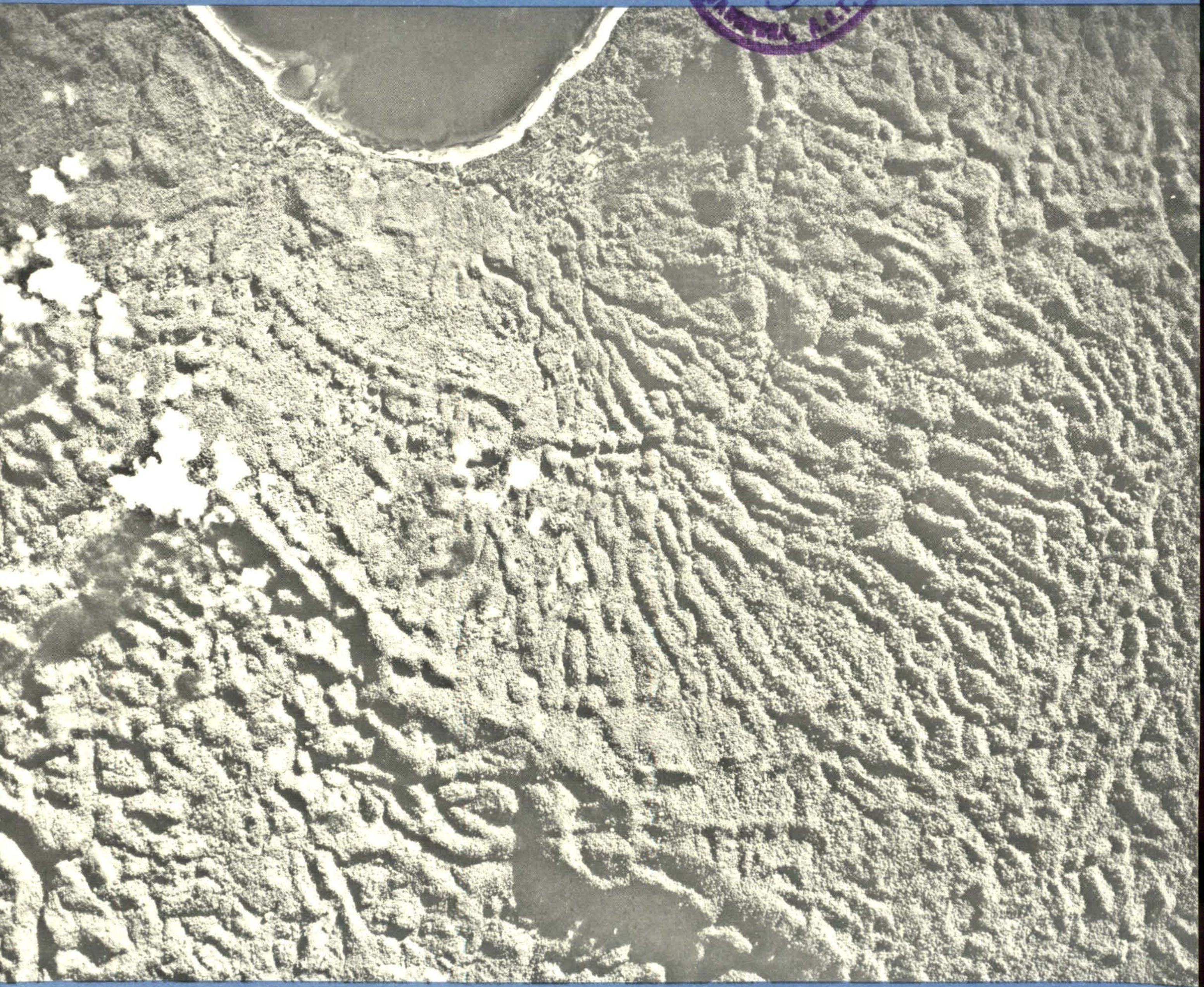
# Geology of New Ireland, Papua New Guinea

P. D. HOHNEN





BUREAU OF MINERAL RESOURCES,
GEOLOGY AND GEOPHYSICS

BULLETIN 194 (PNG 12)

DEPARTMENT OF NATIONAL DEVELOPMENT
BUREAU OF MINERAL RESOURCES, GEOLOGY
AND GEOPHYSICS

BULLETIN 194
PNG 12

# Geology of New Ireland, Papua New Guinea

P. D. HOHNEN

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE
1978

DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. K. E. NEWMAN, M.P.

SECRETARY: A. J. WOODS

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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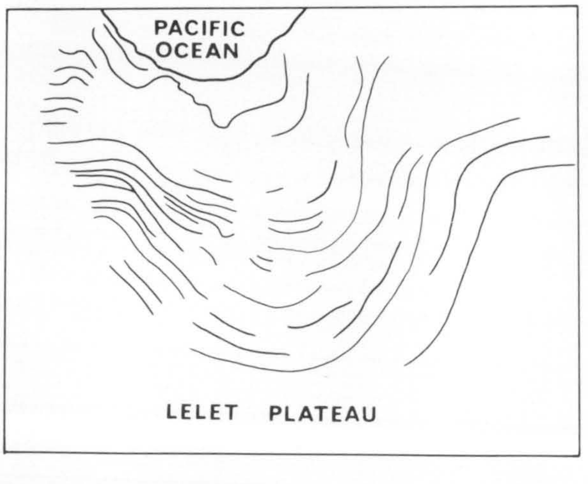
## ABSTRACT

New Ireland, which lies between latitudes 2°30′ and 4°55′S and longitudes 150°40′ and 153°10′E, is a narrow island elongated northwest-southeast. Limestone plateaux tilted to the north-northeast—the Schleinitz Range in the northwest and the Lelet Plateau in the centre—are separated by a low saddle from steep mountains in the south. Outcrop is generally poor and extensively weathered, but entrenched river gorges provide some good sections.

The oldest rocks are the lower to middle (or lower upper) Oligocene andesitic Jaulu Volcanics, which are intruded by acidic to basic stocks and dykes of the Lemau Intrusive Complex. The Lossuk River Beds are derived from and unconformably overlie the Jaulu Volcanics. The main limestone units are the plateaux-forming Lelet Limestone, and the Surker Limestone in the south. The narrow neck of land between these two limestones is largely occupied by volcaniclastic and biogenic ooze sediments of the Rataman Formation. The white, chalky Punam Limestone unconformably overlies the Rataman Formation along a narrow strip of the foothills near the east coast. A thick succession of fanglomerate and beach sands—the Maton Conglomerate, derived from and unconformably overlying the Jaulu Volcanics—flanks the east and west coasts in the south. The conglomerate is overlain only by Pleistocene to Holocene coral terraces.

The Weitin and Sapom Faults are the major structures on New Ireland. Movement on the Weitin Fault may be left-lateral.

Porphyry copper mineralization is known from three localities on New Ireland, and investigations are continuing. Minor occurrences of gold are reported to have been worked; exploration for bauxite proved unsuccessful; and exploration for oil has taken place spasmodically, without drilling.




FRONT COVER
Vertical airphoto showing flight of terraces (outlined in diagram at left) descending the northeast flank of the Lelet Plateau. The well developed karst topography on the Lelet Limestone is characteristic of the Lelet Plateau and Schleinitz Range. (Run M576, photo 3, 7/6/48.)

*Published for the Bureau of Mineral Resources, Geology and Geophysics by the Australian Government Publishing Service*

ISBN 0 642 02904 0

MANUSCRIPT RECEIVED: JANUARY 1975

REVISED MANUSCRIPT RECEIVED: JULY 1976

ISSUED: APRIL 1978

*Printed by Graphic Services Pty Ltd. 516-518 Grand Junction Road, Northfield, S.A. 5085*

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# SUMMARY

New Ireland is a narrow island 360 km from northwest to southeast and up to 48 km wide. The broader southern part of the island is steeply mountainous, with peaks to 2400 m above sea level in the Hans Meyer Range, and is diagonally bisected by the Kamdaru and Weitin valleys. The central and northwestern parts of the island are extensively capped by limestone plateaux which are tilted to the north-northeast. The plateau in the northwest is known as the Schleinitz Range, and the higher plateau in the central region is the Lelet Plateau. A low saddle separates the Lelet Plateau from the southern mountains.

Outcrop is generally poor and extensively weathered beneath the dense primary rainforest that blankets the island, though entrenched river gorges provide some good, though relatively inaccessible, sections. The oldest rocks are the lower to middle (or lower upper) Oligocene Jaulu Volcanics. These consist of lapilli tuff, agglomerate, and subordinate porphyritic pyroxene andesite lava, and are intruded by gabbro, norite, diorite, tonalite, trondhjemite, granodiorite, and leucocratic dyke rocks, which have been named the Lemau Intrusive Complex. Some or all of these intrusives may be related to the Jaulu Volcanics; K/Ar ages are 31.8± 1.0 m.y., 17.5 ± 0.6 m.y., and 13.8 ± 0.5 m.y. The Jaulu Volcanics and Lemau Intrusive Complex are best exposed in southern New Ireland, where erosion has been deepest. Elsewhere they are exposed only along the southwestern fall of the ranges, where the limestone plateaux have been removed by erosion.

The upper lower Miocene Lossuk River Beds are a thin series of clastic sedimentary rocks derived from the Jaulu Volcanics, which they unconformably overlie, and are found only in the northwest. The main limestone units are the Lelet Limestone, which forms the plateaux in the centre and northwest, and the Surker Limestone in the south. The two were probably partly lateral equivalents, but the Lelet Limestone has a longer range (lower Miocene to Pliocene or Pleistocene, compared with lower to middle Miocene). The narrow neck of land between the outcrop areas of Lelet Limestone in the northwest and Surker Limestone in the southeast is largely occupied by uppermost Miocene volcaniclastic (partly turbidite) and biogenic ooze sediments of the Rataman Formation, which are probably deep-water contemporaries of higher beds of the Lelet Limestone. The white, chalky Punam Limestone unconformably overlies the Rataman Formation along a narrow strip of the foothills near the northeastern coast of south-central New Ireland. It is Pliocene or younger. Embayments in the Punam Limestone are filled with Plio-Pleistocene sediments of the Uluputur Beds, which comprise intraformational conglomerate, lithic sandstone, and siltstone. A thick succession of fanglomerate and beach sands, in places cemented to conglomerate and sandstone, flanks eastern and western coasts of the southern, mountainous part of the island. These sediments, named the Maton Conglomerate, unconformably overlie the Jaulu Volcanics, from which they were derived, and also overlie in places the Rataman Formation and Surker and Punam Limestones. The conglomerate is overlain only by Pleistocene to Holocene coral terraces.

The Weitin and Sapom Faults are the major structural features on New Ireland. Movement on the Weitin Fault may be left-lateral.

New Ireland developed presumably on oceanic crust by seafloor (and possibly subaerial) volcanism in the early and middle Oligocene. A landmass emerged in the early Miocene, when the Lossuk River Beds were deposited, and then probably subsided steadily throughout the Miocene and early Pliocene and was rapidly uplifted in the late Pliocene and Quaternary, when a flight of terraces on the northeastern fall of the Lelet Plateau was probably cut by wave-erosion. Left-lateral faulting and crustal extension (?transform faulting) in the late Miocene may have opened a rift between central and southern New Ireland, in which sediments of the Rataman Formation were deposited—partly by turbidity currents.

Porphyry copper mineralization is known from three localities on New Ireland, and investigations are continuing. Minor occurrences of gold are reported to have been worked; exploration for bauxite proved unsuccessful; and exploration for oil has taken place spasmodically, although no drilling has been carried out. Minor occurrences of coal and clay could possibly be exploited for small-scale local industries, and large reserves of high-purity limestone occur in the Lelet Plateau and Schleinitz Range areas.

# INTRODUCTION

*Location:* New Ireland is the second largest island in the Bismarck Archipelago and lies within Papua New Guinea between latitudes 2°30′ and 4°55′S and longitudes 150°40′ and 153°10′E (Fig. 1).

The principal port and administrative headquarters are at Kavieng; a subsidiary port and administrative post are at Namatanai.

*Access:* The coastal regions of New Ireland are well served by roads, except in the south. An all-weather coranus (crushed coral) road, a 160 km section of which was constructed before World War I by the German Administration, follows the east coast from Kavieng to Namatanai, a distance of about 270 km. A secondary road extends from Namatanai south to Cape Mimias. On the west coast there are roads of variable standard which, apart from two stretches of a few kilometres, extend from Wunik Plantation in the north to Donup Plantation in the south. They are largely suitable for use by four-wheel-drive vehicles only, and the numerous creek and river crossings are subject to flash-flooding. The two coastal roads are connected across the island by roads between Namatanai and Uluputur in central New Ireland, and Fangalawa and Lemusmus in the north. A third road between Karu and Konogogo is rough and boggy and crosses rugged hogback topography; this road was closed to Administration vehicles in late 1969.

Copra boats provide access by sea to many plantations on both sides of the island.

There is a regular air service to both Namatanai and Kavieng from Rabaul, New Britain. Short airstrips suitable for light aircraft are sited at Kamiraba, about midway between Kavieng and Namatanai, and at Silur and Manga Missions in the southeast.

Natural helipads are found on the alluvial gravels near the mouths of major streams on the west and southeast coasts (Fig. 26), but higher altitude landings are possible only on the Lelet Plateau, where there is short bracken and grass in populated areas. The paucity of helipads is due to the rugged topography and thick rainforest which characterize New Ireland. Many of the raised coral platforms on the east coast of south-central New Ireland are covered by tall kunai and kangaroo grass, and would be suitable for helicopter landings if cleared by burning (Fig. 27).

*Topography and vegetation:* New Ireland is a narrow island 360 km from northwest to southeast which broadens in the south to a maximum width of 48 km. From the northwest tip of the island, elevations increase gradually southeastwards along the Schleinitz Range to a maximum of about 1480 m at the southern edge of the Lelet Plateau, midway along the island. The Lelet Plateau is up to 25 km wide.

Southeast of the Lelet Plateau there is a low, incipiently dissected saddle. Farther southeastwards, the landmass rises abruptly to form a deeply dissected mountain block with a maximum elevation of about 2400 m (Hans Meyer Range) and relief of up to 2000 m.

Most of New Ireland is covered by mature primary rainforest, which is extremely dense in some areas. Along the coast there are many coconut (copra) plantations, and small areas of grassland have developed on some of the raised Pleistocene coral reefs (Fig. 27). Small areas of secondary vegetation near villages are former subsistence-crop gardens.

*Climate:* Annual rainfall is 3000-5000 mm and is weakly seasonal. The central region of New Ireland tends to be drier during May to November, but to the north the rainfall distribution is remarkably uniform throughout the year. Rainfall in the south is lower between December and March.

*Population and industry:* The population of about 44 000 includes a few hundred people of European and Chinese descent. The indigenous population is concentrated along the northeast coast between Kavieng and Cape Sena. Small villages are sparsely distributed around the remainder of the coastline, and the interior of the island is almost uninhabited. The European and Chinese population is concentrated at Kavieng, to a lesser extent at Namatanai, and on coastal plantations.

The main industry is copra production, which is usually supplemented by cocoa. Coconut-cocoa plantations are scattered around the coast and provide employment for a large number or indentured labourers from the Sepik and Highland regions of mainland Papua New Guinea.

Most villagers carry out subsistence farming, often supplementing this with small areas of cash crops such as copra and cocoa, or by market gardening if they live near the markets at Kavieng and Namatanai.

*Purpose of survey and method of work:* The aim of the survey was to complete the geological mapping of New Ireland at 1:250 000 scale. Work was concentrated on the central and northern parts of the island.

In January and February 1969, I carried out a preliminary geological reconnaissance and logistic appraisal by Landrover. I was accompanied by R. P. Macnab for the first week of the reconnaissance, and by W. Manser (University of Papua New Guinea) towards the end of February.

I returned to New Ireland in September 1969, and carried out five weeks' foot-traverses in southern, central, and northern New Ireland, from starting points gained by four-wheel-drive vehicle or coastal copra boat. In April 1970, with W. Manser and, for part of the time, H. L. Davies, I visited the island briefly to collect igneous rock and limestone for isotopic and micropalaeontological age determination and chemical analysis.

*Previous work:* The earliest published systematic geological fieldwork was undertaken by Karl Sapper in 1908, during the German Administration (Sapper, 1910). Sapper, with assistance from ethnologist Georg Friederici, mapped a large part of New Ireland on a broad reconnaissance scale. Sapper's account of the geology of New Ireland is in the form of generalized traverse notes with a tentative stratigraphy and geological history.

No further geological work (apart from a brief investigation of a coal occurrence near Matakan Plantation: Noakes, 1939) was carried out until 1964, when D. J. French of the Geological Branch, Dept of Lands, Surveys and Mines, began a geological survey of southern New Ireland (French, 1966). He followed Sapper's traverse routes and covered some new ground.

Swiss Aluminium Mining Australia Pty Ltd carried out an intensive geochemical sampling program over most of the island, combined with detailed geological mapping of prospective areas, between 1969 and 1972.

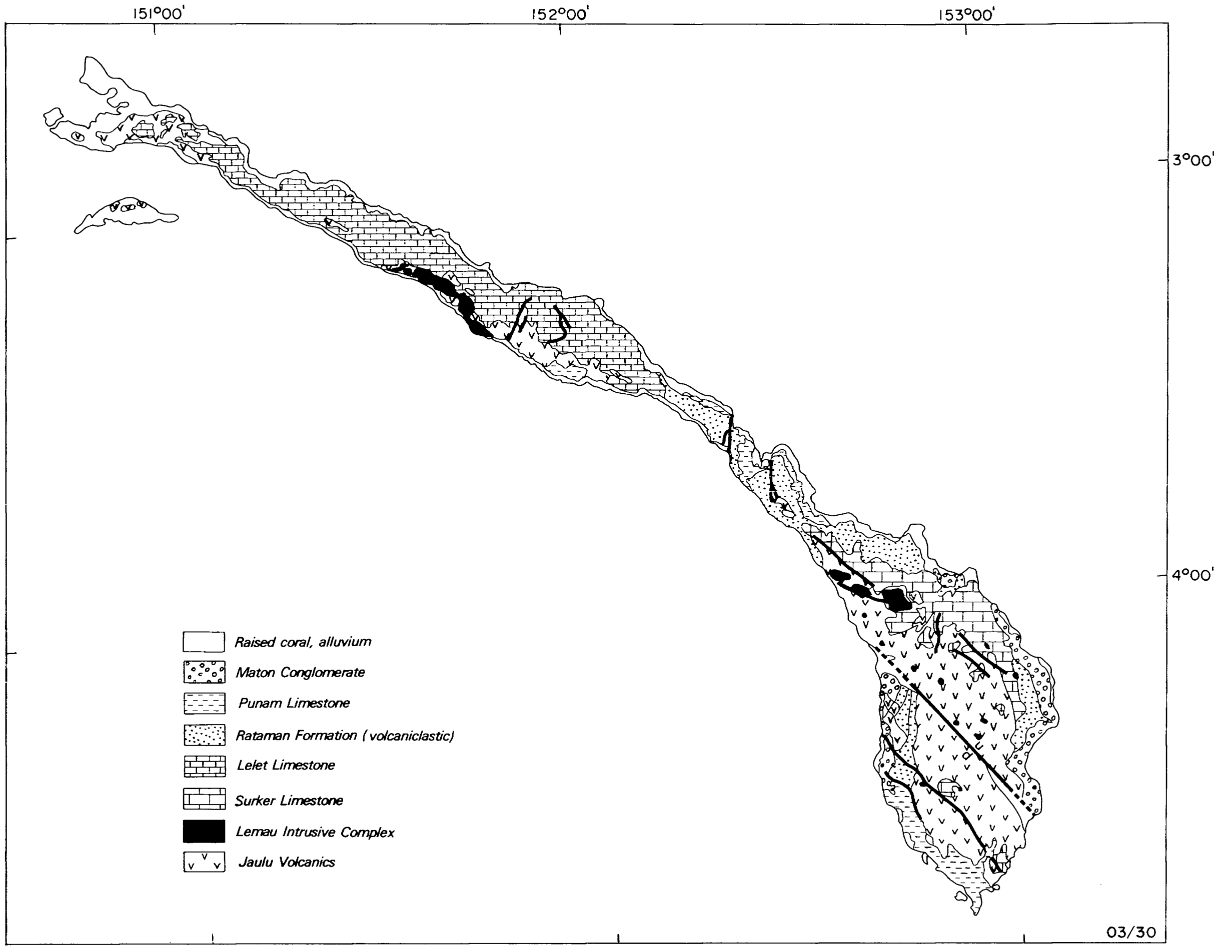

**Fig. 1. Simplified geological map.**

# OUTLINE OF GEOLOGY

(Fig. 1)

The oldest rocks exposed on New Ireland are the lower to middle (or lower upper) Oligocene *Jaulu Volcanics*. These consist predominantly of coarse andesitic lapilli tuff and agglomerate, with some welded ash-flow tuff and amygdaloidal lava and pillow lava. Small lenses of limestone, some of them coralline, indicate a partly shallow marine depositional environment. The volcanics are typically andesitic, both chemically (57.5-62.5% $SiO_2$ and 1.08-1.63% $K_2O$) and petrographically (e.g., modal phenocryst plagioclase is $An_{55-65}$).

The volcanics are intruded by stocks of gabbro, norite, diorite, trondhjemite, granodiorite, and a little porphyritic rhyodacite, which are called the *Lemau Intrusive Complex*. Some or all might be related to the Jaulu Volcanics. Most of the stocks have chilled margins and contain abundant xenoliths of Jaulu Volcanics. Both field and chemical evidence indicate that the intrusives cooled at a depth of less than 3 km. The stocks crop out in a belt; a similar distribution has been reported from the Gazelle Peninsula of New Britain (Macnab, 1970). K/Ar ages of three rocks from southern New Ireland are 31.8 ± 1.0 m.y. (from a gabbro) and 17.5 ± 0.6 m.y. and 13.8 ± 0.5 m.y. (from porphyritic rhyodacite).

Variation diagrams of the major elements of the New Ireland rocks resemble closely those for the 'normal' calc-alkaline rocks of the Gazelle Peninsula; they appear to have quite different trends from the 'high-potash' calc-alkaline rocks of the Central and South Baining Mountains of the Gazelle Peninsula (Macnab, 1970).

The plutonic and volcanic rocks are mantled by a wedge of limestone ranging up to 1400 m in thickness. In the Schleinitz Range and the Lelet Plateau the limestone has been called the *Lelet Limestone,* and in the southern part of the island it is called the *Surker Limestone*. The two formations were probably once coextensive, but the Lelet Limestone has the greater range of the two (lower Miocene to Pliocene compared with lower and middle Miocene). The Lelet Limestone appears to have been deposited as a series of transgressive fringing coral and algal reefs. Fourteen terraces have been preserved on the northeastern fall of the Lelet Plateau. Lower Miocene limestone forms terraces near present-day sea level, and successively younger limestone forms correspondingly higher terraces.

The narrow isthmus connecting the Lelet Limestone in the centre and northwest and the Surker Limestone in the southeast consists of uppermost Miocene volcaniclastic sediments of the *Rataman Formation.* Some of these rocks show turbidite structures and contain deep-water foraminifera, and thus are probably the deeperwater equivalent of the upper part of the Lelet Limestone.

The *Punam Limestone* forms low hills near the coast, mainly in the south of the island. This is stratigraphically higher but topographically lower than the Lelet and Surker Limestones, and it is distinguished from Pleistocene to Holocene raised coral reefs by its greater recrystallization.

The *Maton Conglomerate* consists of poorly consolidated, locally cemented, cobble and boulder beds derived from the Jaulu Volcanics and the Lemau Intrusive Complex. The conglomerate beds indicate the cyclic deposition of alluvial fans and beach deposits. These sediments form foothills and parts of the coastline in southern New Ireland.

The *Uluputur Beds* are an inner-neritic facies formed by the reworking of sediments of the Rataman Formation in embayments to form conglomerates and lithic-coquinoid sandstone and siltstone. They are probably of Plio-Pleistocene age.

*Raised coral terraces* of Pleistocene to Holocene age form the narrow coastal plain along the northeastern coast and some prominent headlands on the southeastern coast.

## STRATIGRAPHY

The stratigraphy is summarized in Table 2.

### *Jaulu Volcanics*

#### *Definition*

*Derivation:* Jaulu River, southern New Ireland, about 475 485*.

*Synonymy:* 'Younger Volcanics' of Sapper (1910). Occurrences of limestone assigned by Sapper to the Lagaiken Beds are lenses within the Jaulu Volcanics, except for the limestone at the type area for the Lagaiken Beds just south of Metlik Plantation, in southeastern New Ireland. Reappraisal of Schubert's (1911) faunal lists for this area has shown the age of the limestone to be in the range middle Miocene to Holocene, rather than Oligocene (Appendix 1). Limestone at this locality does overlie Oligocene volcanics containing limestone lenses (Appendix 1).

The 'Kait Beds' was a hypothetical unit proposed by Sapper to explain the source of lower Oligocene limestone float in the Kait River. This float was probably derived from a limestone lens in the lower part of the Jaulu Volcanics.

*Type section:* Jaulu River, about 477 486 to 482 489. The type section has not been measured.

*Lithology:* Predominantly coarse-grained porphyritic andesite, lapilli tuff (Figs. 3 and 4), and agglomerate. The clasts are largely subangular and some show chilled or altered margins (Fig. 3). Less common are welded ash-flow tuff, amygdaloidal and pillow lava, and tuffaceous limestone. Small lenses of coralline limestone and tuffaceous limestone (Fig. 2), which may be sheared, recrystallized, and locally hornfelsed, occur in the unit near the base of the succession, for example in the Olsigo and Jau Rivers (469 524 and 489 485).

*Thickness:* The maximum exposed thickness is about 2000 m. Thickness is variable because of erosion in the early Miocene and Holocene time.

*Distribution and relations:* The Jaulu Volcanics form the 'basement' of New Ireland. They are exposed along almost the entire length of the island in places where younger sediments have been removed by erosion; some of the Jaulu Volcanics were perhaps never buried. The base of the unit is below present sea level. The irregular top of the unit is unconformably overlain by the lower Miocene and younger biogenic Lelet and Surker Limestones and some clastic sedimentary rocks (Lossuk River Beds).

*Fauna and age:* The volcanics are probably of early to middle or early late Oligocene age. Limestone lenses in volcanics in the Kaluan River near 376 627 include a foraminiferal genus known to range from middle Eocene ($Ta_3$; Table 1) to late Oligocene (lower Te stage; sample 58NG0221, Appendix 1). A large limestone lens in southeastern New Ireland appears to be of similar age to the lower parts of the Jaulu Volcanics and contains early Oligocene (Tc) foraminifera (sample 6432/18, Appendix 1). Schubert (1911) assigned a lower Oligocene (Tc) age to a foraminiferal fauna in tuffaceous limestone float from the Kait River (about 470 506). The float had probably shed from a limestone lens in the Jaulu Volcanics. An early Miocene age has been obtained from the Lossuk River Beds, which apparently overlie the Jaulu Volcanics with low angular unconformity in northwestern New Ireland.

A K/Ar age determination carried out by AMDL on porphyritic andesite from the Kaluan River occurrence of the Jaulu Volcanics yielded an age of 30.7 ± 1.0 m.y. (middle or early late Oligocene).

#### *Description*

The Jaulu Volcanics are generally massive, and only the finer-grained rock types show bedding (Fig. 2). The predominant rock type is calcalkaline andesitic agglomerate which contains lapilli and subangular blocks from 4 mm to about 50 cm across, with a grain-size mode in the range 10-15 cm (Fig. 5). The blocks are generally in contact with one another or very nearly so, and matrix is subordinate (Fig. 5). Some clasts or blocks are themselves agglomerate, and consist of fragments of lava embedded in a tuffaceous matrix. Most clasts making up the framework of the agglomerate are of mela-andesite lava with euhedral plagioclase phenocrysts up to 4 mm long set in an almost aphanitic, dark-grey groundmass. Mafic phenocrysts are also commonly present, but are difficult to distinguish from the dark groundmass in hand specimen. In some examples, angular clasts have chilled margins about 1 cm wide (Fig. 3).

The finer phases of the Jaulu Volcanics are well represented on the southern fall of the Lelet Plateau, where they are interbedded with agglomerate (Figs. 5, 6). Only in this region have bedding attitudes been measured. In the Kaluan River, the dip of the pyroclastics and interbedded tuffaceous limestone varies from 10° south to 15° north, with a fairly consistent strike of 090°. In Kassa Creek, a few kilometres to the northwest, the Jaulu Volcanics have steeper dips, ranging from about 30° to 70° north. The finely bedded rocks in this area include highly indurated welded ash-flow tuff, cemented ash-fall tuff, coarse lapilli tuff, and some weathered lava? Ash-fall tuff appears to be the most common pyroclastic rock in this area and generally shows some grading. Other tuffs exhibit a eutaxitic texture with flow-swirls, indicating partial welding of ash-flow fragments. These tuffs are interbedded with coarse lapilli tuff, agglomerate, and lenses of tuffaceous limestone.

Lava flows appear to be rare and have been observed only in weathered outcrop in the Kaluan River and near the Huru River in the southwest. They are more

* 20 000-metre grid co-ordinates—International Spheroid.

TABLE 1.

## CAINOZOIC TIME SCALE[†]

| ADAMS, 1970[*] Epoch | ADAMS, 1970[*] Tertiary Letter Stage | CLARKE & BLOW, 1969; BLOW, 1969 Planktonic Foram. Zone | Tertiary Letter Stage | Epoch | Papuan Stage |
|---|---|---|---|---|---|
| Pleistocene | Th | N 23 | ? ? | Pleistocene | |
| | | N 22 | | | |
| Pliocene | | N 21 | Th | Pliocene | upper |
| | | N 20 | | | |
| | | N 19 | | | |
| | | N 18 | | | Muruan |
| late Miocene | Tg | N 17 | Tg | late Miocene | lower |
| | | N 16 | | | |
| | upper Tf $(\equiv f_3)$ | N 15 | upper Tf $(\equiv f_3)$ | middle Miocene | Ivorian / Kikorian |
| | | N 14 | | | |
| | | N 13 | | | |
| middle Miocene | lower Tf $(\equiv f_{1-2})$ | N 12 | lower Tf $(\equiv f_{1-2})$ | | Taurian |
| | | N 11 | | | |
| | | N 10 | | | ? |
| | | N 9 | | | ? |
| early Miocene | upper Te $(\equiv e_5)$ | N 8, N 7, N 6, N 5, N 4 | upper Te $(\equiv e_5)$ | early Miocene | Kereruan |
| late Oligocene | lower Te $(\equiv e_{1-4})$ | N 3 | lower Te $(\equiv e_{1-4})$ | Oligocene | |
| | | N 2 | | | ? |
| | | N 1 | | | |
| middle Oligocene | Td | P19 | Td | | ? |
| early Oligocene | Tc | P18 | Tc | | |
| late Eocene | Tb | P17, P16, P15 | Tb | late Eocene | |
| middle Eocene | Ta$_3$ | P14 | —?—?— | —?—?—?— | |
| early Eocene | Ta$_2$ | | | | |
| —?—?—?— | | | | | |
| late Paleocene | Ta$_1$ | | | | |

**ISOTOPIC TIME SCALE**

| | m.y. |
|---|---|
| Pleistocene / Pliocene | 1·85 |
| Pliocene / Miocene | 5·5 |
| Tg / Tf | 9 |
| late Tf / early Tf | 12·5 |
| early Tf / late Te | 15 |
| Miocene / Oligocene | 22·5 |
| late Oligocene / middle Oligocene | 30 |
| middle Oligocene / early Oligocene | 32 |
| Oligocene / Eocene | 36 |
| late Eocene / middle Eocene | 45 |
| middle Eocene / early Eocene | 49 |
| Eocene / Paleocene | 53·7 |
| late Paleocene / early Paleocene | 60 |
| Paleocene / Cretaceous | 65 |


*Adams, C.G., 1970 — A reconsideration of the East Indian Letter Classification of the Tertiary. Br. Mus. nat. Hist. (Geol.) Bull. 19 (3), 137p.

Blow, W. H., 1969 — Late middle Eocene to Recent planktonic foraminiferal stratigraphy. Proc. Ist int. Conf. Planktonic Microfossils, Geneva, 1967, I, 199-421.

Clarke, W. J, & Blow, W.H., 1969 — The interrelationships of some late Eocene, Oligocene and Miocene Foraminifera and planktonic biostratigraphic indices. Proc. Ist International Conf. Planktonic Microfossils, Geneva, 1967, 2, 82-97.


* *Adams (1970) has been adopted as the standard table for 1:250000 series geological maps of Papua New Guinea.*

† *Compiled by Binnekamp & Davies, 1971.*

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TABLE 2. STRATIGRAPHY

| *Series, Tertiary Letter Stage, Planktonic Foram Zone* | *This Bulletin* | *Sapper, 1910* | *French, 1966* |
|---|---|---|---|
| Holocene | alluvium | alluvium | alluvium |
| | raised coral reefs | raised coral | raised coral |
| Pleistocene | Maton Conglomerate | ? ? | Maton Conglomerate |
| | Uluputur Beds | RELATIONSHIPS UNKNOWN<br>Punam Limestone | Punam Limestone; Tamul Beds |
| Pliocene | Punam Limestone | | |
| uppermost Miocene (N 18 or younger) | Rataman Formation | Rataman Beds<br>Tamul Beds | |
| | Lelet Limestone | Umudu Meds | |
| middle Miocene (Tertiary lower *f* stage) | Surker Limestone | Surker Beds | Surker Beds |
| lower Miocene (Tertiary upper *e* stage) | | ? ? | |
| late lower Miocene (N 8 in part) | Lossuk River Beds | | |
| lower or middle Oligocene to middle Miocene | Lemau Intrusive Complex (K/Ar age 31.8 ± 1.0 to 13.8 ± 0.5 m.y.) | Younger Volcanics | Jaulu Volcanics |
| lower to middle or early upper Oligocene (Tertiary *c* stage in part) | Jaulu Volcanics<br>Limestone Lenses<br>(K/Ar age 30.7 ± 1.0 m.y.) | Lagaiken Beds | Lagaiken Beds |
| | Thick oceanic? crust (no rocks older than Jaulu Volcanics exposed) | Gneiss Formation (Float only—probably flow-foliated contact rock from Lemau Intrusives) | Basement ? ? Granodiorite and quartz diorite (Lemau Intrusives) |

densely jointed and more commonly sheared than the agglomerate and might thus weather more readily; this could explain the paucity of lavas in outcrop. The agglomerate and tuff, on the other hand, generally show only superficial weathering in the form of grey, red, or mottled grey and red colours on the surface of outcrops. Highly weathered examples of the agglomerate are usually brown and have a pitted surface due to etching out of plagioclase phenocrysts.

The Jaulu Volcanics are commonly intruded by dykes and stocks of the Lemau Intrusive Complex. Contact metamorphism and metasomatism are described in more detail below.

The limestone lenses within the Jaulu Volcanics are quite varied. Near the southwest coast, the limestone lenses are predominantly of poorly lithified coralline calcirudite in a grey, plastic-clay matrix. In the Jau River, in the southern part of the island, the limestone is a grey recrystallized limestone which appears to have been contact metamorphosed by penecontemporaneous lava flows. There is also a continuous gradation from limestone, through tuffaceous limestone to tuff; such a transition can be seen in the Kaluan River and in the southernmost part of New Ireland.

*Petrography:* The blocks of lava that make up the framework of the agglomerate are invariably porphyritic with a microcrystalline to cryptocrystalline groundmass. The phenocrysts, which make up 30-50% of the lava, are, in order of relative abundance: polysynthetically twinned plagioclase, zoned plagioclase, pale green diopsidic augite, opaques, slightly pleochroic hypersthene or bronzite, green hornblende, and lamprobolite (Table 3). The relative proportions of augite, orthopyroxene, and lamprobolite are variable. Rocks that contain abundant augite and hypersthene contain little or no lamprobolite and vice versa.

Green hornblende and quartz are not common in the Jaulu Volcanics and may be restricted to rocks affected by the Lemau Intrusive Complex. In such rocks, the phenocrystic clinopyroxene is generally corroded and partly altered to opaques, chlorite, and actinolite, and the groundmass consists of a mosaic of granoblastic quartz and albite with abundant, very finely disseminated opaques.

In agglomerate clasts that have not been affected by the Lemau Intrusive Complex, the groundmass generally consists of a mesh of randomly oriented labradorite microlites with interstitial opaques and pale brown

**Fig. 2. Tuffaceous limestone and fine, water-laid tuff of the Jaulu Volcanics, Kaluan River (GA/4996).**

**Fig. 3. Poorly sorted lapilli tuff from the Jaulu Volcanics (GA/4999).**

glass. In other specimens the texture is trachytic, but plagioclase is the dominant feldspar (Figs. 7, 8).

The phenocrysts are generally euhedral in unaltered rocks; in some specimens, augite and lamprobolite are subhedral. Plagioclase phenocrysts generally show polysynthetic twinning and lies in the range $An_{55-65}$. Many plagioclase phenocrysts also exhibit normal or oscillatory zoning with bytownite cores and labradorite or andesine rims. The more calcic plagioclase is generally etched and altered. Grains with normal zoning commonly have corroded and kaolinized cores surrounded by unaltered narrow rims with euhedral crystal faces. In oscillatory-zoned plagioclase, the core and second outermost zones are usually corroded or altered and the remainder of the crystal unaltered.

*Metasomatized or metamorphosed Jaulu Volcanics:* Where the Jaulu Volcanics have been affected by later intrusions, the following mineral assemblages have developed:

1. albite-epidote-chlorite-quartz
2. chlorite-albite-carbonate-epidote-sphene
3. quartz-sericite-chlorite
4. actinolite-quartz-plagioclase
5. quartz-actinolite-tremolite-chlorite
6. hornblende-plagioclase-quartz-biotite
7. hedenbergite-plagioclase-andradite?

These assemblages indicate metamorphism to the albite-epidote hornfels facies in assemblages 1-5, hornblende hornfels facies (6), and pyroxene hornfels facies (7) (Turner & Verhoogen, 1960). Textures are granoblastic or hornfelsic with various amounts of relict primary texture and primary minerals.

Most of these rocks before metamorphism were porphyritic andesite. Assemblage 7 probably represents an impure limestone.

The metamorphism was probably not isochemical. There is some evidence of alkali and silica metasomatism, particularly around the more silicic intrusives. Mafic phenocrysts of the andesite are altered in various degrees to actinolite, chlorite, and opaques. Plagioclase phenocrysts are generally less extensively altered, but in some cases show sodic reaction rims.

Near Palabong, the presence of volcanics hydrothermally altered to propylites—i.e., andesite altered to chlorite, quartz, albite, epidote, zeolites, calcite, and disseminated pyrite—indicates fairly low-temperature, low-pressure alkaline $H_2S$ metasomatism.

*Depositional environment of Jaulu Volcanics*

The Jaulu Volcanics form the 'basement' of an oceanic island; it is assumed that the volcanics built up from the sea-floor and that much of the volcanic material was erupted in a marine environment.

The welded agglomerate and welded ash-flow tuff that represent the latest deposits of the Jaulu Volcanics may have formed subaerially from *nuées ardentes*. Most of the volcanic clasts are angular to subangular, and the finer-grained material shows no evidence of reworking by turbidity currents. Few of the rare lavas show any evidence of pillow structures, though the advanced stage of weathering of these flows would at least partly obscure any such structures.

Lower in the sequence, clay lenses containing reef limestone fragments and tuffaceous limestone beds indicate that the earlier phases of the unit were in part deposited in shallow water. Some of the ash-fall tuffs have been redeposited as lithic arenites, but no coarser volcanic sediments have been found. All the coarse-grained breccias are believed to be of pyroclastic origin.

Some blocks in the agglomerate have angular shapes and planar boundaries, yet have chilled margins about 1 cm wide. These blocks might have been erupted as partly solidified lava in which chilled margins developed

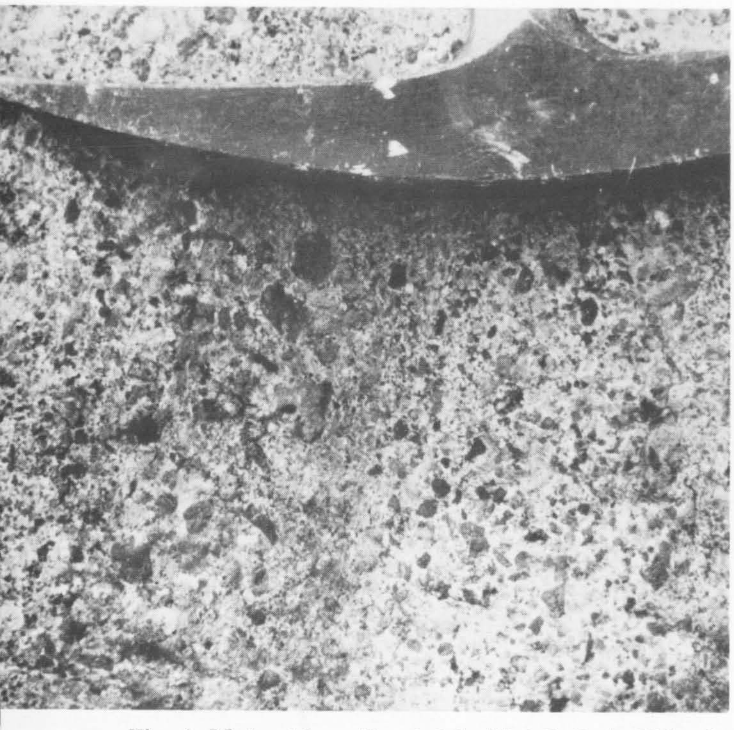


Fig. 4. Moderately well-sorted lapilli tuff, Jaulu Volcanics (GA/4994).

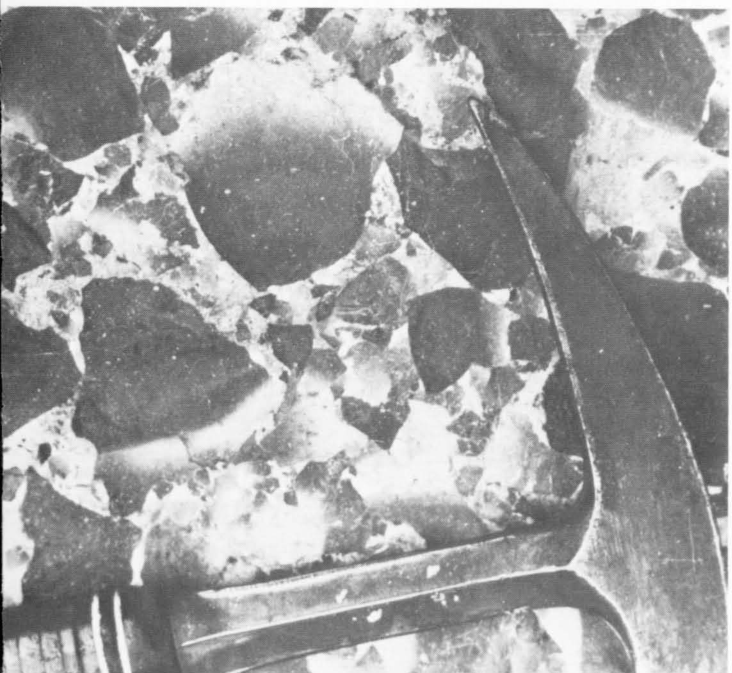


Fig. 5. Andesitic agglomerate, Jaulu Volcanics (GA/4998).

during subaerial or submarine passage; alternatively, they may be brecciated pillow lavas. The two eroded volcanic necks that have been located (Dyaul Island—262 676, and northwestern New Ireland—261 694) are of welded blocks with little interstitial fine-grained material. Agglomerate immediately adjacent to these centres consists of blocks which do not have chilled or altered margins.

Fig. 6. Zeolitic agglomerate, Jaulu Volcanics (M/1045).

### *Lossuk River Beds*

*Definition*

*Derivation:* Lossuk River, northwestern New Ireland (284 690).

*Synonymy:* Includes the sedimentary rocks of the Lossuk River Beds, Kulasi Creek Beds, and Lumis River Beds (Ripper & Grund, 1969).

*Representative section:* Headwaters of the easternmost tributary of the Lossuk River (284 690).

*Lithology:* Finely laminated siltstone, well cemented angular calcirudite, pebbly feldspatholithic labile sandstone, and conglomerate.

*Thickness:* About 150 m in the representative section.

*Distribution and relations:* Unconformably overlie the Jaulu Volcanics, from which they are largely derived. Overlain with apparent conformity by lower Miocene parts of the Lelet Limestone.

Best exposures are in the northwestern extremity of New Ireland, where the Lelet Limestone has been largely eroded off.

*Fauna and age:* A well preserved fauna of pelagic foraminifera indicates a late early Miocene age which is partly equivalent to the N8 planktonic foraminiferal zone (Keston, *in* Ripper & Grund, 1969). A finely comminuted coral, algal, and pelecypod fauna occurs locally.

*Description*

The Lossuk River Beds have been derived largely from the Oligocene Jaulu Volcanics. They include pale grey feldspatholithic labile sandstone flecked with white kaolinized feldspar. Well-rounded pebbles (2-6 cm) of andesite porphyry form up to 30 percent of the sediment and in places form pebble or boulder conglomerate lenses.

The interbedded fine calcirudite consists of angular algal and coral clasts, and a fragmental fauna, in a calcite cement; they are probably fore-reef deposits.

### *Surker Limestone*

*Definition*

*Derivation:* A tributary of the Hirudan River known during the German Administration as Surker Creek (474 558).

TABLE 3. MODAL ANALYSES OF JAULU VOLCANICS (I-IV) AND YOUNGER VOLCANICS (V, RHYODACITE)

Modes are volume percent and are based on 1 500 point counts in each thin section

| *Sample No.* | *Phenocrysts* | | | | | | | | | | | | | | | *Groundmass* | *Sample locality* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Quartz* | *Plagioclase* | *Orthoclase* | *Late sodic plag.* | *Augite* | *Hypersthene* | *Green hornblende* | *Lamprobolite* | *Actinolite* | *Apatite* | *Chlorite* | *Calcite* | *Opaques* | *Brown phyllosilicate* | *% of rock* | | |
| I 58NG0208 | 0.3 | 34 | — | — | 5 | — | 0.1 | — | — | — | 4.6 | 1.2 | 2 | — | 52 | Fine mosaic of quartz and plagioclase and orthoclase? | Kaluan River, central New Ireland |
| II 56NG0016 | — | 22 | — | — | 2 | .05 | — | — | .05 | — | — | 0.3 | 0.7 | 2 | 73 | 16% (of rock) plagioclase, remainder cryptocrystalline | Northwestern New Ireland |
| III 56NG0001A | — | 26 | — | — | 9 | 3 | — | — | — | — | — | — | 2.4 | 0.5 | 59 | Phenocrysts grade to groundmass. Predominantly plagioclase and fresh glass | Northwestern New Ireland |
| IV 56NG0001D | — | 30 | — | — | 8 | 1.3 | — | 0.1 | — | — | — | — | 1.0 | — | 59 | Flow-oriented plagioclase microlites set in brown glass | Dyaul Island, NW of New Ireland |
| V 60NG0104 | — | 24 | 2+ | 0.2 | — | — | 8 | — | 0.3 | 0.1 | .04 | — | 0.1 | — | 65 | Mosaic of quartz, albite, and orthoclase | Kamdaru River, southern New Ireland |

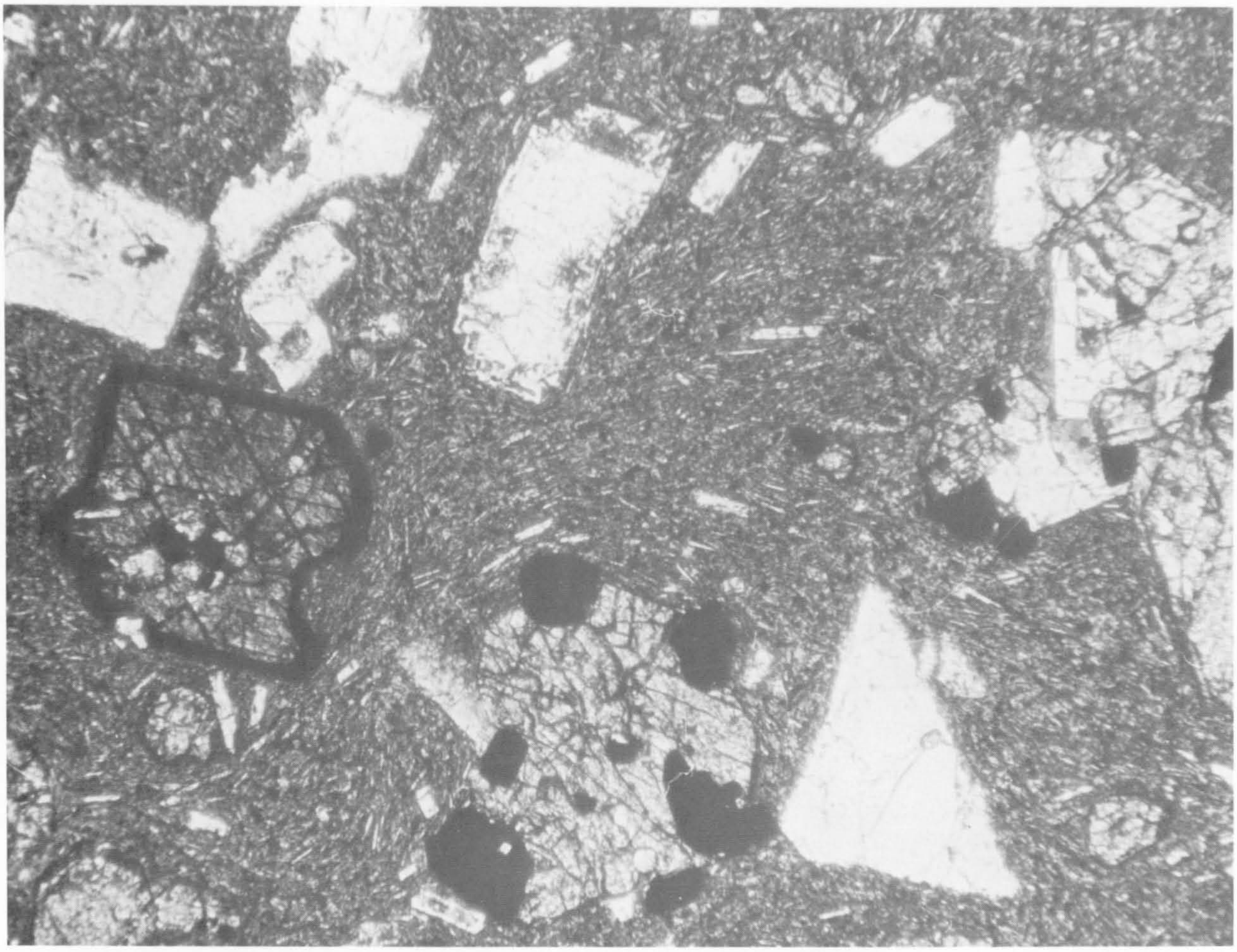


**Fig. 7. Photomicrograph of Jaulu Volcanics andesite showing trachytic texture of groundmass (M/1095).**

*Synonymy:* The Surker Beds, as named by Sapper (1910), and as adopted by French (1966). During an examination of Schubert's (1911) faunal lists, J. G. Binnekamp noted that a species of foraminifera from the type locality of the Lagaiken Beds and assigned by Schubert to the Oligocene is now known to range from middle Miocene to Holocene (Appendix 1). This area of limestone is now tentatively assigned to the Surker Limestone.

*Type section:* Hirudan River (474 558 to 485 559). Surker Creek no longer appears on maps of the area and its precise locality is not known. The Hirudan River cuts through the Surker Limestone along 10 km of its course.

*Lithology:* Lepidocycline chalk, clayey calcarenite, and calcirudite; less common is arenaceous limestone containing bivalves and rare calcareous and volcanolithic sandstone.

*Thickness:* About 500 m in the type section; probably up to 1300 m maximum thickness in the southeast, and less than 100 m in the most elevated occurrences such as on Mount Konogaiang, where it caps the central dividing range of this part of New Ireland.

*Distribution and relations:* Unconformably overlies the Jaulu Volcanics and Lemau Intrusive Complex in parts of southern New Ireland. The uppermost Miocene Rataman Formation abuts against the Surker Limestone in the north and east.

*Fauna and age:* The Surker Limestone characteristically contains a lepidocycline fauna which indicates an early Miocene (upper Te stage) age (Appendix 1). Other fauna indicates that the limestone is not older than mid-middle Miocene (lower Tf; Appendix 1). A modern interpretation of the age of the fauna listed by Schubert (1911) indicates an age range for the Surker Limestone of upper Te to lower Tf stages (Appendix 1).

*Description*

The Surker Limestone forms a curviplanar sheet with irregular undulations which appear to reflect the relief of the underlying Jaulu Volcanics. The gentle warping of the unit is thought to be a primary feature resulting from deposition of coral on an igneous 'basement' of moderate relief.

The limestone is characteristically white and massive and forms vertical cliffs. Clay is common, and the rock unit includes locally common pelagic foraminifera and much coral debris; the depositional environment may have been, in part, an intra-reef or back-reef lagoon into which foraminifera were washed from the open sea.

### *Lelet Limestone*

*Definition*

*Derivation:* Lelet Plateau, central New Ireland.

*Synonymy:* The Schleinitz Range-Lelet Plateau Limestone (Ripper & Grund, 1969) has been renamed to include limestone on the southern slopes of the Lelet Plateau. These limestones were not named by Sapper.

*Type section:* Along the foot track from Kantembu village (385 642) to Limbin village (382 633).

*Lithology:* Coral and algal biostromal calcarenite, calcirudite, and minor foraminiferal biomicrite; *in situ* coral and algal biohermal reef material. The limestones are pure, white to cream, and range from completely recrystallized at the base of the succession to only slightly recrystallized at the top.

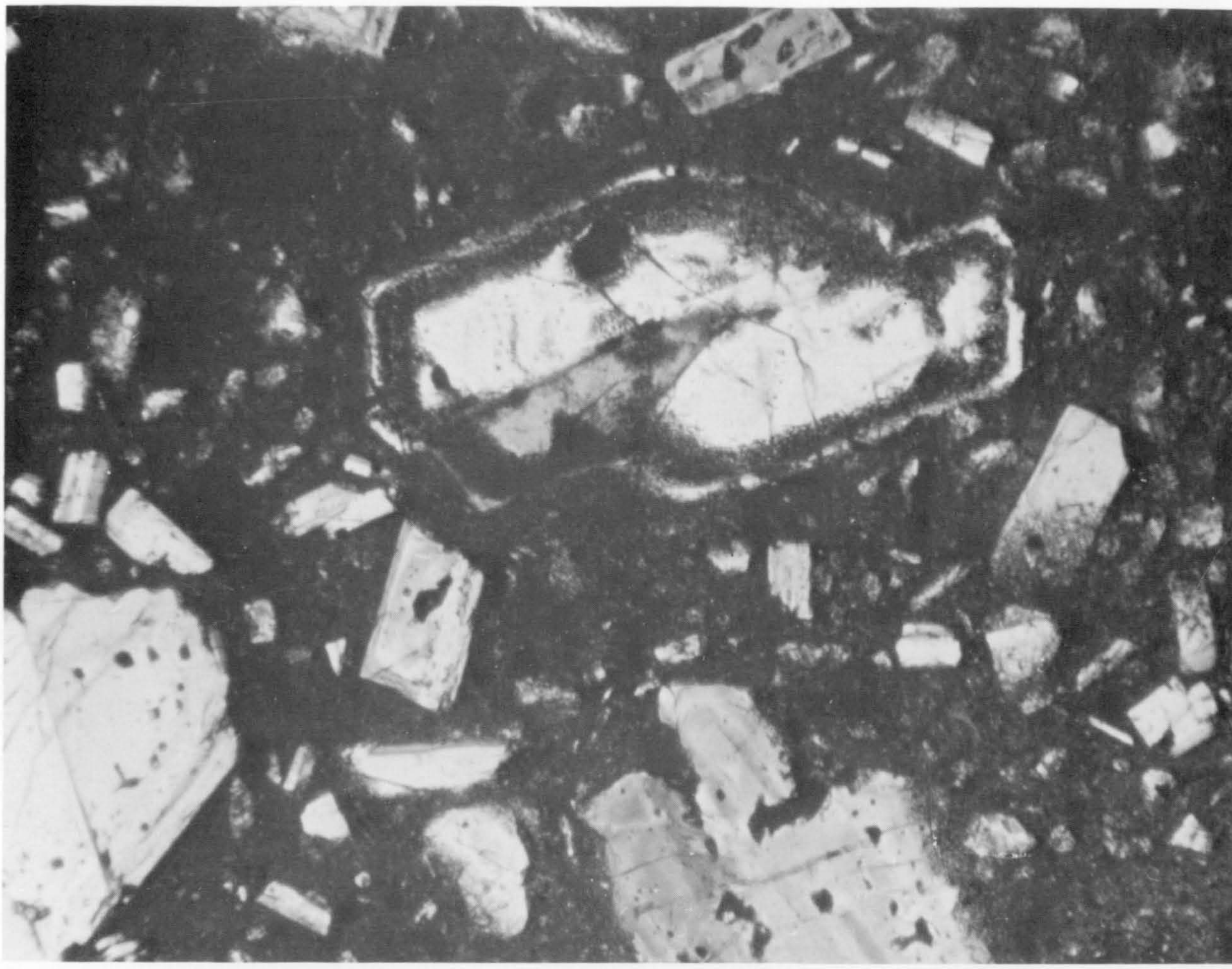


**Fig. 8. Photomicrograph of Jaulu Volcanics andesite showing corroded zone of plagioclase phenocryst and aphanitic groundmass (M/1117).**

*Thickness:* Up to 1400 m. The Lelet Limestone is made up of a series of onlapping limestone platforms which were deposited on a basement of high relief; the thickness of the unit probably varies considerably.

*Distribution:* The unit caps the Lelet Plateau and Schleinitz Range in the northern half of New Ireland and mantles the northeastern and, in places, the southwestern fall of the ranges. The thickness gradually decreases from the Lelet Plateau to the northwest, where only the lower part of the succession is represented. Thin outliers of Lelet Limestone in northwesternmost New Ireland (267 695) overlie the Jaulu Volcanics and Lossuk River Beds. The distribution of deep karst topography approximately coincides with the areal extent of the unit. Karst is not as well developed on any other limestone on the island.

*Relations with contiguous units:* The Lelet Limestone unconformably overlies the Oligocene Jaulu Volcanics and Lemau Intrusive Complex and conformably overlies the lower Miocene Lossuk River Beds. According to geologists of Swiss Aluminium Mining Australia Pty Ltd, windows in the unit expose rocks of the Lemau Intrusive Complex. Apparently, no evidence of skarn or other contact metasomatic or metamorphic alteration has been found to prove that the intrusives have intruded the Lelet Limestone. However, the association cannot be fortuitous and so some of the younger phases of the Lemau Intrusive Complex must have intruded at least the base of the Lelet Limestone in a few, very localized areas. The lower to middle Miocene parts of the Lelet Limestone appear to abut against the uppermost Miocene to Pliocene Rataman Formation. The uppermost beds of the Lelet Limestone, though probably of broadly similar age to the Punam Limestone, are characterized by karst topography and consist in part of *in situ* coral and algal material, whereas these features are absent in the Punam Limestone.

*Relations with non-contiguous units:* The lower to middle Miocene beds of the Lelet Limestone can probably be correlated with the Surker Limestone, which appears to be exclusively Miocene. Because the Lelet Limestone is longer-ranging than the Surker Limestone, and the two formations are geographically and geomorphically distinct, it is thought worthwhile to distinguish between them.

*Fauna and age:* The Lelet Limestone appears to range in age from lower Miocene (upper Te) to Pliocene or possibly Pleistocene (see Description below). This determination is based on a sparse foraminiferal fauna (Appendix 1, this Bulletin; Ripper & Grund 1969). The unit is characterized by abundant coral and algal remains.

### *Description*

On the northeast fall of the Lelet Plateau, a sequence of about fourteen terraces extends from sea level to an elevation of about 1480 m. The terraces have a vertical spacing of about 100 m, are about 100 m wide, and are generally several kilometres long. They appear to converge slightly towards the northwest. Samples taken from the edges of the terraces have yielded an early Miocene (upper Te stage) age near sea level and middle or late Miocene ages at higher levels. A sample from about 300 m stratigraphically below the top of the formation yielded a Pliocene or younger foraminiferal fauna.

The uppermost beds of the unit dip at up to 5° northeast; the older parts dip about 10-15° northeast. The youngest limestone (Pliocene or younger) occurs only in the southern part of the Lelet Plateau. Slightly older (probably Pliocene) limestone caps the remainder of the plateau and the Schleinitz Range.

The lithology of the unit is quite uniform. At the base of the sequence, the limestone consists of extensively recrystallized coral and algal reef material and biodismicrite* or biosparite. In all but the uppermost beds diagenetic modifications have resulted in a massive, almost structureless, white limestone. The biodismicrite contains scattered smaller foraminifera and is cloudy in thin section, suggesting the presence of clay.

Near the Lossuk River, in the extreme northwest, a log of calcified wood about 1 m in diameter and 4 m long was found. The cellular structure of the wood has been retained as a network of dark organic stains in the carbonate, and the calcite crystals have grown parallel to the fibres of the wood. The calcified wood was found in a largely coralline lower or middle Miocene (upper Te or lower Tf) part of the Lelet Limestone.

*Depositional environment and history*

The Lelet Limestone was probably deposited as fringing reefs on an elongate volcanic island of considerable relief. That part of the island had emerged by the late Oligocene or earliest Miocene is indicated by the 500-m difference in elevation between lower Miocene fringing reefs and the highest elevation of the basement on which the reefs formed, a difference far greater than the tolerance of living corals (about 100m).

The unit appears to have formed, initially, as a series of fringing-reef platforms which grew outwards from a lower Miocene island shelf or slope. Each limestone platform probably formed by upward growth of the reef complex, keeping pace with gradual subsidence of the island. The whole sequence of limestone platforms which makes up the Lelet Limestone indicates conditions of gradual subsidence from the early Miocene to the Pliocene, at least, with periods of stability and erosion probably throughout this time.

After the Pliocene or younger platforms had completely capped the volcanic island as atolls, the whole of the island must have been rapidly uplifted. If it is assumed that the uppermost limestone beds are lower Pliocene (see Appendix 1) then the *minimum average* rate of uplift for the interval early Pliocene to now was at least 0.3 mm/yr. If we assume that the uppermost limestone is basal Pleistocene, then the minimum average rate since then has been about 0.83 mm/yr.

Between Lamerika Point and Cape Lemeris, on the northeastern slopes of the Lelet Plateau, a large, amphitheatre-shaped embayment in the Lelet Limestone contains a flight of about 14 terraces between sea level and the edge of the plateau at 1360 m above sea level (see front cover). The terraces are about 100 m wide and 100 m apart. Similar terraces are found elsewhere on the slopes flanking the Lelet Plateau and Scheinitz Range, especially along the northeast side of the island, but are neither as numerous nor as well-developed.

Some terraces have in situ coral and algal material in growth position at their margins, and back-reef biomicrites taken from the surface of terraces have yielded Pliocene or younger fauna at the top of the plateau, and early Miocene (upper Te) fauna near the bottom of the flight of terraces at about 300 m above sea level. It is impossible to assign ages to the coral and algal reef material at the elevated margins of terraces and so determine whether they formed during transgression or regression. However, the flatter surfaces of most terraces were probably formed by wave-erosion during pulsatory uplift or, alternatively, during steady uplift associated with regular, cyclical changes in sea level at intervals of 120 000 to 330 000 years.

The last few terraces, from about 100 m above sea level downwards, are formed on young, incompletely recrystallized coral and were probably formed by off-lap of fringing reefs during the most recent phases of emergence of New Ireland.

### *Rataman Formation*

*Definition*

*Derivation:* Rataman District of New Ireland (during German Administration only), or Rataman village (452 575), which has long been abandoned.

*Synonymy:* The Rataman Formation as redefined here includes the Rataman Beds and Tamul Beds as named by Sapper (Sapper, 1910; French, 1966). The two units are indistinguishable lithologically and stratigraphically.

*Type section:* Along the foot track from Komalu Plantation to the top of the divide at 520 m (4216 6035 to 4225 6050).

*Lithology:* Andesitic and dacitic crystal-lithic tuff, volcanolithic labile arenite and lutite, foraminiferal marl, and limestone.

*Thickness:* About 500 m in the type section. This is probably the thickest section exposed above sea level. In other areas flanking southern New Ireland, the Rataman Formation covers 'basement' with substantial relief, and its thickness is variable.

*Distribution and relations:* The Rataman Formation forms much of the area between the narrow isthmus near Karu (410 619) and near Palabong (453 563) on the west coast and Cape Sena on the east coast. It unconformably overlies the lower areas of the central range of Jaulu Volcanics and Surker Limestone below about 500 m above sea level on both sides of the island in the south. The base is generally below sea level, and the underlying rocks are largely concealed.

The Rataman Formation is overlain unconformably by poorly indurated calcarenite and calcirudite of the Punam Limestone. In smaller areas, it is overlain by coarse sedimentary breccia and conglomerate of the Uluputur Beds.

*Fauna and age:* The abundant fauna of foraminifera and, locally, mollusca indicate latest Miocene or younger age (N18 or younger) (Appendix 1, this Bulletin; Fisher & Noakes, 1942).

*Description*

On the narrow isthmus that extends from Nabuto Bay to Karu Bay, the Rataman Formation forms a planar dip-slope that strikes parallel to the long axis of the island and is truncated along the southwest coast by a fault. In this region, a maximum thickness of 500 m of fine tuffaceous calcilutite and arenite is exposed. Strata dip between 5° and 20° northeast and strike between 280° and 310°. Immediately below the fault scarp on the western side of the isthmus, the attitude of the strata abruptly changes to a southwesterly dip of up to 20°.

In the south, bedding attitude is more variable, possibly because of post-depositional compaction of originally subhorizontal sediments. Compaction appears to have increased low initial dips to about 25-30° where

* Terminology of microscopically examined limestone after Folk (1965).

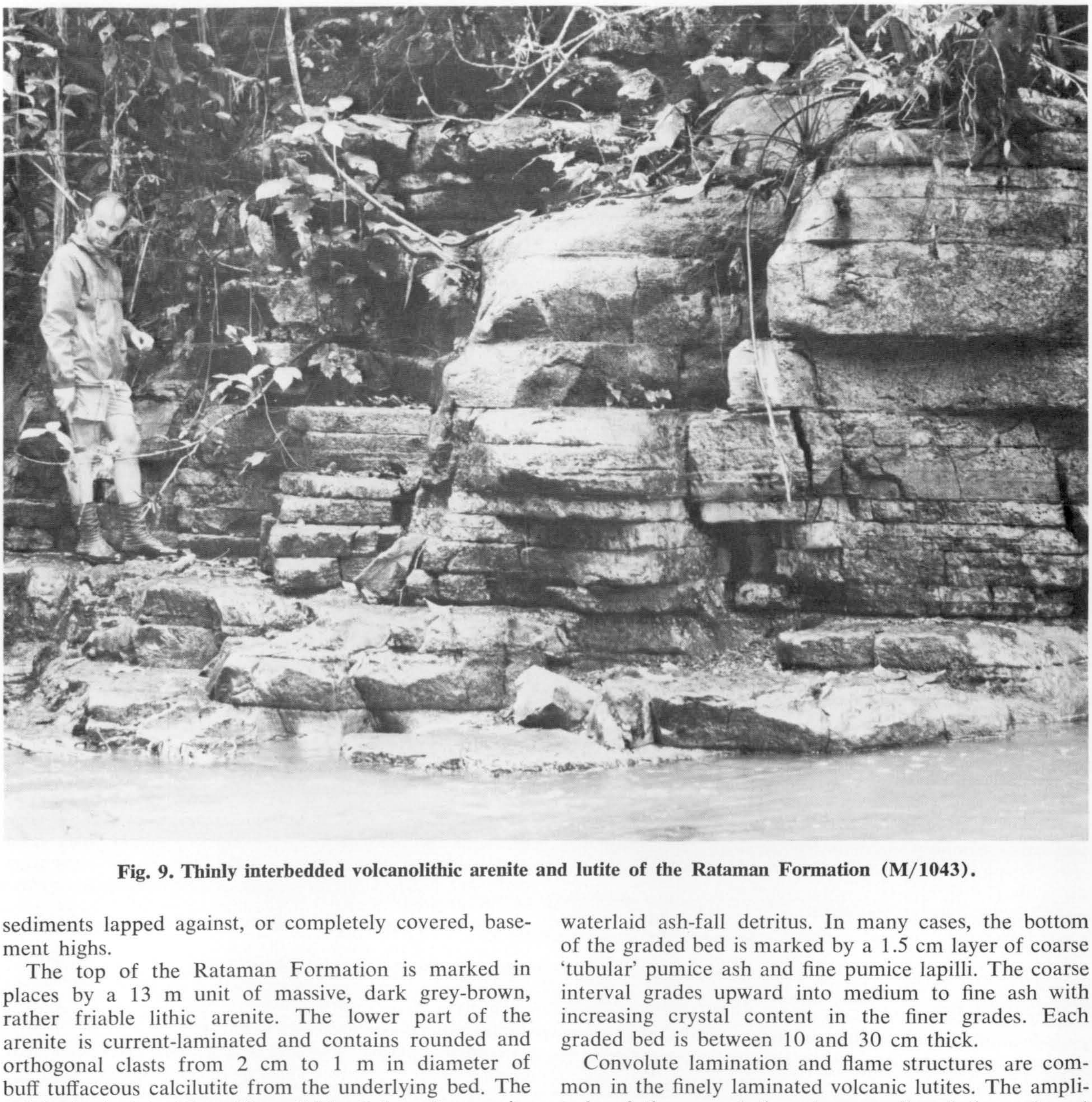


**Fig. 9. Thinly interbedded volcanolithic arenite and lutite of the Rataman Formation (M/1043).**

sediments lapped against, or completely covered, basement highs.

The top of the Rataman Formation is marked in places by a 13 m unit of massive, dark grey-brown, rather friable lithic arenite. The lower part of the arenite is current-laminated and contains rounded and orthogonal clasts from 2 cm to 1 m in diameter of buff tuffaceous calcilutite from the underlying bed. The calcilutite bed is 15 to 30 m thick. Below the arenite and calcilutite, the succession consists of about 500 m of alternating thickly bedded tuff, grading to volcanolithic arenite, and volcanolithic lutite which grades in turn into foraminiferal calcilutite (Fig. 9). Individual beds generally range from 15 to 45 cm thick and exhibit flaggy parting. The lithic arenites are derived from ash-fall vitric-crystal and crystal-lithic tuff and many are finely current-bedded. The calcilutites are generally buff coloured and are soft and semi-plastic; the volcaniclastic lutites are orange or blue, and are brittle with a conchoidal fracture. The formation contains lenses of pebble conglomerate near the base of the succession in the south. The clasts are predominantly porphyritic andesite. At a few localities in the south of the distribution of this unit, low-grade lignitic brown coal seams up to 1 m thick are interbedded with the volcanolithic sedimentary rocks.

The sedimentary and fine pyroclastic rocks are generally well-bedded and are well-sorted by mass if not by size; graded bedding is present in some outcrops. The grading appears to be a gravity sorting of waterlaid ash-fall detritus. In many cases, the bottom of the graded bed is marked by a 1.5 cm layer of coarse 'tubular' pumice ash and fine pumice lapilli. The coarse interval grades upward into medium to fine ash with increasing crystal content in the finer grades. Each graded bed is between 10 and 30 cm thick.

Convolute lamination and flame structures are common in the finely laminated volcanic lutites. The amplitude of the convolutions is generally of the order of 2 cm, and the peaks of the folds generally have a preferred inclination (Fig. 10). This suggests that the convolutions may be current rather than load structures (Bouma, 1962). Current lamination is common in arenite beds and corresponds to Walker's (1963) type-2 ripple-drift cross-lamination. The latter two sedimentary structures are commonly spatially related, but, as most of the structures were seen in small river boulders, their precise relation could not be determined.

*Petrography:* The clastic sedimentary rocks have a small proportion of matrix and a continuous, or almost continuous, framework. The framework generally consists of labile mineral grains (Fig. 11) which are angular to subrounded and predominantly of low to moderate sphericity; opaque grains are commonly of high sphericity. The clasts of the tuffs and labile arenites include diopsidic augite, oscillatory and normally zoned plagioclase, pumice, cuspidal glass shards, green and brown hornblende, opaques, and a little biotite, lamprobolite, hypersthene or bronzite, actinolite, apatite, and quartz. The matrix is made up of palagonite

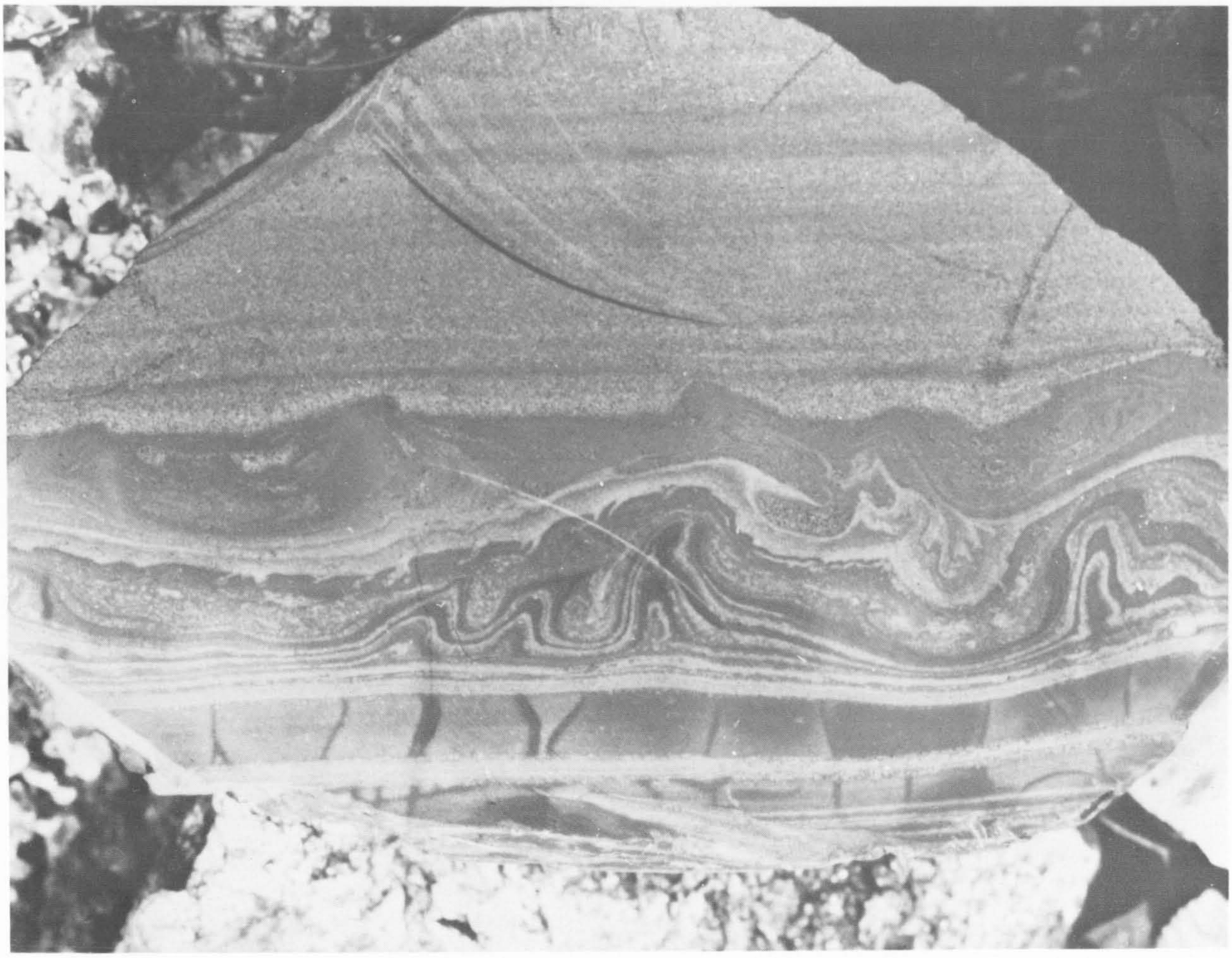


Fig. 10. Convolute laminations in a boulder from the Rataman Formation (GA/4995).

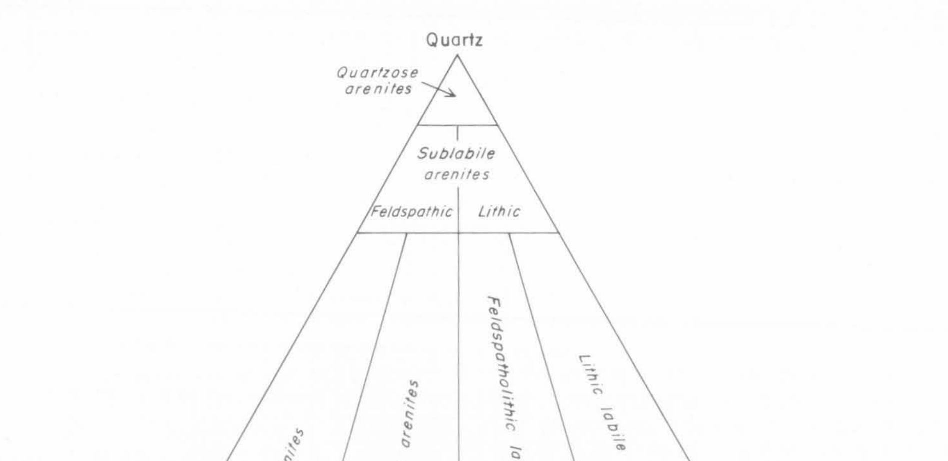



Fig. 11. QFR diagram for arenites of the Rataman Formation.

or allophane, kaolin, zeolites, chalcedony, and other alteration or replacement products of volcanic rock fragments. Micrite forms most of the matrix of the calcilutites. The bulk of the sedimentary rocks is thus texturally and mineralogically immature.

*Diagenesis of Rataman Formation:* Zeolites are the principal diagenetic minerals of the Rataman Formation, though in some samples calcite, which may be of remobilized primary origin, is common. Very fine-grained zeolites are common in most of the volcanolithic sediments, though grainsize is generally too small to allow microscopic identification. Where indentification was possible, the minerals chabazite, analcime, and heulandite? were found in that order of abundance. These are early diagenetic minerals (Packham & Crook, 1960) and indicate diagenetic conditions of the uppermost zones of the zeolite facies (Coombs et al., 1959). The zeolites appear to replace very fine volcanic glass shards and to fill tubules in pumice clasts.

Coombs et al. (1959) listed chabazite as stable at or near the surface in an environment that is oversaturated with respect to silica. This precludes burial of the Rataman Formation to depths greater than about 500 m, or the present greatest observed depth of burial. Analcime is not a good depth indicator and may persist to depths of 5000 m or more.

Not all of the volcanic glass is replaced by zeolites. Some is fresh and some has altered to a honey-coloured isotropic substance which is probably palagonite or allophane. Calcite fills the tests of foraminifera, and in many examples it partially replaces etched plagioclase along cleavages and forms grain coatings.

Near Matakan Plantation, on the southwest coast (438 578), the Rataman Formation is locally siliceous and is much disturbed by localized faulting and folding. The fine-grained siliceous beds are interbedded with coarse dacite or rhyodacite crystal-lithic tuff which contains large quartz crystals; they are so fine-grained (microcrystalline to cryptocrystalline) that it is not known whether the silica they contain is primary or authigenic.

*Depositional environment and history*

The thick succession of alternating graded and current-bedded lithic labile arenites and clay-rich globigerinal ooze limestones, both of which occur as beds 14-45 cm thick, suggests an alteration of contrasting bottom conditions. The current and convolute laminations which are characteristic of the clastic sediments indicate quite strong bottom currents. The globigerinal ooze limestone and marls, on the other hand, indicate extremely quiet bottom conditions. It appears that a quiet depositional environment was interrupted at regular intervals by density currents bearing detritus of volcanic origin. Schubert (Sapper, 1910) believed that the globigerinal oozes of the Rataman Formation were deposited at depths of 1000 m or more. He reached this conclusion after comparing the fauna of the Rataman Formation with that collected during the *Challenger* voyage. This estimation of depth agrees with that obtained by subtracting the elevation of the observed base of the Rataman Formation from that of the base of penecontemporaneous coralline limestones in the Lelet Plateau region.

The absence of any 'basement' rocks in the isthmus that extends from Nabuto Bay to Karu Bay, as well as of any reef limestones equivalent to the Lelet Limestone, can be explained by postulating that much of the Rataman Formation was deposited in a graben or dilated shear zone. A hypothetical mechanism for the formation of such a trough in the upper Miocene is shown in Figure 24. Troughs, which may be grabens, with similar dimensions and orientation to that in which the Rataman Formation might have been deposited have been mapped on the floor of the adjacent Bismarck Sea (W. A. Wiebenga & B. C. Barlow, BMR, pers. comm. 1972).

### *Punam Limestone*

*Definition*

*Derivation:* Punam village, southeastern New Ireland (448 582).

*Synonymy:* The Punam Limestone of French (1966) and the Punam Beds of Sapper (1910) have been redefined to include only limestone; volcanolithic sediments are now included in either the Rataman Formation or the Uluputur Beds.

*Type section:* Along the northern tributary of the Puk River (445 583-448 582).

*Lithology:* Finely bedded, friable, moderately recrystallized chalky limestone and foraminiferal calcarenite. Coralline calcirudite occurs in the southwest of the island.

*Thickness:* About 200 m in the type section. The shallow-water facies to the south, which has also been mapped as Punam Limestone, is up to 1000 m thick.

*Distribution and relations:* Unconformably overlies the Rataman Formation along a narrow strip on the northeast coast of south-central New Ireland. The Punam Limestone also unconformably overlies the Jaulu Volcanics along the west coast of central and southernmost New Ireland.

*Fauna and age:* The abundant *Globigerina* and *Pulvinulina* (= *Globorotalia*) fauna compares closely with Holocene forms (Schubert, 1911). Stratigraphic relations indicate a Pliocene or younger age.

*Description*

The formation is composed of white vuggy limestone which ranges from friable and chalky calcarenite to fine calcirudite. Bedding is subhorizontal, with individual beds ranging from 15 cm to 1 m thick. The unit is generally only slightly recrystallized and is distinguished from older, massive limestones by its well-developed bedding.

### *Uluputur Beds*

*Definition*

*Derivation:* Uluputur village, southwest coast of New Ireland (432 589).

*Synonymy:* That part of the Punam Beds of Sapper (1910) and of the Punam Limestone of French (1966) which consists of coarse lithic labile rudite and arenite derived from the Rataman Formation.

*Type section:* Northwest tributary of the Sae River, where it is crossed by a bridge on the Namatanai-Uluputur road (4319 5920).

*Lithology:* Finely bedded calcareous cobble and boulder conglomerate with clasts of tuff and volcanolithic arenite and lutite, overlain by coquinoid lithic sandstone, which passes upwards into alternating blue-grey siltstone and pale brown lithic coquinoid sandstone.

*Thickness:* About 100 m in the type section and near Punam village.

*Distribution and relations:* Abuts against, and forms restricted embayments in, the Punam Limestone; the two may be coeval in part. Unconformably overlies the Rataman Formation in the type section.

*Fauna and age:* Contains an abundant molluscan fauna, the few well preserved examples of which range up to Holocene time. The sediments are derived from the uppermost Miocene Rataman Formation and are therefore probably of Plio-Pleistocene age.

*Description*

The attitude of the Uluputur Beds ranges from horizontal to a northwesterly dip of about 5°. The base of the succession consists of 15 m of finely bedded buff arenaceous siltstone and mudstone. These sediments pass upwards into a poorly sorted intraformational pebble to boulder conglomerate with a calcite matrix. Clasts range from about 9 cm to 3 m diameter with a mode at about 30 cm. The smaller clasts are angular, but roundness increases with diameter. They consist almost entirely of augite crystal tuff, volcanically derived sandstone, and lutite, and appear to be derived from the uppermost Miocene or younger Rataman Formation. The upper surface of the conglomerate is extremely irregular and is overlain by about 4 m of massive, poorly sorted lithic sandstone. The top of the Uluputur Beds consists of about 6 m of alternating 10-20 cm thick beds of blue-grey tuffaceous siltstone and buff-coloured lithic coquinoid sandstone. Sole marks and horizontal worm-burrow casts are common at the base of the sandstone beds; flute casts are common and groove casts are rare. Shell fragments in the sandstone beds include abundant gastropods as well as bivalve fragments.

*Depositional environment*

The Uluputur Beds appear to represent an inner neritic facies which was deposited on the Rataman Formation in small, shallow embayments in the Pleistocene coastline.

### *Maton Conglomerate*

*Definition*

*Derivation:* Maton River (468 528), southwestern New Ireland.

*Synonymy:* Maton Conglomerate (French, 1966).

*Type section:* Maton River, near Mala Plantation (466 530 to 470 526).

*Lithology:* Coarse current-bedded cobble and boulder conglomerate and interbedded pebbly sandstone. The framework consists predominantly of well-sorted fragments of Jaulu Volcanics and is generally continuous; the matrix is sand.

*Thickness:* 200-300 m.

*Distribution and relations:* Unconformably overlies the Jaulu Volcanics, Rataman Formation, and Punam and Surker Limestones on different parts of the coastal area of southern New Ireland. Unconformably overlain along the coast by Pleistocene to Holocene coral terraces.

*Age:* Stratigraphic evidence indicates a probable Plio-Pleistocene age.

*Description*

The Maton Conglomerate consists of conglomerate with some very friable sandstone, siltstone, and mudstone. The sediments are generally unconsolidated or poorly cemented, except where they contain much finely comminuted coral debris. Cross-bedding and scour-and-fill structures are common. The cobble and boulder conglomerate contains well rounded fragments of andesite porphyry, gabbro, diorite, and granodiorite. In some places (for example 512 523) the unit consists of well-cemented sandy beach-rock with lenses of cobble conglomerate.

In the region of the Daulum River (486 558) an isolated tongue of conglomerate occurs in an embayment in the Rataman Formation. At this locality the conglomerate shows evidence of cyclic deposition; basal boulder layers grade upwards to cobble then pebble conglomerate over an interval of about 2 m. These graded units form a sequence about 60 m thick.

*Depositional environment*

The Maton Conglomerate probably represents a coalesced series of fanglomerate deposits which have been reworked locally by wave action. The unit dips at 15-20° towards the coast on both sides of southern New Ireland; this is probably a primary depositional dip. Beach deposits forming at the present time in southern New Ireland are indistinguishable from parts of the Maton Conglomerate. The cyclic nature of the unit reflects the pulsations of the uplift of the island during the Pleistocene.

### *Raised fringing coral reefs*

Broad, unrecrystallized offlapping coral terraces occur on the northeastern fall of southern New Ireland at elevations of about 100-200 m, 80-85 m, and at close intervals from 65 m to sea level. At the lower levels, up to 30-40 m above sea level, the raised fringing reefs form an almost continuous strip along the northeast coast. At many places along the coast, the raised reefs form low headlands, some of which extend out to sea for 6 km (Fig. 27). Raised coral is also patchily developed along the southwest coast.

The margins of the raised terraces consist of *in situ* colonial corals. The back-reef facies is made up of coarsely to finely comminuted coral material, *Tridacna* clam shells, foraminiferal tests, and, locally, oolites.

## INTRUSIVE ROCKS

### *Lemau Intrusive Complex*

*Definition*

*Derivation:* Lemau village (348 648).

*Synonymy:* That part of the 'Older Volcanics' of Sapper (1910) made up of holocrystalline fine to coarse intrusive rocks. Includes the part of the Jaulu Volcanics of French (1966) that consists of gabbroic and dioritic intrusives. Also includes the Lemau Igneous Belt of Ripper & Grund (1969).

*Type area:* The larger creeks that drain into Katherine Harbour (349 651 to 352 648).

*Lithology:* Gabbro, norite, diorite, tonalite, trondhjemite, granodiorite, and leucocratic dyke rocks. Gabbro and norite are in places alkali-metasomatized and in places exhibit igneous flow foliation. Most of the plutonic rocks contain abundant finely disseminated and vein-forming pyrite. On the map, acidic rocks of the Lemau complex are distinguished from the intermediate and basic rocks.

*Extent and relations:* Discontinuously exposed in areas up to 64 km long and 8 km wide in a belt about 200 km long which lies along the southwestern side of the island and diagonally transects southern New Ireland. Rocks of the Lemau Intrusive Complex occur as dykes and stocks in the lower to middle or lower upper Oligocene Jaulu Volcanics and contain abundant volcanic xenoliths. The intrusives are mostly overlain by the lower Miocene part of the Lelet Limestone, but some of the younger phases must have intruded the base of the limestone.

*Age:* The intrusions probably range in age from early or middle Oligocene to middle Miocene. K-Ar ages have been determined on three samples: a dolerite from the Kamdaru River, southern New Ireland, 31.8 ± 1.0 m.y. (early or middle Oligocene), and two samples of float—porphyritic

TABLE 4. MODAL ANALYSES (VOLUME) OF INTRUSIVE ROCKS FROM NEW IRELAND
(CIPW norms (wt%) shown in brackets)

| | *A* | | *B* | | *C* | | *D* | | *E* | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Plagioclase* | 44 | (43) | 32 | (32) | 57 | (52) | 44 | } (52) | 63 | } (62) |
| *Late sodic plagioclase* | — | | ND | | ND | | 6+ | | 2 | |
| *Potash feldspar* | 23 | (20) | 10 | (12) | 5+ | (8) | 0.4 | (1) | 0.3 | (3) |
| *Quartz* | 26 | (25) | 24 | (25) | 19 | (21) | 0.8 | (3) | — | (6) |
| *Augite* | 1+ | (4) | — | (1) | — | (5) | — | (16) | — | (6) |
| *Hypersthene* | 0.2 | (5) | — | (8) | — | (9) | — | (21) | — | (16) |
| *Hornblende* (green) | 1+ | (2) | — | | 11 | | 44 | | — | |
| *Biotite* | 1— | (0.2) | 12 | | 2 | | — | | — | |
| *Opaque minerals* | 1— | | 3+ | (4) | 1 | (4) | 0.3 | (4) | 2+ | (6) |
| *Apatite* | 0.2 | | — | (0.2) | — | (0.3) | 0.1— | (0.05) | 0.1— | (0.3) |
| *Actinolite* | 2 | | 18 | | 5 | | — | | 32 | |
| *Chlorite* | — | | — | | — | | 1 | | — | |
| *Calcite* | — | (0.1) | 0.3 | (0.4) | — | (0.2) | 2 | (1) | — | (0.1) |
| *Epidote* | 1 | | — | | — | | 0.4 | | — | |
| *Zeolites* | — | | — | | — | | 1+ | | — | |

ND—Not determined
— —slightly less than
\+ —slightly more than
A —58NG0057, xenolith from granodiorite near 58NG0058
B —58NG0058, granodiorite about 3 km north of Lemau
C —58NG0060, granodiorite about 2.4 km north of Patlangat plantation
D —60NG0016, hornblende gabbro from Tanpon River, near Matop plantation
E —60NG0105, uralitized dolerite from Kamdaru River

rhyodacite—from this river, 17.5 ± 0.6 m.y. and 13.8 ± 0.5 m.y. (early and middle Miocene respectively) (Appendix 2). Stratigraphic evidence indicates that the intrusions are younger than or coeval with the Jaulu Volcanics (dated by the K/Ar method at 30.7 ± 1.0 m.y.), and partly older than and partly coeval with the Lelet Limestone (lower Miocene to Pliocene or possibly Pleistocene).

*Description*

The numerous high-level basic, dioritic, and granodioritic stocks which intrude the Jaulu Volcanics are collectively referred to as the Lemau Intrusive Complex. They crop out discontinuously along two linear northwesterly belts each about 65 km long and 8 km wide, whose trends diverge by an angle of 2°30′. The northern belt lies along the southwest coast of northern New Ireland (southern fall of the Lelet Plateau), and the southern belt transects southern New Ireland north of the subparallel Weitin Fault. These two belts may once have been collinear and continuous, and the stocks could have been emplaced along a fissure or a series of eruptive centres immediately after volcanic activity ceased in the middle or early late Oligocene. A third, less well-defined belt about 50 km long and 6 km wide lies just north of the Weitin Fault; it consists of at least seven stocks and plugs, each about 0.8 km in diameter. A few other very small stocks or plugs have been mapped to the south of the Weitin Fault (P. Bessiére, written communication). The margins of most stocks include numerous volcanic xenoliths, presumably derived by stoping of Jaulu Volcanics. Contact metamorphic and metasomatic aureoles are generally narrow. Areas of metasomatized Jaulu Volcanics that are remote from outcropping plutonics probably indicate the presence of near-surface concealed intrusions.

Granodiorite forms large irregular stocks, while gabbro, norite, diorite, trondhjemite, and rhyodacite form small, plug-like bodies and dykes.

The intrusives are generally medium or fine-grained and more or less equigranular. Many have subophitic texture, are leucocratic, and have a gabbroic composition. The gabbro and norite are at various stages of modification to subidiomorphic granular textures and granodiorite composition.

*Petrography:* Some of the petrography is quantified in Table 4. Unaltered gabbro and norite consist of diopsidic augite and hypersthene or bronzite (moderately pleochroic from pale pink to pale green; 2V = 50-70°) in variable proportions, with plagioclase which shows polysynthetic twinning and some oscillatory zoning. Unzoned plagioclase in about 20 thin sections has compositions within the range labradorite to bytownite, and zoned crystals have cores of bytownite to anorthite. The colour index of rocks of intermediate to acid composition is generally less than 30, but the basic plutonics range from leucocratic to very melanocratic.

Many of the rocks are characterized by what appears to be normal gabbroic mineral composition modified by late crystallization of silica and alkali-rich mineral phases. The later minerals include biotite, sodic plagioclase, actinolite, quartz, and, rarely, potash feldspar. These are commonly peripheral to earlier-formed minerals such as pyroxene and calcic plagioclase. In the extreme case, modification of this type has resulted in basic rocks being made over to rocks of granodiorite composition and subidiomorphic and allotriomorphic granular texture. Such rocks contain relict grains of diopsidic augite, orthopyroxene, and bytownite. Corroded pyroxene crystals occur at the centres of actinolite aggregates and, less commonly, in the cores of green hornblende crystals. In addition, calcic plagioclase is in many cases rimmed and partly replaced by more sodic plagioclase (albite to andesine; generally about $An_{40}$). Biotite forms up to 15 percent of some of the modified basic plutonics, and is generally associated with potash feldspar, fibrous actinolite, chlorite, and opaques. A little magnetite is found in most of the plutonic rock types; pyrite is very common and forms up to 10 percent by volume of parts of some stocks. Apatite occurs as euhedral crystals in many specimens.

The examples cited indicate the alteration of early-formed crystals by late-stage fluids, presumably before the magma had completely solidified. Other types of alteration indicate alkali metasomatism, i.e., the alteration of completely crystallized rocks by highly mobile aqueous fluids rich in alkalis and silica. This has caused replacement of quartz and labradorite in intermediate rocks by a fine-grained mosaic of quartz and albite, as well as the alteration of pyroxene to actinolite.

The more acid plutonic rocks in the type area commonly contain fine-grained melanocratic xenoliths 10-15 cm across and with ill-defined boundaries. In hand specimen, the xenoliths resemble lava fragments from the Jaulu Volcanics. One thin section (58NG0057) of a small melanocratic xenolith from a granodiorite consists of small clusters of fine-grained orthopyroxene, clinopyroxene, and opaques; the clusters are rimmed by fibrous actinolite, chlorite, and biotite. The remainder of the xenolith has been made over to granodiorite similar to the host rock. This alteration is not confined to the margins of the xenolith, but pervades it, leaving only scattered minute patches unaltered. The clusters of mafic minerals may represent relict fragments of Jaulu Volcanics.

Norite (60NG0011) from the headwaters of the Hirudan River has a weak foliation formed by ill-defined alternating felsic and mafic bands in which the minerals have subparallel long axes. This is probably an igneous flow foliation developed during intrusion of the norite as a near-solid crystal mush.

*Discussion*

The apparent late-stage enrichment of the gabbro and norite in silica and alkalis might be explained by partial melting and assimilation of abundant intermediate xenoliths in partly crystallized magma. Alternatively reaction between early-formed crystals and accumulated late-stage alkalic and silicic fluids from the same melt may have produced a rock of acid composition, with some relict basic minerals.

Rocks of the Lemau Intrusive Complex probably represent the slowly crystallized portion of the magma that gave rise to the Jaulu Volcanics. They probably crystallized at less than 3 km below the surface (see Fig. 15).

The intrusives are generally strongly jointed parallel to the northwesterly trend. They may therefore be late syntectonic; that is, they may have been emplaced along a crustal weakness parallel to the southwest coast of the island and have been jointed by renewed stresses (see p. 25).

# CHEMISTRY

Silicate analyses of eleven rocks are summarized in Table 5 and Figures 12 to 18. The Jaulu Volcanics and Lemau Intrusive Complex are probably comagmatic, and there is therefore some justification for treating them as an igneous suite. The tuff from the Rataman Formation (58NG0132) is not related to either one of these rock units. Compositions range from undersaturated (gabbro) to oversaturated (rhyodacite). The volcanic rocks analysed are lavas and lava clasts from agglomerate and comprise about 30-50 percent phenocrystic material set in an aphanitic groundmass of oriented plagioclase microlites and interstitial brown glass. These fall within the ranges 57.5-62.5% $SiO_2$ and 1.08-1.63% $K_2O$ and hence have typically andesitic compositions (cf. Taylor, 1969), as well as showing typically andesitic textures and mineralogy.

The only xenolith analysed is from granodiorite (58NG0057, Table 5), and was believed from field relations and petrographic features to be a fragment of Jaulu Volcanics. It contains, however, less CaO, $Al_2O_3$, total Fe, and MgO, and twice as much $K_2O$, as analysed examples of Jaulu Volcanics, and its $K_2O$ content is 1.65 times that of the host granodiorite. The apparent change in composition may be due to reaction of the xenolith with late-stage fluids rich in potash and silica (such as are now preserved as aplite veins near the margins of the granodiorite body). This suggestion is supported by the fact that the composition of the xenolith plots close to the ternary minimum on a normative silica-orthoclase-albite diagram.

### *CIPW normative compositions*

*Jaulu Volcanics:* The normative composition of plagioclase from three specimens analysed is in the range $An_{44-53}$; petrographic determinations fall within the range $An_{55-65}$. This can be explained, at least in part, by the abundance of oscillatory-zoned plagioclase, for which an overall composition is difficult to establish. The groundmass plagioclase is also probably more sodic than the phenocrystic plagioclase. The andesites have normative quartz compositions of 12-26%, indicating that there is probably much free silica in the glass of the andesites, as no crystallized $SiO_2$ minerals were detected in thin sections.

*Lemau Intrusive Complex:* Normative plagioclase compositions are in the range $An_{39-77}$, while petrographic determinations by Michel-Levy's method are within the range $An_{40-84}$. Normative quartz ranges from 1% to 25%; petrographic determinations for the same rocks range from 0.1% to 26%.

### *Comparison of ternary diagrams for New Ireland rocks with those for Gazelle Peninsula (New Britain) plutonics*

The analyses of volcanic, plutonic, and dyke rocks from New Ireland have been plotted on the same diagrams as analyses of plutonic rocks from the Baining Mountains, Gazelle Peninsula (Macnab, 1970). In the systems orthoclase-anorthite-albite, quartz-orthoclase-albite, $K_2O$-CaO-$Na_2O$, and quartz-plagioclase-orthoclase, the plots for New Ireland rocks have trends very similar to the 'normal' calc-alkaline rocks of the North Baining Mountains; but quite different trends from the 'high-K' calcalkaline rocks of the Central and South Baining Mountains.

FMA plots of Gazelle Peninsula plutonics and New Ireland rocks show parallel trends, but the Gazelle Peninsula rocks are poorer in MgO (Fig. 13). Again, the New Ireland rocks, representing both volcanic and plutonic types, show a broader spread than the Gazelle Peninsula rocks, and a flattening off of the slight tendency for iron enrichment at the expense of MgO at the more basic end of the inferred fractionation trend.

Both these trends are fairly close to the Cascades calc-alkaline trend (Carmichael, 1964), but the latter is slightly less steeply inclined towards the iron apex than trends of the Bismarck Archipelago rocks.

The more basic New Ireland and Gazelle Peninsula rocks have been plotted on a modified Macdonald &

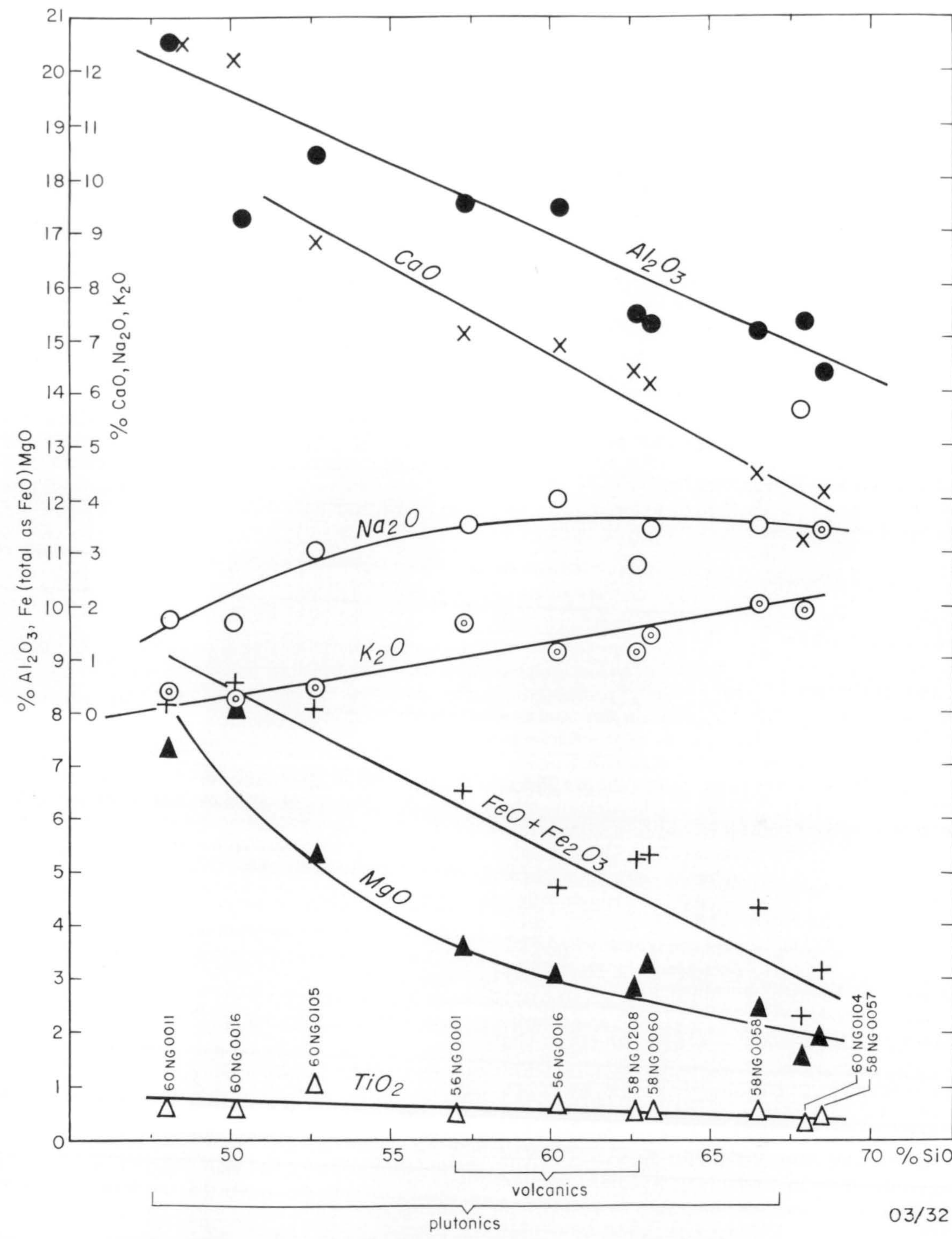



**Fig. 12. Variation diagram of igneous rocks from New Ireland.**

Katsura (1964) total alkalis/silica diagram (Fig. 17). The line co-ordinates $Na_2O + K_2O = 0.5$, $SiO_2 = 43$ and $Na_2O + K_2O = 5$, $SiO_2 = 55$ was extrapolated to $SiO_2 = 60$ to allow more analyses to be plotted. All the New Ireland analyses that can be plotted on this diagram and 14 Gazelle Peninsula analyses fall below the line—that is, within the calcalkaline and Hawaiian tholeiitic region. Two of the Gazelle Peninsula analyses ($SiO_2 = 51.5$ and 48.6), however, plot above the line, that is, in the Hawaiian alkalic region of the diagram. These two analyses are of high-K calcalkaline rocks (Macnab, 1970).

Macnab (1970) used a $K_2O/Na_2O$ *v* $SiO_2$ diagram to broadly classify the Gazelle Peninsula rocks that were chemically analysed (Fig. 18). He found that the $K_2O/Na_2O$ ratio reflects the K-feldspar/plagioclase ratio and hence K-feldspar/total feldspar ratio for the Gazelle Peninsula rocks. This is also true of the analysed New Ireland rocks, which, with few exceptions, do not contain appreciable biotite: (see p. 22, column 1).


**Fig. 13. FMA diagram, New Ireland rocks.**

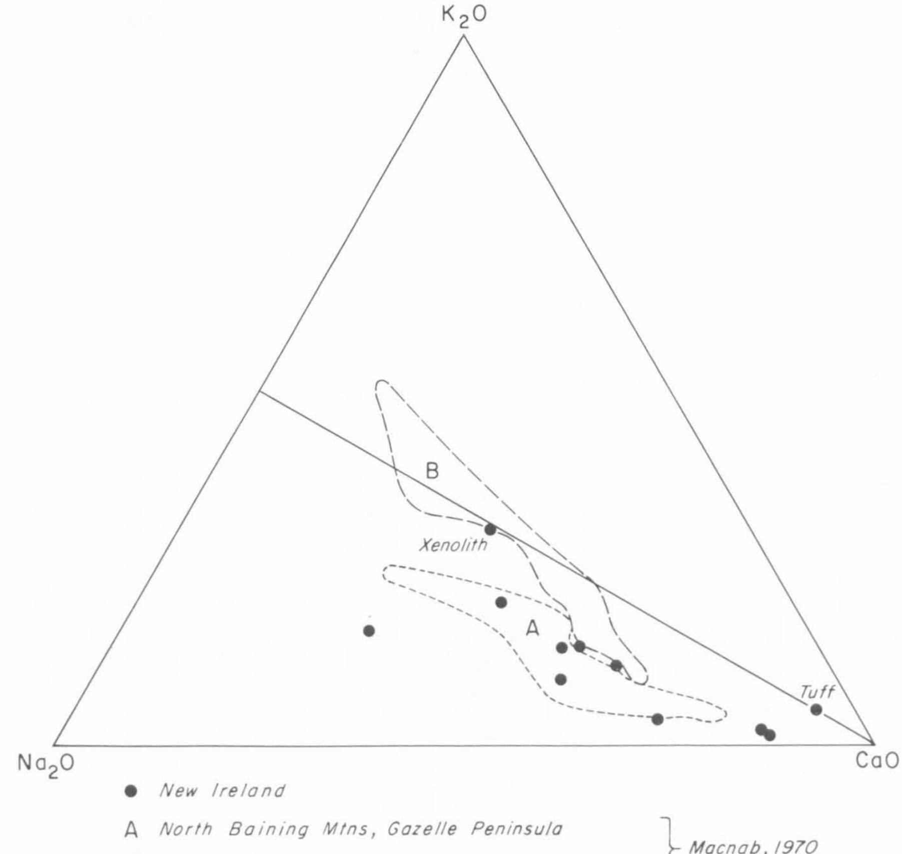



**Fig. 14. KCN diagram for New Ireland rocks.**

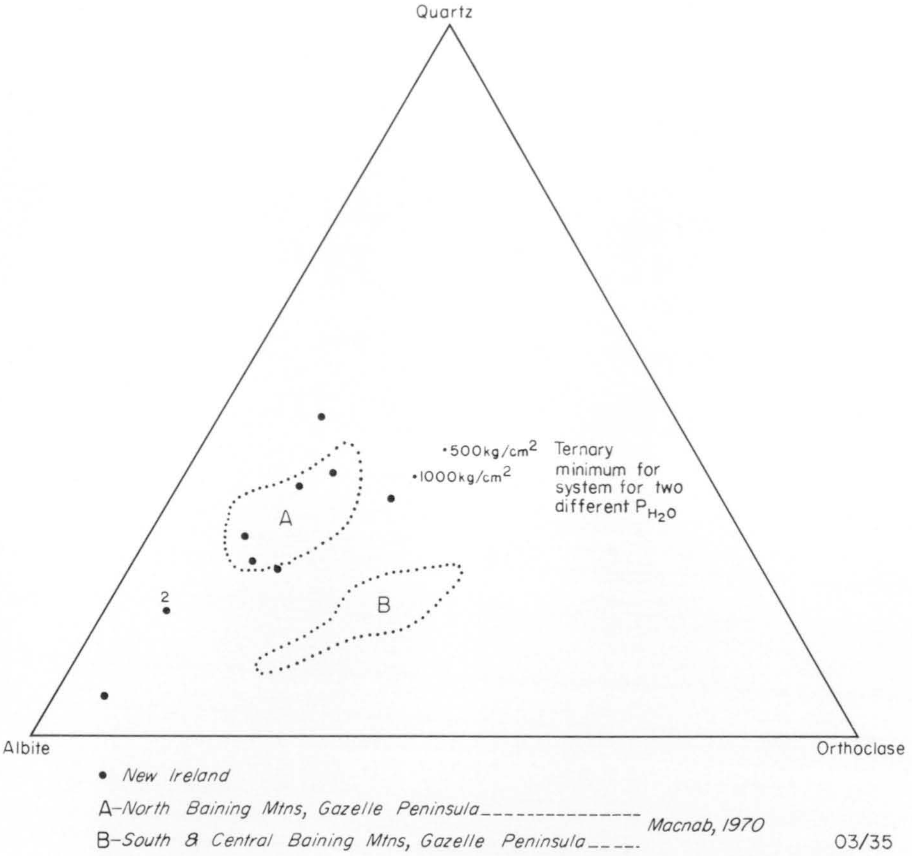



**Fig. 15. Normative Qtz-Or-Ab diagram, New Ireland and Gazelle Peninsula Rocks.**

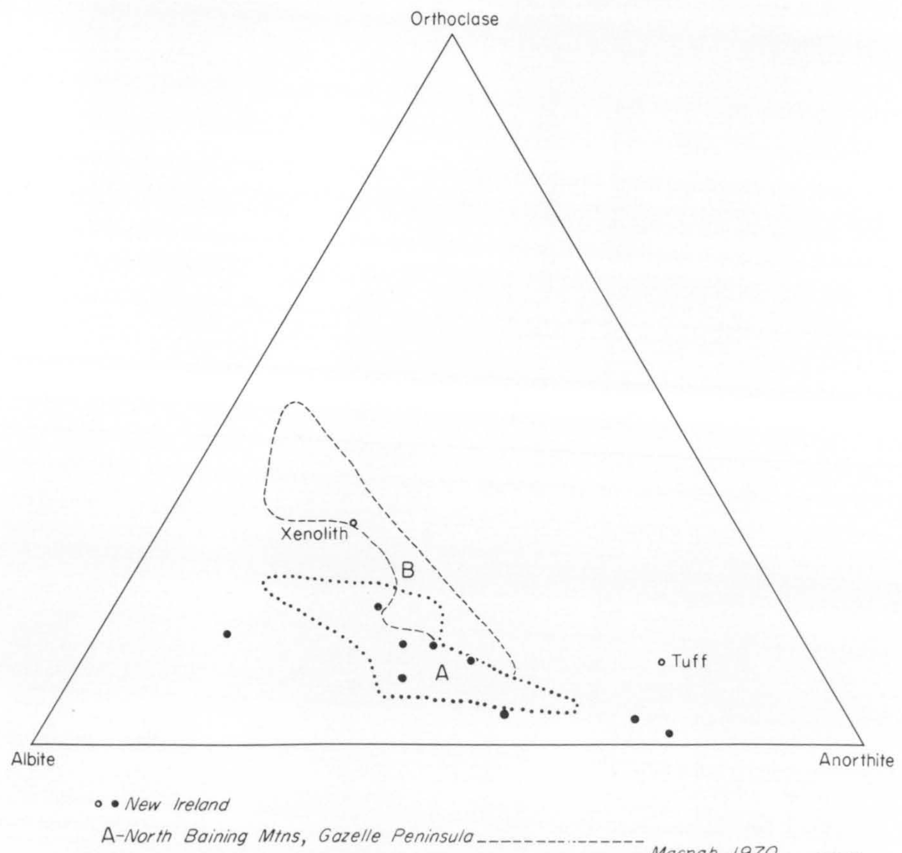



**Fig. 16. Normative Or-An-Ab diagram, New Ireland and Gazelle Peninsula rocks.**

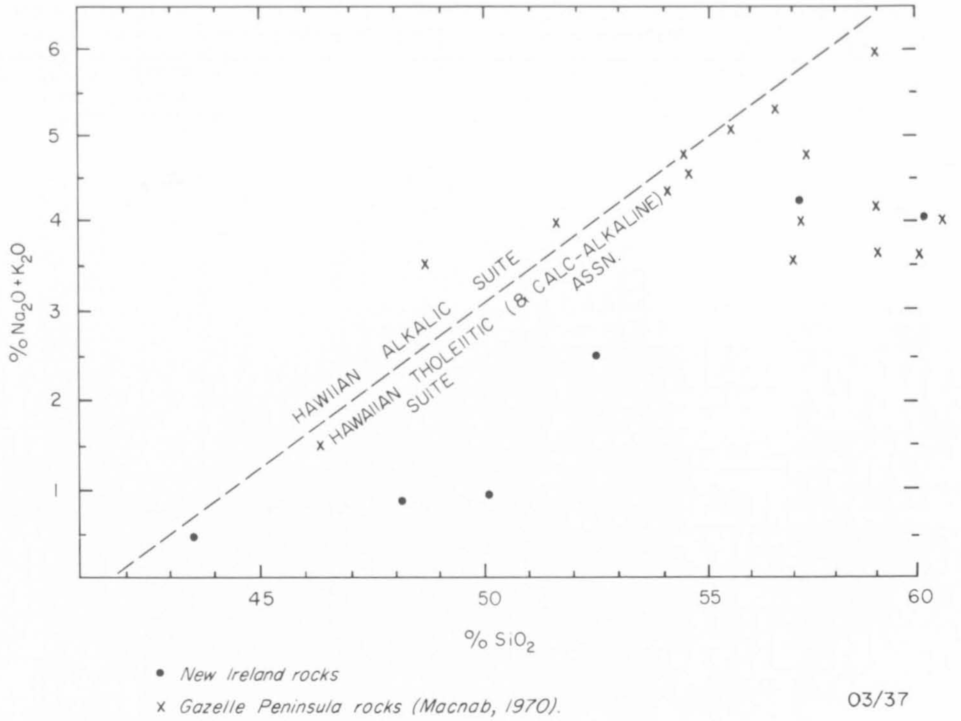



**Fig. 17. Silica *v* total alkalis diagram for rocks with less than 61% $SiO_2$.**

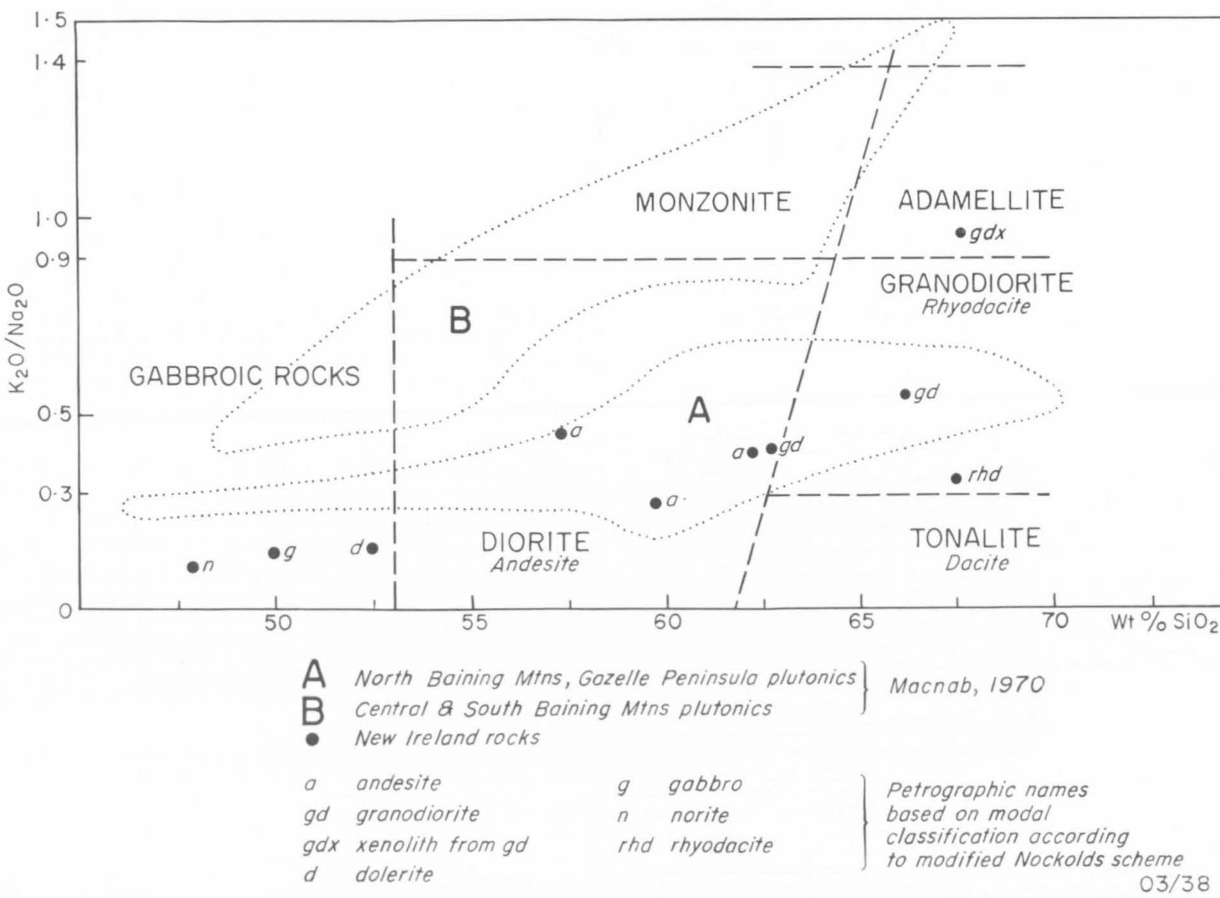



**Fig. 18. $K_2O/Na_2O$ *v* $SiO_2$ diagram for New Ireland igneous rocks.**

TABLE 5. CHEMICAL ANALYSES OF ELEVEN ROCKS FROM THE JAULU VOLCANICS, LEMAU IGNEOUS COMPLEX, AND RATAMAN FORMATION

| *Sample No.* | *(a)* | *56NG 0001* | *56NG 0016* | *58NG 0208* | *60NG 0105* | *58NG 0058* | *58NG 0057* | *58NG 0060* | *60NG 0104* | *60NG 0016* | *60NG 0011* | *58NG 0132* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 59.5 | 57.2 | 60.1 | 62.5 | 52.5 | 66.4 | 68.2 | 63.0 | 67.8 | 50.1 | 48.1 | 43.6 |
| $TiO_2$ | | 0.63 | 0.61 | 0.53 | 0.88 | 0.53 | 0.45 | 0.65 | 0.31 | 0.47 | 0.59 | 0.76 |
| $Al_2O_3$ | 17.2 | 17.6 | 17.4 | 15.5 | 18.4 | 15.1 | 14.4 | 15.3 | 15.3 | 16.7 | 20.6 | 10.7 |
| $Fe_2O_3$ | 6.10 | 4.20 | 2.85 | 2.35 | 3.30 | 2.05 | 0.91 | 2.10 | 1.36 | 2.50 | 3.45 | 6.40 |
| $FeO$ | | 2.70 | 2.10 | 3.10 | 5.05 | 2.45 | 2.30 | 3.40 | 1.09 | 6.20 | 4.95 | 3.85 |
| $MnO$ | | 0.11 | 0.14 | 0.11 | 0.13 | 0.05 | 0.07 | 0.09 | 0.04 | 0.15 | 0.13 | 0.16 |
| $MgO$ | 3.42 | 3.40 | 2.95 | 2.75 | 5.20 | 2.40 | 1.87 | 3.15 | 1.48 | 7.90 | 7.15 | 9.55 |
| $CaO$ | 7.03 | 7.05 | 6.80 | 6.35 | 8.80 | 4.50 | 4.10 | 6.10 | 3.20 | 12.2 | 12.6 | 14.8 |
| $Na_2O$ | 3.68 | 3.55 | 3.95 | 2.75 | 3.05 | 3.55 | 3.40 | 3.40 | 5.70 | 1.66 | 1.69 | 0.75 |
| $K_2O$ | 1.60 | 1.63 | 1.08 | 1.14 | 0.42 | 2.00 | 3.30 | 1.40 | 1.86 | 0.22 | 0.17 | 0.67 |
| $P_2O_5$ | | 0.15 | 0.21 | 0.11 | 0.13 | 0.09 | 0.08 | 0.11 | 0.14 | 0.02 | 0.03 | 0.28 |
| $H_2O+$ | 0.70 | 0.77 | 0.83 | 1.82 | 1.54 | 0.44 | 0.44 | 0.77 | 1.32 | 1.41 | 0.39 | 3.95 |
| $H_2O-$ | | 0.91 | 0.54 | 0.57 | 0.27 | 0.14 | 0.24 | 0.23 | 0.15 | 0.18 | 0.07 | 3.30 |
| $CO_2$ | | 0.03 | 0.20 | 0.64 | 0.03 | 0.18 | 0.05 | 0.09 | 0.09 | 0.49 | 0.25 | 1.03 |
| *Totals* | 99.23 | 99.93 | 99.76 | 100.22 | 99.70 | 99.88 | 100.01 | 99.79 | 99.80 | 100.20 | 100.17 | 99.80 |
| *CIPW Norms* | | | | | | | | | | | | |
| *Quartz* | | 11.99 | 16.08 | 25.70 | 6.30 | 25.16 | 24.64 | 20.71 | 20.06 | 3.41 | 0.97 | 3.11 |
| *Orthoclase* | | 9.80 | 6.49 | 6.88 | 2.53 | 11.90 | 19.67 | 8.37 | 11.17 | 1.32 | 1.01 | 4.28 |
| *Albite* | | 30.56 | 33.95 | 23.77 | 26.35 | 30.24 | 29.01 | 29.11 | 49.01 | 14.24 | 14.34 | 6.85 |
| *Anorthite* | | 27.77 | 27.00 | 27.18 | 36.04 | 19.50 | 14.42 | 22.63 | 10.85 | 38.00 | 48.26 | 25.77 |
| *Diopside* | | 5.21 | 3.62 | 0.12 | 6.03 | 0.99 | 4.28 | 5.41 | 2.97 | 16.22 | 10.11 | 34.80 |
| *Hypersthene* | | 6.84 | 6.53 | 10.09 | 15.77 | 7.58 | 5.49 | 8.97 | 2.80 | 21.06 | 18.54 | 10.38 |
| *Magnetite* | | 6.20 | 4.20 | 3.48 | 4.89 | 2.99 | 1.33 | 3.08 | 2.00 | 3.68 | 5.02 | 10.03 |
| *Ilmenite* | | 1.22 | 1.18 | 1.03 | 1.17 | 1.01 | 0.86 | 1.25 | 0.60 | 0.91 | 1.12 | 1.56 |
| *Apatite* | | 0.36 | 0.51 | 0.27 | 0.31 | 0.21 | 0.19 | 0.26 | 0.34 | 0.05 | 0.07 | 0.72 |
| *Calcite* | | 0.07 | 0.46 | 1.49 | 0.07 | 0.41 | 0.11 | 0.21 | 0.21 | 1.13 | 0.57 | 2.53 |
| *Solidification index* | | 21.96 | 22.82 | 22.75 | 30.55 | 19.28 | 15.87 | 23.42 | 12.88 | 42.75 | 41.07 | 45.00 |
| *Thornton-Tuttle differentiation index* | | 52.35 | 56.52 | 56.36 | 35.19 | 67.30 | 73.32 | 58.2 | 80.24 | 18.97 | 16.31 | 14.24 |
| *% An in norm. plag.* | | 47.6 | 44.3 | 53.3 | 57.8 | 39.2 | 33.2 | 43.7 | 18.1 | 72.7 | 77.1 | 79.0 |

(a) Average andesite (from S. R. Taylor, 1969)
56NG0001—Mela-andesite from Jaulu Volcanics near Wunik Plantation, NW New Ireland
56NG0016—Mela-andesite from Jaulu Volcanics near Wunik Plantation, NW New Ireland
58NG0208—Andesite from Jaulu Volcanics, Kaluan River
60NG0105—Dolerite from Lemau Intrusive Complex, Kamdaru River
58NG0058—Granodiorite from Lemau Intrusive Complex near Kulot, near type locality
58NG0057—Xenolith from Lemau Intrusive Complex near Kulot
58NG0060—Granodiorite from Lemau Intrusive Complex about 8 km NW of Lemau
60NG0104—Probable plug of rhyodacitic composition from Lemau Intrusive Complex, Kamdaru River
60NG0016—Pyritic gabbro from Lemau Intrusive Complex near Matop Plantation, SW New Ireland
60NG0011—Banded norite from Lemau Intrusive Complex, Hirudan River, SW New Ireland
58NG0132—Crystal-vitric tuff from Rataman Formation, Sae River, central New Ireland
*Analyst:* A. H. Jorgenson, AMDL.

| *Sample* | *Orthoclase/ total feldspar (%)* | $K_2O/Na_2O$ | *Rock type* |
|---|---|---|---|
| 60NG0105 | 0.48 | 0.14 | dolerite |
| 60NG0016 | 0.90 | 0.13 | gabbro |
| 60NG0011 | 1.0 | 0.10 | norite |
| 58NG0060 | 8.1 | 0.41 | granodiorite |
| 60NG0104 | 17.0 | 0.33 | porphyritic rhyodacite |
| 58NG0058 | 23.8 | 0.56 | granodiorite |
| 58NG0057 | 34.3 | 0.97 | xenolith from granodiorite |

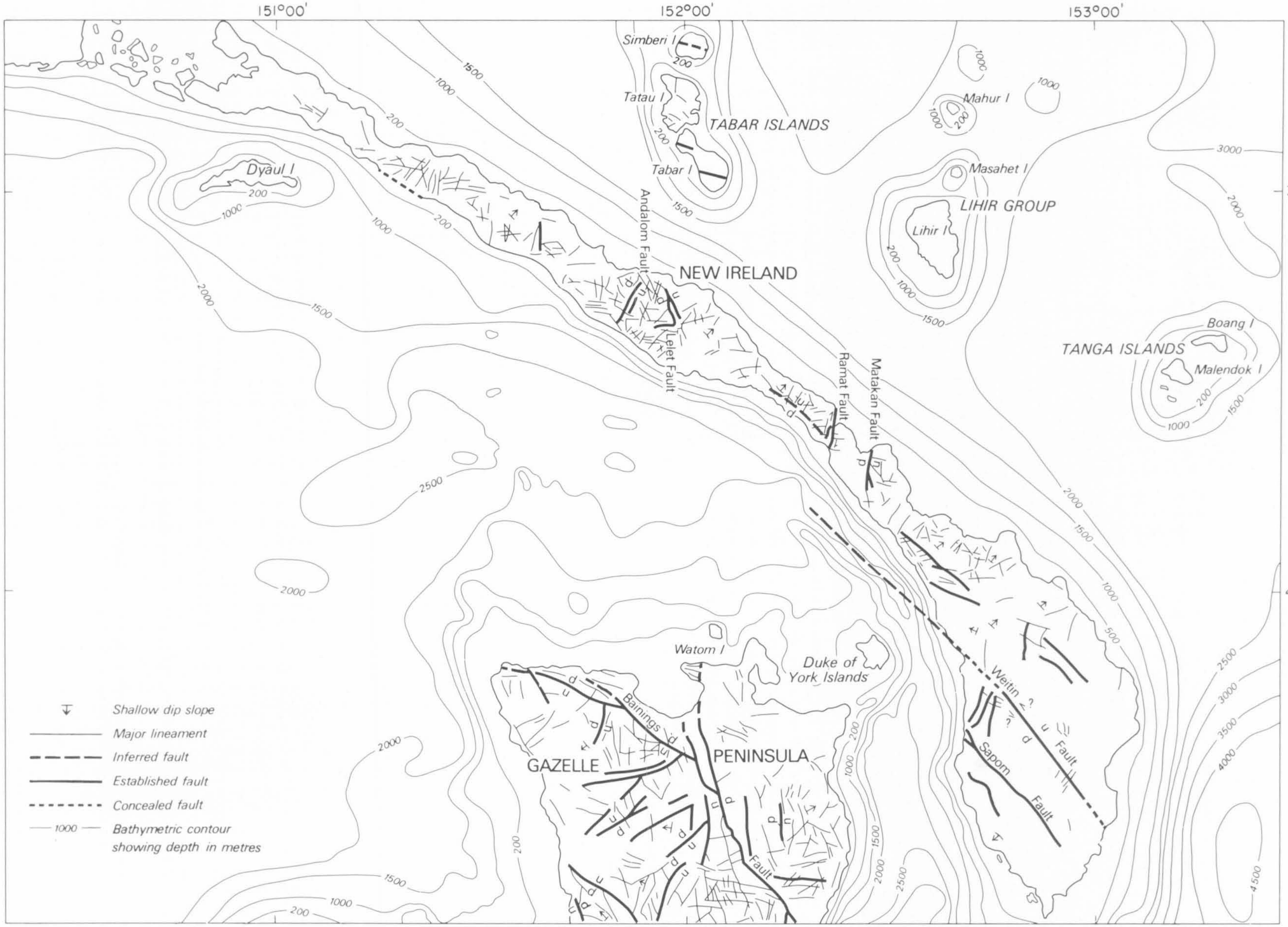
This indicates that Macnab's chemical classification may have general application so long as a reasonable correlation exists between the modal orthoclase/total feldspar ratios for plutonic rocks and their $K_2O/Na_2O$ ratios.

Because the New Ireland igneous rocks analysed are either medium-grained or porphyritic, they are not entirely suitable for representation on a Harker variation diagram because in theory they would not accurately represent the change in composition of the liquid phase of the magma with cooling. However, the regressions for MgO, total Fe, $TiO_2$, $Al_2O_3$, and CaO *v* $SiO_2$ (Fig. 12) are fairly linear and are consistent with variations caused by fractionation. It appears that the normal sequence of crystallization of a magma has been followed with the emplacement of different fractions of the crystallized magma at different stages of crystallization. The greater compositional range of the plutonic rocks presumably reflects more rapid emplacement of the volcanic rocks from depth without fractionation.

## STRUCTURE

### *Faulting*

Four common orientations of steeply dipping faults, large-scale joints, and lineaments are found in New Ireland. Most commonly faults and joints have northwest and northeast trends; fewer trend north, and easterly trending lineaments are uncommon. The faults with a northwest trend appear to have the largest displacements: for example, the *Sapom Fault,* and the *Weitin Fault* and its probable continuation to the northwest along the coast of the island (Fig. 19). Small to considerable movements have taken place on faults which trend north, for example the *Matakan* and *Ramat Faults;* displacement has been demonstrated on only one northeast-trending fault (the *Andalom Fault*).




03/39

**Fig. 19. Structural map of New Ireland and Gazelle Peninsula.**

Fault displacements are difficult to determine because of the homogeneity of the rocks they transect. Vertical displacements have been determined for a few faults: the Matakan Fault appears to be a normal fault with a scissor-like displacement of about 150 m (maximum); the northwest-trending fault near Komalu Bay has a measured vertical displacement of 500 m; and the Lelet Fault appears to be an arcuate normal fault with a vertical displacement of about 250-300 m.

The *Andalom Fault,* a high-angle normal? fault, appears to have been active since the early Miocene. The volcanic basement is strongly sheared in a broad fault zone, about 0.5 km wide, which appears to dip steeply west. The Lelet Limestone has also been sheared, though not as strongly, indicating renewed movement after the limestone was deposited. The boundary between the limestone and the volcanics has been displaced vertically by a maximum of about 150 m at the northern end of the fault. The amount of displacement diminishes southward and indicates scissor-like movement along the fault.

The escarpments of most of the other dip-slip faults are too eroded to determine the attitudes of fault planes. Strike-slip displacements along the northwesterly faults have not been proved, but the remarkably straight traces indicate that they are probably strike-slip. French (1966) attempted to demonstrate that Holocene left-lateral strike-slip movements on the *Weitin Fault* had displaced the courses of small tributary streams of the Kamdaru River: I have not found conclusive evidence of left-lateral transcurrent movement, though it seems most likely (Fig. 20). The surface expression of the fault is in unconsolidated Quaternary alluvium, so that any small displacement of stream channels would be quickly masked by deposition. The floor of the Weitin-Kamdaru valley is quite flat (Fig. 26) and is largely bounded by parallel rectilinear fault traces, up to 2 km apart (Fig. 20).

Detailed bathymetry by BMR geophysicists has delineated a submarine canyon which lies beneath the St Georges channel and is collinear with the Weitin Fault.

The *Sapom Fault* is parallel to, but younger than, the Weitin Fault; unlike the Weitin Fault, it does not appear to have controlled sedimentation since the late Miocene. Strongly sheared coal-bearing strata were reported by French (1966) from the northwestern part of the *Sapom Fault,* but he did not determine sense of movement.

The *Ramat Fault* is a Pleistocene to Holocene structure and has displaced the coastline on both sides of central New Ireland by about 6 km. The sense of movement on this fault is right-lateral strike-slip.

### *Folding*

Local folding and tilting of blocks has been observed in the Andalom and Matakan Faults. Near the Andalom Fault, the Jaulu Volcanics dip 45° to 70° north, whereas to the south, in the Kaluan River, dips are generally less than 30°. This indicates that there has been tilting of small blocks in the fault zone. In the Matakan River, on the other hand, the less competent sedimentary rocks have responded to movement on the Matakan Fault by localized folding as well as tilting. In the lower reaches of the Matakan River, the Punam Limestone on either side of the river dips away from the fault. Upstream, where the fault displaces the Rataman Formation, the rocks are gently folded along the fault zone.

French (1966) reported small-scale tight folding in tuffaceous siltstone (Rataman Formation) containing coal seams in the valleys of the Tamul and Tamai Rivers. He attributed most small-scale folding in unconsolidated or poorly cemented sediments to compaction and slumping. This mechanism appears to have caused much of the folding in the Rataman Formation, where the folding is non-cylindrical about randomly oriented fold axes.

### *Structural evolution*

The narrow elongate shape of New Ireland is probably structurally controlled. The island may have formed as a continuous chain of volcanoes, but more probably formed as a volcanic island of undefined but possibly of more equant dimensions than the present shape. The island may have been sheared and drawn out by a series of west-northwest to northwest transcurrent faults. There is evidence for at least one such fault, which is believed to have been active in late Miocene time (Fig. 20). After the island was sheared into an elongate shape, it was probably further lengthened by uplift in the Pleistocene along two parallel northwesterly faults which bounded a horst-like structure. Erosion and sedimentation have largely obscured the faults which bound the horst, but good evidence of faulting is found on the southwest sides of the Lelet Plateau and the isthmus of Rataman Formation strata in central New Ireland. The thick sequence of subhorizontal limestone beds which forms the northeast fall of the Lelet Plateau thickens towards the northeast but is abruptly truncated; so this part of New Ireland has been uplifted as a rigid block with a few degrees of tilt to the northeast.

Large thicknesses of uncemented or poorly cemented uplifted beach gravels, raised coral that is still aragonitic, and numerous waterfalls testify to continued uplift of New Ireland—which may still be taking place along the faults which bound the inferred horst and which controlled sedimentation throughout the Miocene and Pliocene.

## GEOLOGICAL HISTORY

*Early and middle Oligocene:* A volcanic pile built up from the sea floor from less than abyssal depths. Predominantly pyroclastic calcalkaline andesitic volcanics accumulated to shallow depths and formed one or more islands (Fig. 21, I). Parental or subvolcanic magma intruded the volcanic pile along planes which were probably fault-controlled.

*Late Oligocene to earliest Miocene:* Subaerial erosion exposed plutons and smoothed the volcanic landforms slightly (Fig. 21, II). Some thin deposits of clastic sediment derived from the volcanics formed in shallow seas in the northwest.

*Early Miocene (upper Te stage) to early late Miocene:* The island gradually submerged and a series of at least 500 m thick of onlapping fringing reefs grew on what is now the northeast side of the island (Fig. 21, III). The volcanic pile and the base of the reef complex were intruded by stocks representing the final phases of the Lemau intrusives.


**Fig. 20. Map of Weitin Fault area showing possible left-lateral strike-slip displacements of drainage channels in Holocene alluvium.**

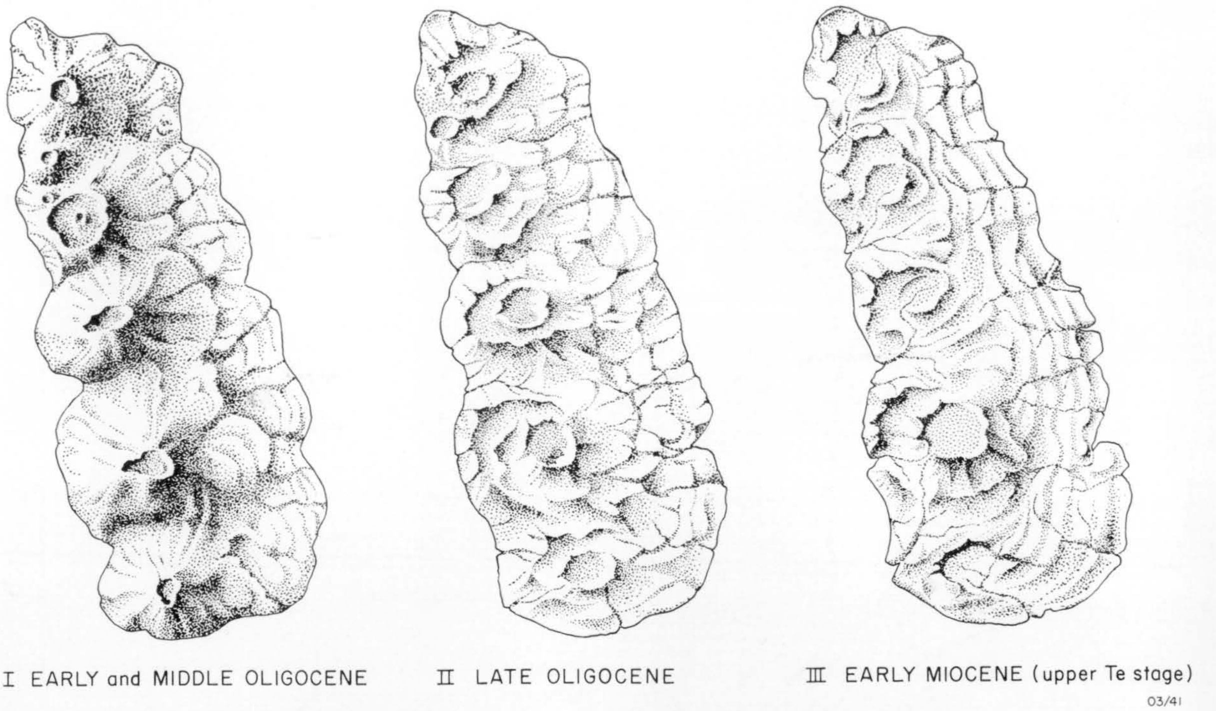



**Fig. 21. Diagrammatic geological history of New Ireland; early and middle Oligocene to early Miocene.**

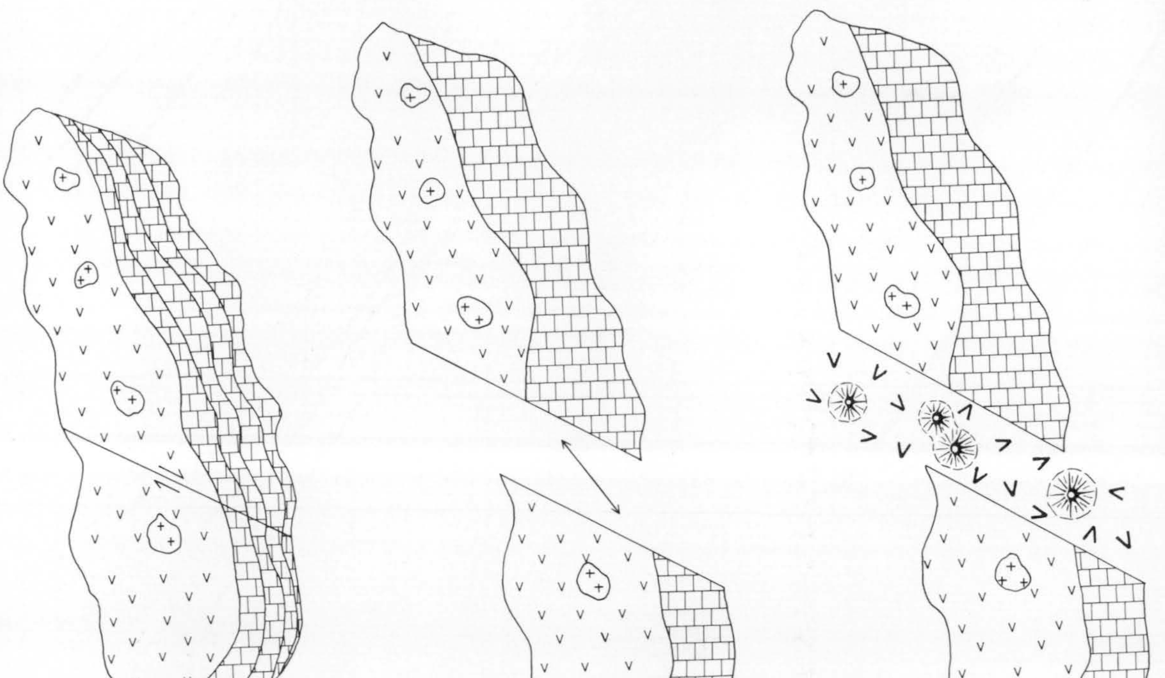



**Fig. 22. Diagrammatic geological history of New Ireland; early late Miocene to latest Miocene/early Pliocene.**

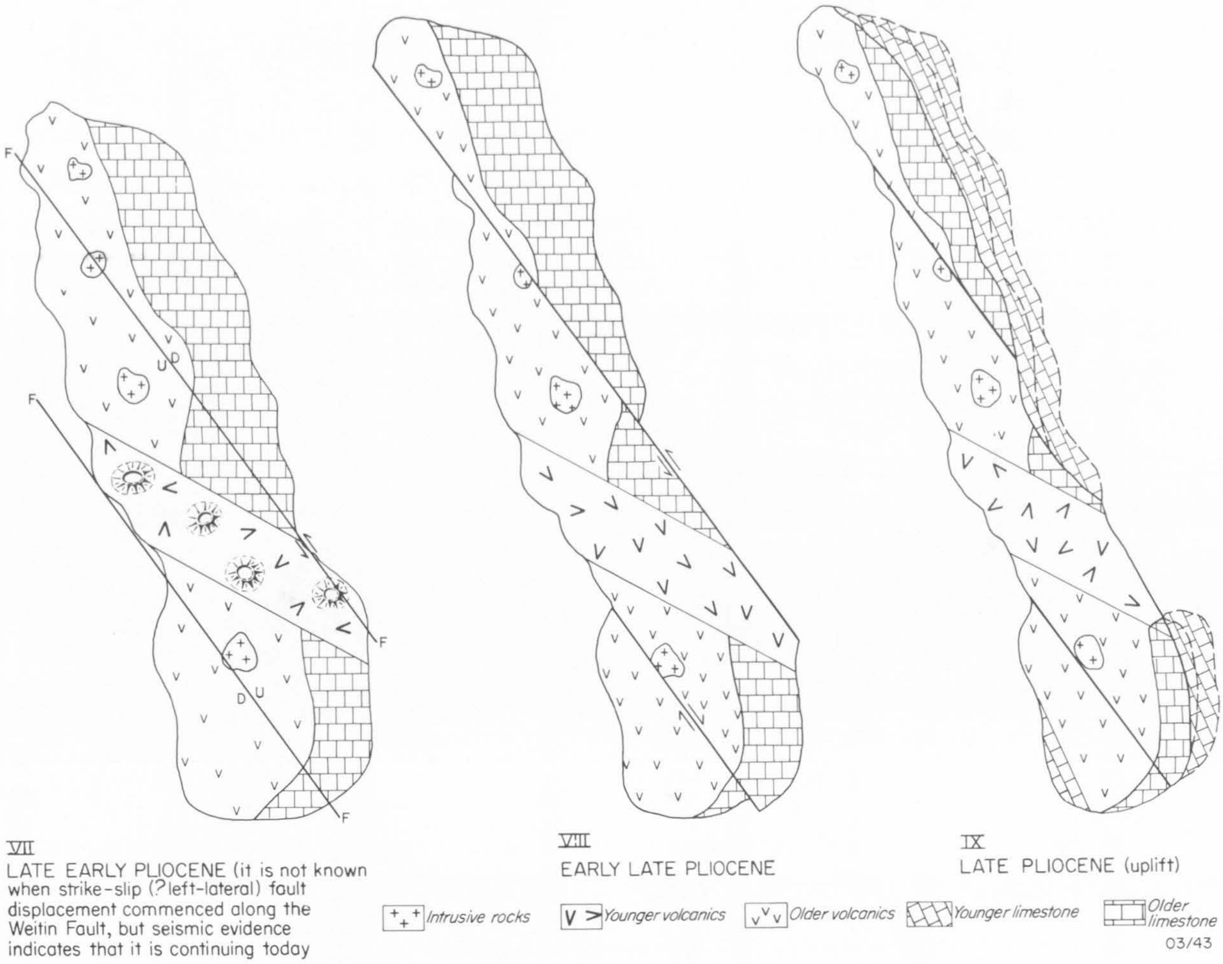



**Fig. 23. Diagrammatic geological history of New Ireland; late early Pliocene to late Pliocene.**

*Early late Miocene to latest Miocene:* The submerged island was separated into two parts by a fault or faults, probably bounding a graben (Fig. 22, IV, V). Figure 24 shows a tentative reconstruction of the island as it might have been in the early late Miocene. The reconstruction was obtained by deleting post-middle Miocene rocks from the map at the right of Figure 24 and closing the gap created by removing the Rataman Formation. The reconstruction brings the Surker and Lelet Limestones into contact so that a once continuous sheet of limestone is indicated; the Oligocene Jaulu Volcanics and Lemau Intrusive Complex also form a very nearly continuous belt of igneous rocks. The early late Miocene reconstruction, then, provides a much more compact and realistic distribution of rock types than does the present-day geological map. Evidence of the hypothetical fault or graben is lacking, apart from several air-photo lineaments parallel to the inferred fault in the northern part of southern New Ireland (Fig. 19). Late Miocene and younger erosion and sedimentation would obviously have obliterated and concealed much evidence of such faulting. The inferred presence of grabens beneath the Bismarck Sea (W. A. Wiebenga & B. C. Barlow, pers. comm. 1972) makes the hypothesis difficult to reject.

*Latest Miocene to early Pliocene:* Ash-fall tuff, volcanolithic turbidite, and foraminiferal ooze were deposited in the graben, and tuff and volcanolithic sandstone along the flanks of the southern part of the island. This sedimentation is now represented by the Rataman Formation. Subsidence continued, and conformable fringing reefs developed on more elevated areas to the northwest and perhaps southeast of the graben (Fig. 22, VI).

*Late Pliocene:* The island was uplifted as a horst bounded by northwest-trending faults which now lie offshore (Fig. 23, VII, VIII). Deposition of carbonate sediments and coral and algal reefs continued along that part of the island that now forms the Lelet Plateau, and reef-building began in the southwestern extremity of the island (Fig. 23, IX). The whole island was tilted through 5 to 10° to the north-northeast during uplift.

*Late Pliocene and Quaternary:* Uplift was renewed or continued during this period and probably continues now. It was greatest in the southeast and least in the northwest, and resulted in a further tilt of 5 to 10° to the north-northeast. In the south, fanglomerates were shed from the rapidly eroded Jaulu Volcanics; in the central isthmus an embayment filled with polymict conglomerate, sandstone, and siltstone (Uluputur Beds) derived from the Rataman Formation. On the flanks of the Lelet Plateau and Schleinitz Range, offlapping fringing reefs formed thin strips of limestone along the coasts, which now are found up to 200 m above present sea level. In the northwest, uplift was too slow to allow much accumulation of sediment. Instead, there was probably some stripping of limestone cover by wave-erosion.

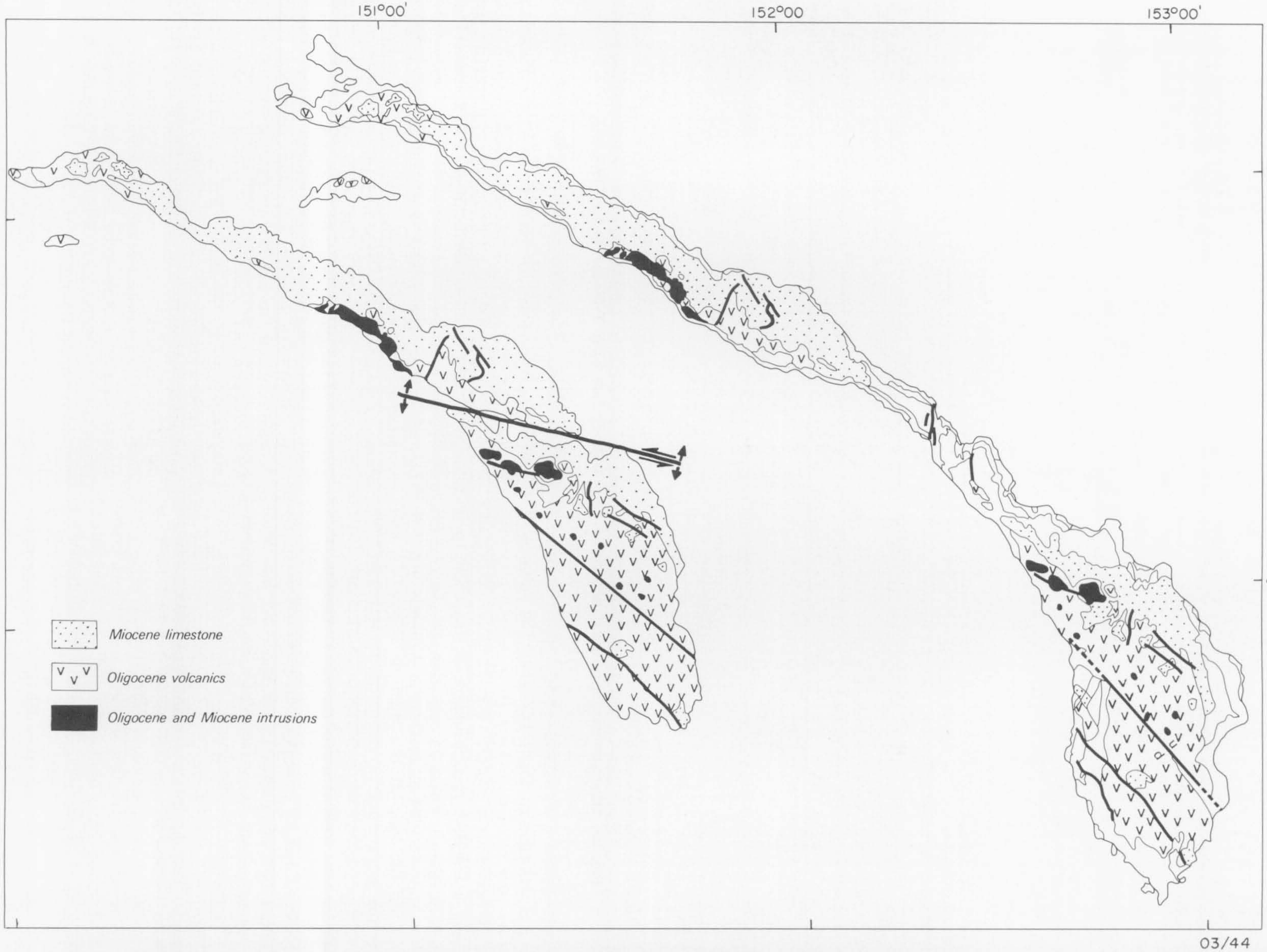



**Fig. 24. Hypothetical early late Miocene New Ireland precursor shown for comparison with the same relation to sea level and at the same stage of erosion as the present island.**

# REGIONAL GEOLOGICAL SETTING

New Ireland, New Britain, and the Solomon Islands were largely constructed by island-arc volcanism in the Early Tertiary (Fig. 25). New Ireland is approximately collinear with the Solomon Islands and may have been a part of the Early Tertiary Solomons Arc. However, the Solomon Islands differ from New Ireland in having an Upper Cretaceous? basement which has been slightly metamorphosed (Coleman, 1966). The stratigraphy of New Ireland is similar to that of New Britain except that the oldest rocks on New Britain are late Eocene rather than Oligocene (Davies, 1973). Also, New Britain is apparently not as strongly faulted, except on the Gazelle Peninsula.

The New Britain trench (Fig. 25) probably represents a Quaternary zone of crustal shortening between the Pacific and the Australian lithospheric plates. A trench north of Manus Island, New Hanover, and New Ireland may represent an Oligocene zone of crustal shortening between those plates. This trench (Fig. 25) is seismically active (Denham, 1969). For an extended discussion of the evidence for plate movements, see Curtis (1973a, b).

The southern part of New Ireland is also seismically active and lies near the intersection of the deep seismic zones which parallel New Britain and the Solomon Islands, and the Bismarck Sea seismic zone. The Bismark Sea seismic zone (after Denham, 1969, 1971; Everingham, 1975) has been explained by Johnson & Molnar (1972) as the expression of a left-lateral strike-slip fault separating two lithospheric plates below the Bismarck Sea.

Connelly (1974) suggested that sea-floor spreading in the area of the Bismarck Sea is unrelated to the Bismarck Sea seismic zone, and that non-magnetic blocks at the centre of the seismic zone represent a zone of fractured rock produced by strike-slip movement. Later, Connelly (1976) found evidence to suggest that the spreading activity under the Bismarck Sea is being accommodated along two northwest-trending segments of the zone; thus the seismic zone and the spreading are related. Connelly (1976) also was of the opinion that the strike-slip faulting activity postulated by Johnson & Molnar (1972) is being taken up in a northwesterly direction on the eastern half of the seismic zone with a northwesterly movement of the North Bismarck plate relative to the South Bismarck plate (Connelly, 1976, fig. 3). Connelly believed that this relative motion of plates must be accompanied by underthrusting of both plates under the Papua New Guinea mainland and possibly by underthrusting of the Pacific plate along the Outer Melanesian trench.

The stratigraphy of the chain of islands which parallels New Ireland at a distance of about 60 km from the northeast coast is not known in detail. Some information on the geology of three of these islands (Simberi, Tatau, and Tabar) has been obtained from discussions

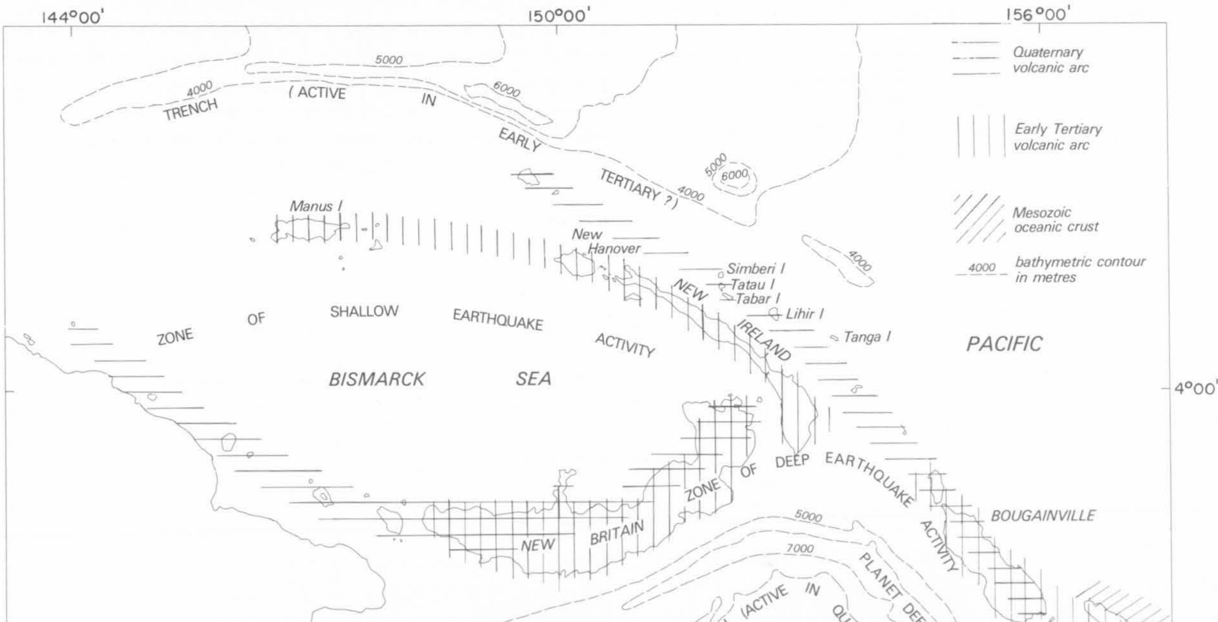



**Fig. 25. Major structural units, Papua New Guinea.**

with the late G. A. M. Taylor. The following comments are based on these discussions and the results of air-photo-interpretation.

The eastern part of *Simberi Island* is formed of pre-middle Miocene volcanics; the western half appears to consist predominantly of middle Miocene limestone. A low-lying strip of raised coral forms the perimeter of the island.

*Tatau Island* lies about 5 km south of Simberi, and consists largely of Tertiary volcanics, which are commonly altered near the eastern coast. Airphoto-interpretation suggests that there may be Tertiary limestone in the northwestern part of the island, and Quaternary raised corals fringe the entire island.

*Tabar Island* lies to the southeast and is separated from Tatau Island by Saraware Passage, which is about 300 m wide. Tabar Island is predominantly of volcanic origin. Photo-interpretation indicates that the island may be formed of two Pleistocene? volcanoes joined by a narrow isthmus. The larger inferred volcano has the form of a deeply eroded cone, whereas the smaller remnant to the northwest has been almost obliterated by erosion. A narrow fringe of raised coral surrounds the southern part of the island and becomes a broad platform around the northern part. The inferred southern volcano appears to be transected by a west-northwest strike-slip fault.

Volcanic rock types found on these islands include alkali olivine basalt and andesite. The common occurrence of altered volcanics led Taylor to believe that they might be Tertiary in age. This is supported on Simberi Island by the apparent relation of middle Miocene limestone overlying volcanics. The volcanics might be correlated with the andesitic Jaulu Volcanics, though the islands seem to lie fairly close to the 'andesite line', or the boundary between calcalkaline and oceanic volcanics.

## GEOMORPHOLOGY

### *Lelet Plateau and Schleinitz Range*

The Lelet Plateau provides a spectacular example of deep karst topography. The plateau is underlain by a thick sequence of biostromal and less common biohermal limestone, wedge-shaped in cross-section. The plateau surface is roughly planar and dips about 5° northeast. The northeastern fall is made up of a series of fourteen narrow, regularly spaced, subhorizontal terraces, many of which persist for the length of the plateau. The southwestern edge is marked by steep limestone cliffs up to 530 m high.

In detail, the planar surface of the plateau is completely covered by closely spaced, low rounded-conical hills, which rise 30 to 100 m above the interspersed sink-holes or dolines. Subparallel sinuous hogback ridges up to several tens of kilometres long and 100 m high are also common on the plateau surface of the Schleinitz Range and parts of the Lelet Plateau. The ridges are probably biohermal structures and may represent former growing edges at the windward side of atolls. A lower, anastomosing series of ridges enclosing sink-holes has formed as a result of the drainage system that has developed on the amphitheatre-like slopes on the northern side of the Lelet Fault.

Elsewhere, little well-defined surface drainage is developed on the plateau, except on the flanks. Runoff from the plateau is fed by the dolines or sink-holes into large caverns and thence into underground streams. These leave the base of the limestone just above sea level on the northeast coast and discharge into the sea as strongly flowing rivers. Most of the runoff from the flanks of the plateau is distributed in a subparallel anastomosing network of stream channels and in single consequent or joint-controlled rectilinear gullies.

The stepped coral terraces flanking the Schleinitz Range and the Lelet Plateau generally have outer margins slightly raised above the inner level of the terraces. *In situ* biohermal reefs of coral and algae in growth attitudes have been found on some of these elevated margins. This suggests that the terraces are growth structures rather than wave-cut benches formed during uplift.

The terrace margins on the northeast fall of the plateau are dissected transversely by closely spaced consequent stream channels which are narrow and steep-sided. As a result, the terraces have a serrated appearance, and fluting similar to karst knolls has formed. Such knolls have not developed on narrower terraces on the southwestern fall of the Schleinitz Range and Lelet Plateau, and this led some previous workers to regard the southwestern limestones as a distinct stratigraphic unit (Ripper & Grund, 1969). It seems likely that the lack of fluting is due to the paucity of runoff on the southwestern side of the plateau.

### *Southern New Ireland limestone*

In the northeastern part of the southern New Ireland block, the Surker Limestone forms a thin veneer, probably less than 500 m thick, over an igneous basement. The limestone forms a gently undulating sheet which appears to reflect the relief on the underlying basement, and dips at low angles to the northeast. Rare dolines occur, probably in the thicker parts of the limestone, but, surprisingly, no karst topography is developed. The lack of karst may be due to the high clay content of the limestone, which would make it relatively resistant to solution effects. An irregular dendritic drainage system has developed on the otherwise smooth curviplanar surface of the limestone. Most stream channels are extremely narrow and steep-sided and are generally not deeply incised, except the larger Hirudan and Daulum Rivers, which are entrenched in narrow V-shaped valleys up to 300 m deep.

### *Basement volcanics*

The landforms developed on the Jaulu Volcanics are also distinctive. The predominant form of erosion is parallel slope retreat of the deep, narrow, V-shaped valleys (Fig. 28). Where the rivers are cutting down through fresh rock, the gorges generally have vertical walls owing to the breaking off of large blocks of agglomerate along subvertical widely spaced joints. Valleys are controlled by joints, or less frequently by faults. Good examples of the latter are the collinear Kamdaru and Weitin Rivers (Fig. 26), whose valleys form a single, broad, V-shaped valley which cuts diagonally across southern New Ireland and is remarkably straight throughout its length of 62 km: it marks the trace of the Weitin Fault.

Three small, eroded volcanic cores of probable Oligocene age have been recognized in the northwestern extremity of New Ireland. These were probably exhumed in the Quaternary by erosion of Miocene limestone cover (see Jaulu Volcanics).

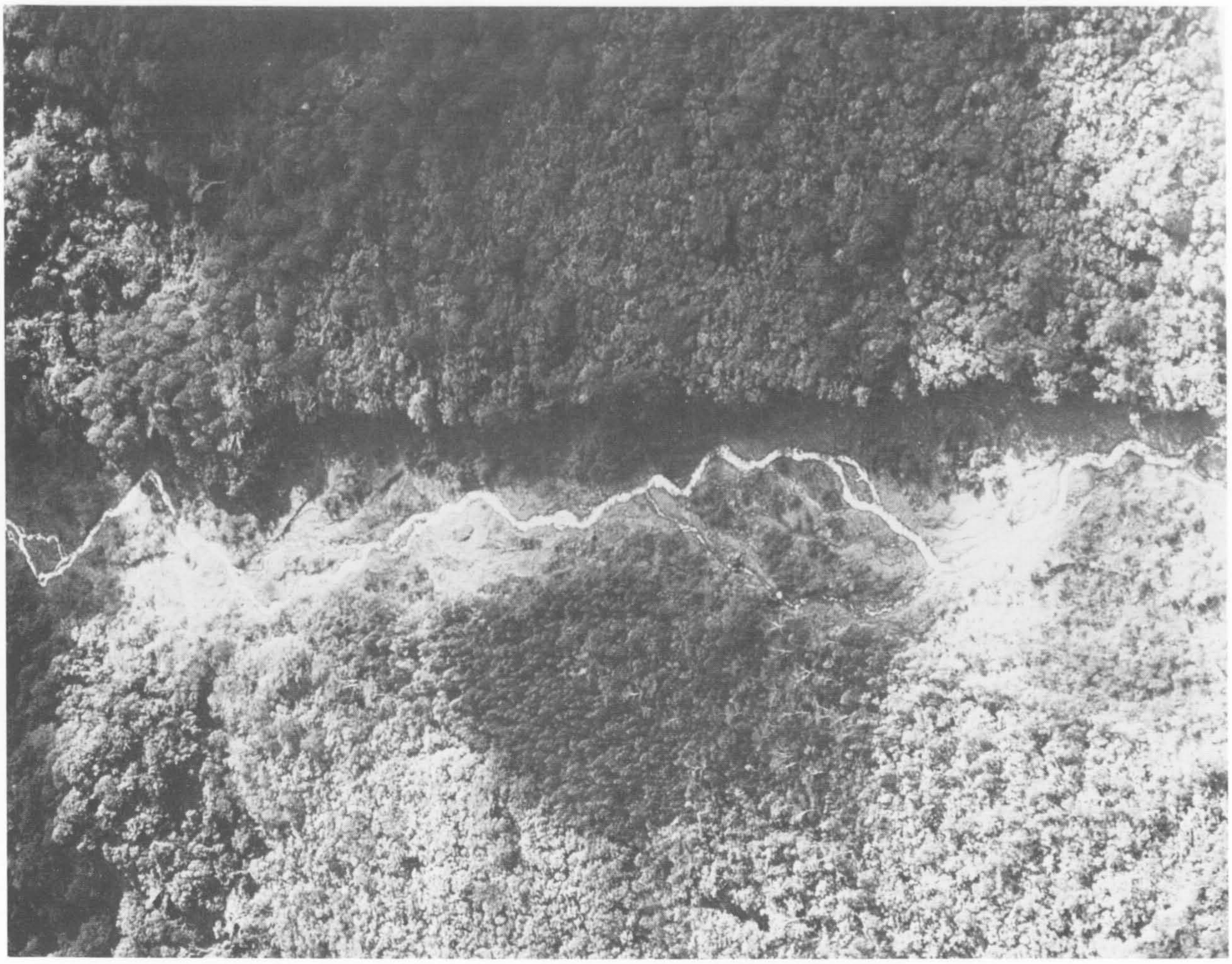


**Fig. 26. Dense rainforest flanking the broad gravelly bed of the Kamdaru River (GA/3148).**

*Raised Quaternary coral terraces*

Coral terraces form low, narrow strips along most of the northeast coast and parts of the southwest coast (Fig. 27). The terraces on the present coastline commonly show solution effects caused by wave action, such as blow-holes (e.g., near Kaf Kaf) and double and single wave-cut notches.

Wave-cut notches in raised coral are common around much of the coastline. In many examples there is a pair of notches separated by a narrow cusp, with the lower notch in the zone of wave action at high water. In some places, however, such as at Kolonoboi and at Ramat on the central northeast coast, both notches have been raised above sea level, and here the raised reef-flat below the lower notch is about 3-4 m above the present-day reef-flat (Fig. 29).

Christiansen (1963) concluded that the upper notch of a pair is probably the older and was formed at a time of higher sea level. The evidence is that in some cases stalactites have formed on the upper notch but not on the lower. The alternative explanation is that the notches were formed at high and low water, but if so the separating cusp should not have formed as there must be all gradations of wave-erosion between these two levels.

Well-developed single notches occur along the northeast coast near Kaf Kaf, and on the opposite side of the island at about latitude 3°00′S. In these cases, the notch lies within the zone of wave action at high water or perhaps 0.5 m above.

The elevation of raised wave-cut notches appears to increase southeastwards, but the regularity is disturbed in places by late Pleistocene to Holocene faulting. The double notches probably occur only on the southwest coast and the southern part of the northeast coast. The evidence suggests that tectonism rather than eustasy has been the main factor in the development of the raised notches.

## ECONOMIC GEOLOGY

At the time of writing (1974), three companies—Placer Prospecting, Conzinc Riotinto of Australia Exploration Pty Ltd, and Swiss Aluminium Mining (Australia) Pty Ltd (Samaust)—had carried out geochemical sampling in New Ireland. The results obtained by the first two did not reveal any significant anomalies; some results of Swiss Aluminium's program are outlined below. French (1966) also sampled stream sediment in southern New Ireland. Two of French's samples, which were from the headwaters of the Weitin River, yielded total copper values of 200 ppm; background values for the volcanics in this area are about 35-40 ppm.

*Porphyry copper deposits*

Three low-grade copper deposits with affinities with porphyry copper deposits have been discovered by

**Fig. 27. Open grassland with raised Quaternary coral terraces, Cape Sena (GA/3137).**

Samaust. The description of the mineralization given below is based on communications from Dr A Somm and P. Bessière of Samaust.

*Legusulum prospect.* The Legusulum copper prospect lies 3.2 km inland from Katherine Harbour on the west coast at latitude 3°11'S, longitude 151°40'E (see map).

Attention was first drawn to the prospect by the occurrence of anomalous copper concentrations in several stream-sediment samples. Soil sampling there defined a cohesive copper anomaly, flanked by ridges and spurs capped by limonite-stained leached cap rock. The area of interest thus outlined covered over 1 km$^2$. The host rock of the primary mineralization is a stock-like complex consistingly mainly of biotite trondhjemite with subordinate biotite-quartz diorite. The mineralized part of the stock is morphologically expressed by the Legusulum knob (about 400 m ASL) which forms the centre of curvature of a large semi-annular area bounded to the northeast by limestone-capped ridges up to 900 m above sea level. This area may be the eroded core of an Oligocene or lowermost Miocene volcano (see map) which has been intruded by the remainder of the magma that gave rise to the volcanic rocks of the area.

Faults striking northeast bound the Legusulum knob to the north and south. A prominent lineament 8 km long and striking east terminates near the eastern boundary of the prospect.

The mineral assemblage at the knob consists of chalcopyrite and pyrite, with scattered traces of bornite, chalcocite, and molybdenite. The predominantly fine-grained sulphides are mostly disseminated throughout the host rock but also heal microfractures.

Samaust mapping to date has shown the copper mineralization to fade towards the east/northeast, while pyrite increases to the extent where an arcuate 'pyrite zone' with up to 10 percent pyrite exists. To the south/southeast this zone has not been outlined because of masking by alluvial cover.

Molybdenite flakes occur irregularly, and mainly in the transitional zone between copper and pyrite. Soil geochemistry has delineated zones of higher zinc values surrounding the pyrite zone.

The hydrothermal-alteration pattern in the host rock and surrounding basement broadly coincides with the zoning of sulphides. The major copper mineralization is associated with an alteration assemblage which commonly includes biotite $\pm$ K-feldspar + quartz $\pm$ carbonate. The more pyritic zones are generally accompanied by a quartz + sericite $\pm$ chlorite assemblage. The outermost zone which affects the surrounding 'basement' volcanics is propylitic with a calcite + epidote + chlorite assemblage and pyrite.

Samaust have observed that quartz-sericite alteration is structurally controlled and transgresses the older biotite-K-feldspar assemblage.

The limonite-stained leached cap is up to 70 m thick and has formed as a result of weathering of the altered sulphide-bearing host rock.

**Fig. 28. Ridge and ravine topography of Jaulu Volcanics, showing recent landslip scar (GA/3124).**

*Sinelu River and Kaluan River deposits.* Two other deposits with porphyry copper affinities have been discovered by Samaust in the headwaters of the Sinelu and Kaluan Rivers, but no details are known to me.

*Gold*

Gold is believed to have been obtained by German prospectors from the Tomadin River (464 548), and, according to Palabong villagers, a local inhabitant extracted small quantities of gold from a creek north of Palabong (4530 5607). Gold is also reported to have been worked at Tugitugi (Toigitoig?) in the Tabar Islands (152°00′E, 2°45′S), where production of 9.7 kg of alluvial gold was recorded up to 1951 (Nye & Fisher, 1954); details of this occurrence are not known.

The common occurrence of propylitized andesite, diorite, and gabbro in the mountains above Palabong (455 561), together with that of malachite-stained rocks on the beach close to Palabong (Sapper, 1910), and the possible occurrence of gold, indicate an area that warrants detailed prospecting. I panned a few kilograms of stream sediment in each of the creeks near Palabong, but could not distingiush any gold amongst the concentrates of abundant heavy minerals. Neither did I find any evidence of copper minerals in the Palabong area, but some copper minerals were found farther south in float from the Danilian River (465 541).

*Pyrite*

Pyrite is found in many of the volcanic, plutonic, and hypabyssal rocks which form the basement of New Ireland. Eight pyritic rock-chip samples have been analysed as well as hundreds of stream-sediment samples (French, 1966; Placer Prospecting, 1966; CRA Exploration Pty Ltd, 1968), but no gold, copper, or other base metals have yet been detected in economically significant quantities.

*Alumina*

Moderately thick soils of the terra rossa type are developed to varying degrees on the limestone of the Lelet Plateau and Schleinitz Range. A few samples of these soils were collected and analysed, and, though none was of economic grade, they were sufficiently rich in alumina to indicate that further sampling is warranted.

*Petroleum*

New Ireland was evaluated for petroleum potential by Continental Oil Company of Australia, who abandoned the island without drilling. Exploration for oil is now being conducted by Buka Minerals NL.

*Coal*

Coal has been reported from three localities on New Ireland: near Matakan Plantation (4398 5790), in the Topaio River (470 510), and in the Tamul and Tamai Rivers (501 509). However, the deposits are too small and the coal is too difficult to extract and of too low quality to be considered economic. The coal is largely

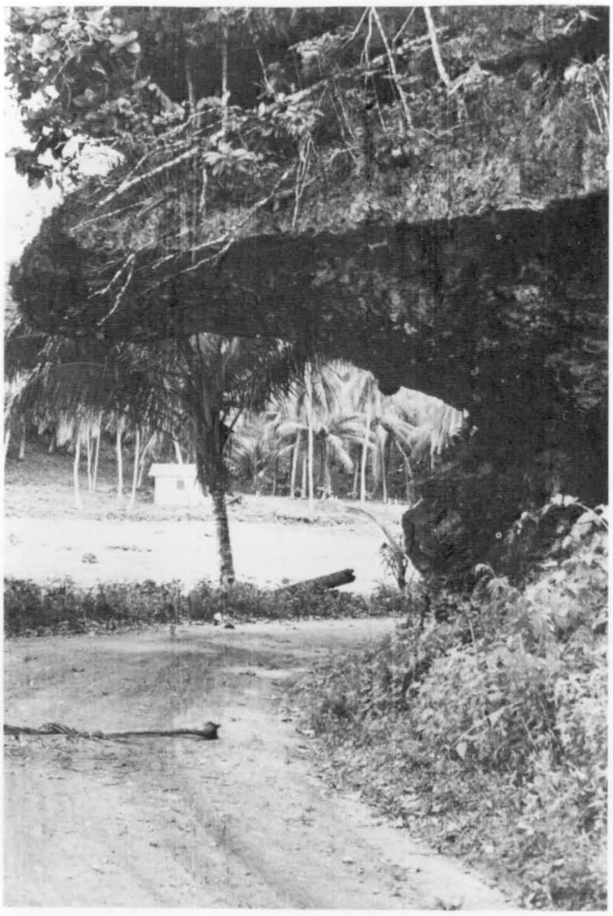


**Fig. 29. Wave-cut double notch in raised Pleistocene coral at Kolonoboi on Namatanai-Kavieng road (M/1043).**

of lignite grade, and analyses show high sulphur content (Sapper, 1910; Noakes 1939).

*Titaniferous magnetite*

The beaches of New Ireland are composed largely of coarse gravel in the south; coral wave-cut platforms predominate in the north. Small patches of sand occur along a small stretch of coastline from Rukalik to Purabunbun (485 559 to 487 559), but only very small quantities of titaniferous magnetite occur in them. Two panned concentrates assayed 5% $TiO_2$.

*Limestone*

Abundant raised Pleistocene to Holocene coralline limestone occurs along the northeast coast of New Ireland at numerous readily accessible localities. This material, which is largely clayey calcirudite and locally referred to as coranus, is used for surfacing roads and airstrips.

Large amounts of very pure limestone are available in the Schleinitz Range and Lelet Plateau for the manufacture of cement. The limestone could be quarried close to the all-weather road between Kavieng and Namatanai.

*Clay*

Blue-grey clay occurs in large quantities in the lower reaches of the Matakan River (4388 5906) about 3 km from Namatanai. It may be suitable for use in a local pottery industry, or, if it occurs in sufficient quantity and has the required physical and chemical properties, it may prove useful for a clay brick industry.


## ACKNOWLEDGEMENTS

The valuable assistance, both in the field and in writing this report, of W. Manser (University of Papua New Guinea) and H. L. Davies is gratefully acknowledged. The co-operation and assistance of the following people must also be acknowledged: Mr L. Williams, then the District Commissioner, New Ireland District; Mr H. Redman, then the Assistant District Commissioner, Namatanai Sub-district; A. Somm, P. Bessière, and G. Cifali of Swiss Aluminium Mining (Australia) Pty Ltd; Fr A. Gendusa; planters R. Lanzarote, M. Griffiths, P. Bull, and other hospitable planters; and local government councillors whose assistance is gratefully remembered.

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# APPENDIX 1

# MICROPALAEONTOLOGICAL REPORTS

*Comments by J. G. Binnekamp on Schubert's (1911) micropalaeontological report.*

All Schubert's determinations are based on random sections which do not permit classification beyond the generic level. The comments below are based on re-interpretation of Schubert's faunal lists combined with inspection of plates where possible.

329 (Bakop). *Alveolinella* is now known to range from middle Miocene to Holocene.

330 (near 329). *Cycloclypeus communis* (as discussed on p. 97 of Schubert's paper) is tentatively included in the references of *C.* cf. *carpenteri* Brady by Tan (1932). Schubert's illustrations do not allow identification beyond the generic level. An association of *C. carpenteri* and *Miogypsina* (mentioned by Schubert as possibly present) would indicate lower Tf stage, middle Miocene.

*Tangula Lambel* (lower Jaulu River, southern New Ireland). This fauna could indicate Te stage. No illustration is given with the description (p. 116) and verification of the identification, apparently based on a random section, is not possible.

345 (Kait River). Tc stage, lower Oligocene.
361 (Huru River). See remarks for 330.
373 (Suralil). See remarks for 330.
373a (Suralil). See remarks for 330 and 329.
373c (Suralil). See remarks for 330.
380 (headwaters of Huru River). An association of *Lepidocyclina, Miogypsina, Miogypsinoides,* and *Cycloclypeus* indicates upper Te to lower Tf stage, lower to middle Miocene.

*Timaifluss* (Tamai River). An association of *Alveolinella, Cycloclypeus,* and *Lepidocyclina* is now known to indicate lower Tf stage, middle Miocene.

*Umudu.* See remarks 329 and 330.

*Foraminifera and age of samples collected by P. D. Hohnen from Cape Lemeris 1:50 000 Sheet area, New Ireland*

by D. J. Belford

Thirty-one samples collected over two profiles, and three samples from separate localities, have been examined. Most lack a diagnostic foraminiferal fauna, and few can be precisely dated. Coral, algal, and bryozoan fragments occur commonly.

*Lelet Limestone:* Of samples 58NG0041 (N. 41) to 58NG-0054 (N. 54) inclusive, collected over one profile, only three, 58NG0042 (N. 42), 58NG0043 (N. 43), and 58NG-0044 (N. 44), contain a fauna which permits any attempt at a definite age determination.

58NG0042 (*N. 42*) contains: *Lepidocyclina* sp. (no subgeneric determination possible), *Gypsina* sp., *Amphistegina* sp., *Planorbulina* sp., *Cycloclypeus,* sp., *Carpenteria* sp.

58NG0043 (*N. 43*) contains: *Lepidocyclina* sp. (possibly *Nephrolepidina*), *Cycloclypeus* sp., *Amphistegina* sp.

58NG0044 (*N. 44*) contains: *Lepidocyclina*? sp. fragments, *Cycloclypeus* sp., *Amphistegina* sp., *Planorbulina* sp.

These three samples are *early to middle Miocene* (upper Te-lower Tf) in age, but no more definite age determinations can be made.

The remaining samples in this profile consist largely of coral and algal limestone; the foraminifera include *Amphistegina, Planorbulina, Cycloclypeus, Carpenteria,* an indeterminable rotaline genus, and miliolids. These samples are considered to be most probably from a raised Quaternary limestone, but the fauna is insufficiently diagnostic for a definite age determination.

Samples from the second measured profile, 58NG0111 (N. 111) to 58NG0127 (N. 127) inclusive, give a similar result. Only two samples, 58NG0120 (N. 120) and 58NG-0120A (N. 120A), give any indication of a *Miocene* age.

58NG0120 (N. 120) contains: *Lepidocyclina* sp. (very small specimens), *Amphistegina* sp., *Carpenteria* sp., *Planorbulina* sp.

58NG0120A (N. 120A) contains: *Miogypsina*? sp., *Marginopora* sp. or *Sorites* sp. (fragments), *Planorbulina* sp., *Amphistegina* sp., indeterminable rotaline genus.

A *middle Miocene* (lower Tf) age is most probable, but they could be of *early Miocene* (upper Te) age.

The foraminiferal fauna of the remaining samples in this profile includes: *Amphistegina, Cellanthus, Operculina, Marginopora* (fragments), *Planorbulina, Sphaerogypsina, Cycloclypeus, Carpenteria, Calcarina*?, an indeterminable rotaline genus, and miliolids; coral and algal fragments and echinoid spines occur commonly.

These samples are *not older than Pliocene,* but are considered to be most probably from a *raised Quaternary* limestone.

*Rataman Formation.* Sample 58NG0024, inland from the south coast near Nakudukudu Bay, contains abundant planktonic foraminifera (Globigerinidae and Globorotaliidae) including *Globorotalia* sp. cf. *G. tumida tumida,* and is latest *Miocene or younger* (N. 18 or younger).

Sample S10, a float from near the north coast, east of Dalomakas Bay, contains planktonic foraminifera (Globigerinidae and Globorotaliidae) including *Sphaeroidinellopsis-Sphaeroidinella,* and is given a *late Miocene to early Pliocene age.*

*Jaulu Volcanics.* Sample 58NG0221, on the Kaluan River, contains *Halkyardia* sp., an indeterminable rotaline genus, and rare miliolids. The specimen of *Halkyardia* observed is very small and not specifically determinable; the genus ranges from *Ta$_3$ to lower Te stage (middle Eocene to upper Oligocene),* but it is not possible to fix a precise age within this range.

*Micropalaeontological report*

by G. R. J. Terpstra

(6 Feb. 1970)

Samples collected by P. D. Hohnen from limestone outcrops of New Ireland have been examined.

60NG0008 Hirudan River, southern New Ireland, Surker Limestone.
*Amphistegina* sp., *Cycloclypeus* sp., *Planorbulinella* sp., planktonics, and indeterminable smaller foraminifera.
No age determination.

60NG0011b Huru River, southern New Ireland, Surker Limestone.
*Amphistegina* sp., *Operculina* sp., and planktonic foraminifera including *Globorotalia* cf. *cultrata.*
Not older than *mid-middle Miocene* (zone N. 11).

60NG0014 Huru River, southern New Ireland, Surker Limestone.
*Amphistegina* sp., *Carpenteria* sp., *Operculina* sp., rare planktonic foraminifera, and indeterminable smaller foraminifera.
No age determination.

60NG0018 3 km north of Palabong, southern New Ireland, Surker Limestone.
*Lepidocyclina* (*Eulepidina*) sp.
Age: *early Miocene,* upper Te stage.

58NG0064 (Matakan River).
*Amphistegina* sp., *Operculina* sp., and algae.
No age determination.

58NG0065 Kulot, central New Ireland.
Algae.
No age determination.

56NG0031 Near Cicacui Plantation, Lelet Limestone.
*Amphistegina* sp., *Carpenteria* sp., *Lepidocyclina* (*Nephrolepidina*) sp., *Miogypsina* sp., corals, and algae.
Age: *middle Miocene* (lower Tf) to *early? Miocene* (upper Te).

The following samples, submitted by D. J. French, are included to show all the available palaeontological work carried out by BMR on New Ireland.

6432/4 (Jaulu Volcanics), Jaulu River (exact location unknown). Black fine-grained volcanic rock with grey fossiliferous inclusions. In section *Globigerina* sp. and coral fragments have been observed. No age determination can be made.

6432/5 (Punam Limestone), Tangat Creek (469625E, 500125N). White massive coral limestone. A few foraminifera and coral fragments have been observed in sections. No age determination can be made.

6432/6 (Jaulu Volcanics?), Tangat Creek (exact location unknown). Massive volcanic rock with fossiliferous inclusions. In section tests of lamellibranchs have been observed. No age determination can be made.

6432/18 (Jaulu Volcanics), Metlik Plantation area (488400E, 485000N). Boundary of light grey volcanic rock and limestone. The sample appears to be a nummulitic rock containing *Nummulites* cf. *fichteli* (Michelotti). The age of the rock is early Oligocene (Tc stage).

6432/24 (Maton Conglomerate), Maton River (4700000E, 526000N). Cross-bedded siltstone. No microfossils have been observed.

6432/67 (Jaulu Volcanics), King River (exact location unknown). Contact volcanic rock and limestone. The limestone contains coral fragments. No age determination can be made.

6432/83 (Surker Limestone), Muliama (493000E, 549600N). White coral limestone. This is an *Amphistegina* limestone containing also coral fragments. The sample is not older than Miocene, but could well be younger.

*Sample Locations*

| *Map number* | *Grid reference E* | *N* | *Sample number* | *Age/Tertiary letter stage* | *Remarks* |
|---|---|---|---|---|---|
| 1 | 28370 | 68940 | 56NG0031 | lower Tf to upper Te? | |
| 2 | 34800 | 65100 | 58NG0065 | algae, no determination | |
| 3 | 38390 | 64050 | 58NG0042 | upper Te to lower Tf | |
| 4 | 38330 | 63990 | 58NG0043 | upper Te to lower Tf | |
| 5 | 38310 | 63940 | 58NG0044 | upper Te to lower Tf | |
| 6 | 38440 | 63990 | 58NG0125 | a Miocene (lower Tf) age is most | |
| 7 | 38430 | 63890 | 58NG0120 | probable for these samples, but | |
| | | | 58NG0120A | they could be of early Miocene | Lelet Limestone |
| 8 | 38370 | 63790 | 58NG0117 | (upper Te) age | |
| 9 | 38340 | 63670 | 58NG0114 | | |
| 10 | 38150 | 63480 | 58NG0113 | not older than Pliocene, but most | |
| 11 | 38110 | 63410 | 58NG0112 | probably from a raised Quaternary | |
| 12 | 38090 | 63360 | 58NG0111A | limestone | |
| 13 | 38040 | 63300 | 58NG0111 | | |
| 14 | 37450 | 62590 | 58NG0221 | within the range $Ta_3$ to Te stage | Jaulu Volcanics |
| 15 | 43760 | 58970 | 58NG0064 | algae, no determination | |
| 16 | 43540 | 58400 | (Noakes, 1942) | basal late Miocene | Rataman Form. |
| 17 | 44230 | 57660 | 58NG0024 | latest Miocene or younger (N.18) | |
| 18 | 44640 | 57630 | S10 | late Miocene to early Pliocene | |
| 19 | 45910 | 56230 | 60NG0018 | upper Te stage | |
| 20 | 47460 | 55530 | 60NG0008 | no determination | |
| 21 | 46690 | 55195 | 60NG0(011b | not older than mid-middle Miocene | Surker Limestone |
| | | | (014 | (zone N.11) | |
| 22 | 49300 | 54960 | 6432/83 | not older than Miocene | |
| 23 | 48840 | 48500 | 6432/18 | Tc stage | Jaulu Volcanics |

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# APPENDIX 2

# PETROGRAPHIC DESCRIPTIONS AND ISOTOPIC AGE DETERMINATIONS OF FOUR IGNEOUS ROCKS FROM NEW IRELAND

by G. G. Lowder and A. W. Webb

## *Petrographic descriptions*

by G. G. Lowder

*Samples:* 60NG0101, 60NG0104, trachyandesite.

*Hand specimen:* These are off-white porphyritic rocks, with numerous white feldspar and black mafic phenocrysts.

*Thin section:* An optical estimate of the constituents gives:

| | % |
|---|---|
| Plagioclase | 20-30 |
| Amphibole | 5-10 |
| Opaques | 1-2 |
| Apatite | Trace |
| Groundmass | 60-70 |

The rocks have a distinctly porphyritic texture with numerous phenocrysts of plagioclase and amphibole in a fine-grained felsophyric groundmass. The plagioclase crystals are zoned, but of fairly sodic composition, and they range up to about 5 mm in size. The amphibole has reaction rims and appears to be a green hornblende. It ranges in size up to 2-3 mm. There are traces of remnant? pyroxene and secondary? biotite in the amphibole. Other phenocrysts include scattered opaques (average size 0.1 mm) and occasional apatite crystals up to nearly 1 mm in length.

The groundmass of these rocks is a fine-grained (0.01-0.05 mm) aggregate of quartz and feldspar, with opaque specks and possible incipient mafic crystals. The groundmass is very rich in potash feldspar, as shown by staining.

Without a chemical analysis, the name ascribed to these rocks may be a little uncertain. However, they lack quartz phenocrysts so they are unlikely to be rhyolite or dacite. The phenocrysts are essentially those of an andesite, but the potash feldspar in the groundmass is too abundant for a normal andesite. Hence an appropriate rock name would appear to be trachyandesite.

*Sample:* 60NG0105, dolerite.

*Hand specimen:* This is a medium-grained feldspar-rich rock, with some mafic crystals evident.

*Thin section:* An optical estimate of the constituents gives:

| | % |
|---|---|
| Plagioclase | 65-75 |
| Mafic | 15-25 |
| Quartz | 3-5 |
| Opaques | 3-5 |
| Apatite | Trace |

The rock has an hypidiomorphic granular texture with a medium grainsize averaging about 1 mm. Plagioclase is the principal constituent, occurring as zoned laths. The cores of these laths have a composition of about $An_{65}$. Many plagioclase crystals contain small inclusions (0.05 mm) of pale green pyroxene. The other major constituent is a pale green, slightly pleochroic amphibole, probably tremolite-actinolite. This mineral fills interstices between plagioclase laths and is probably secondary after primary pyroxene. That pyroxene was a primary constituent is shown by the presence of pyroxene inclusions in plagioclase, which protected it from alteration. Some of the pseudomorphs after pyroxene are composed of both amphibole and chlorite, others of chlorite. All the pseudomorphs contain tiny opaque granules and this opaque matter is more abundant where chlorite is also present. Primary opaque crystals (average 0.3 mm) also occur. A little quartz occurs interstitially to both the plagioclase and mafic components.

The rock is of basic composition and, as it originally consisted of plagioclase and pyroxene, can best be described as a dolerite.

*Sample:* 58NG0208, latite.

*Hand specimen:* A moderately porphyritic rock with dark mafic and white feldspar crystals set in a greenish-grey matrix. There is also a darker, finer xenolith.

*Thin section:* An optical estimate of the constituents gives:

| | % |
|---|---|
| Plagioclase | 20-30 |
| Chlorite | 4-8 |
| Augite | 3-6 |
| Opaques | 2-3 |
| Carbonate | 2-3 |
| Quartz | 1-2 |
| Epidote, apatite | Trace |
| Groundmass | 50-60 |

The rock is highly porphyritic, with numerous phenocrysts of plagioclase, up to about 4 mm, and smaller amounts of other minerals in a fine-grained groundmass, which seems to be holocrystalline. The plagioclase is strongly zoned and is of labradorite to andesine composition. Some plagioclase crystals are slightly to extensively altered, chiefly to chlorite, but others show no sign of alteration.

The size of these pseudomorphs is generally greater than that of the augite crystals. In a few places augite-chlorite composites are present. Some of the pseudomorphs contain carbonate, and irregular patches of carbonate, up to about 2 mm across, are scattered through the section. Opaque crystals are fairly numerous, but none is larger than 1 mm and most are of the order of 0.1 mm in size. Quartz phenocrysts are also present and they show reaction with the groundmass as the crystal margins are not sharp but grade into the groundmass.

The accessory minerals include a few radiating clusters of an epidote mineral and occasional apatite crystals. The groundmass is composed of an interlocking network of quartz and feldspar, with chlorite and opaque matter. The presence of abundant potash feldspar was suspected, and confirmed by staining. Incipient pyroxene crystals may also be present in the groundmass.

Precise identification of this rock would probably require a chemical analysis. However, the rock is characterized by plagioclase and augite phenocrysts with a potash-feldspar-rich groundmass. These features suggest that the rock is best described as a latite.

## *K-Ar ages*

by A. W. Webb

| *Sample no.* | *%K* | *$Ar^{40}/K^{40}$* | *% atmospheric $Ar^{40}$* | *Age (x$10^6$ yrs)* |
|---|---|---|---|---|
| 60NG0101 Hornblende | 0.604; 0.606 | 0.001024 | 66.7 | 17.5 ± 0.6 (early Miocene, upper Te) |
| 60NG0104 Total rock | 1.743; 1.735 | 0.0008116 | 27.1 | 13.8 ± 0.5 (middle Miocene, lower Tf) |
| 60NG0105 Plagioclase | 0.403; 0.405 | 0.001873 | 52.1 | 31.8 ± 1.0 (early or middle Oligocene) |
| 58NG0208 Plagioclase | 0.235; 0.235 | 0.001807 | 65.8 | 30.7 ± 1.0 (middle Oligocene) |

Constants used: $K^{40} = 0.119$ atom %; $\lambda_\beta = 4.72 \times 10^{-10}$/year; $\lambda_e = 0.584 \times 10^{-10}$/year.

*Comments*

by P. D. Hohnen

Samples *60NG0101* and *0104* were collected in the Kamdaru River and probably were derived from small dykes which intrude the Jaulu Volcanics. No fresh, coarse-grained, equigranular plutonic rocks were found that were sufficiently fresh or lacking in alteration products for K-Ar age determination.

Sample *60NG0105* has a chemical composition similar to that of a high-alumina basalt (see Table 5) and was collected as a floater from the Kamdaru River. Its early or middle Oligocene age indicates that the dolerite was emplaced at about the same time as the more basic intrusives of the Lemau Intrusive Complex.

The chemical analysis of sample *58NG0208* indicates that the rock could be more appropriately named andesite. The sample is of Jaulu Volcanics and was collected in the Kaluan River. The middle Oligocene age obtained for this rock agrees with the range of early to middle Oligocene obtained by combined stratigraphic and micropalaeontological age determinations.

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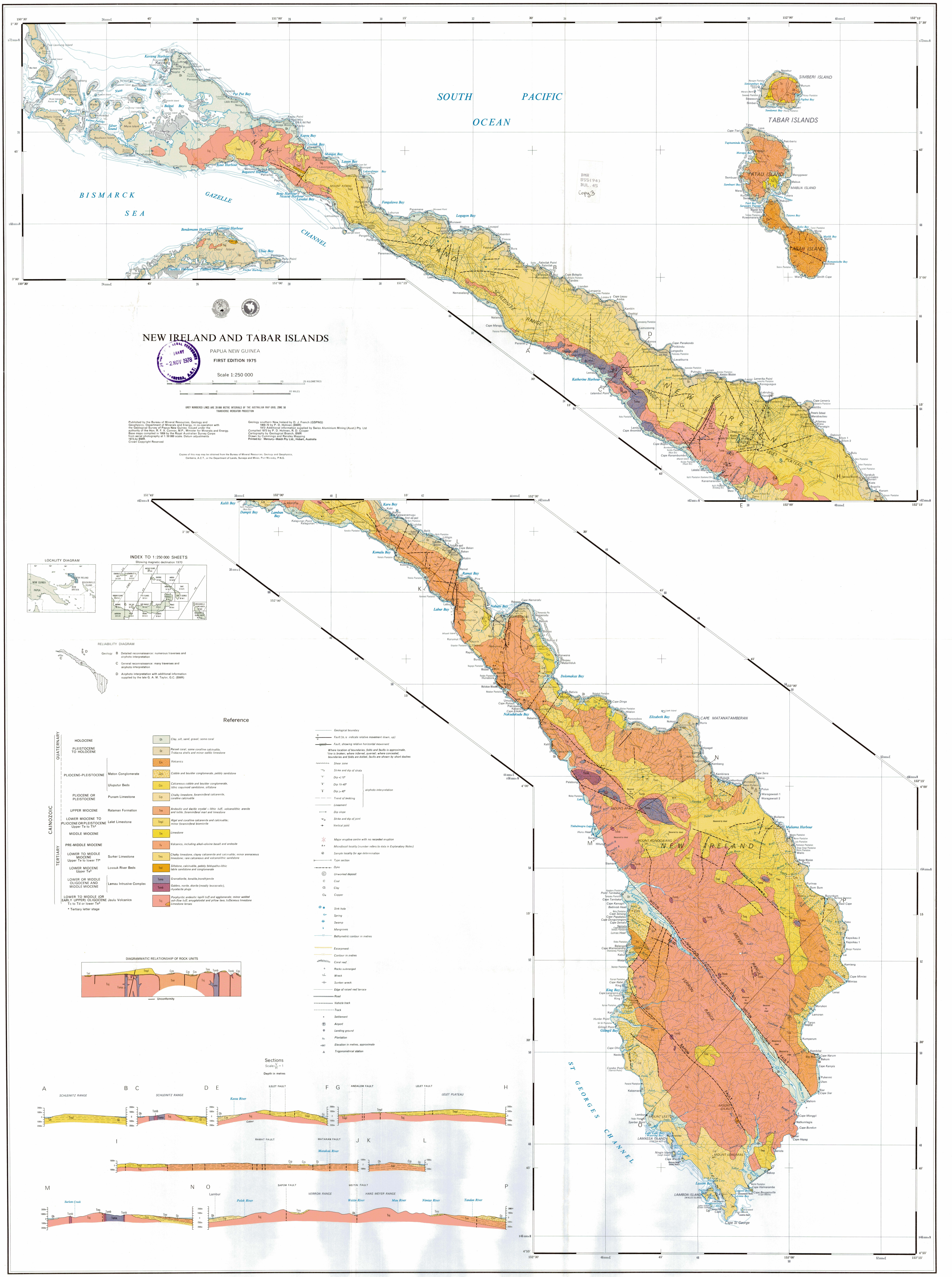

SOUTH PACIFIC OCEAN
BISMARCK SEA
GAZELLE CHANNEL
ST GEORGES CHANNEL
SIMBERI ISLAND
TABAR ISLANDS
TATAU ISLAND
MABUA ISLAND
TABAR ISLAND
NEW IRELAND
SCHLEINITZ RANGE
LELET PLATEAU
CAPE MATANATAMBERAN
HANS MEYER RANGE
VERRON RANGE
LAMBOM ISLAND
Cape St George
NEW IRELAND AND TABAR ISLANDS
PAPUA NEW GUINEA
FIRST EDITION 1975
Scale 1:250 000
25 KILOMETRES
10 MILES
GREY NUMBERED LINES ARE 20 000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 56
TRANSVERSE MERCATOR PROJECTION
Published by the Bureau of Mineral Resources, Geology and Geophysics, Department of Minerals and Energy, in co-operation with the Geological Survey of Papua New Guinea. Issued under the authority of the Hon. R. F. X. Connor, M.P., Minister for Minerals and Energy. Base maps compiled in 1959 by the Royal Australian Survey Corps from aerial photography at 1:50 000 scale. Datum adjustments 1973, by BMR.
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1969-70 by P. D. Hohnen (BMR)
1972 Additional information supplied by Swiss Aluminium Mining (Aust.) Pty Ltd
Compiled 1973 by P. D. Hohnen, R. D. Cooper
Cartography by Geological Branch, BMR
Drawn by Cummings and Ransley Mapping
Printed by: Mercury—Walch Pty Ltd., Hobart, Australia
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LOCALITY DIAGRAM
INDEX TO 1:250 000 SHEETS
RELIABILITY DIAGRAM
Geology B Detailed reconnaissance: numerous traverses and airphoto interpretation
C General reconnaissance: many traverses and airphoto interpretation
D Airphoto interpretation with additional information supplied by the late G. A. M. Taylor, G.C. (BMR)
Reference
CAINOZOIC
QUATERNARY
TERTIARY
HOLOCENE — Qh — Clay, silt, sand, gravel; some coral
PLEISTOCENE TO HOLOCENE — Qc — Raised coral; some coralline calcirudite, Tridacna shells and minor oolitic limestone
Czv — Volcanics
PLIOCENE–PLEISTOCENE — Maton Conglomerate — Czm — Cobble and boulder conglomerate, pebbly sandstone
Uluputur Beds — Czu — Calcareous cobble and boulder conglomerate, lithic coquinoid sandstone, siltstone
PLIOCENE OR PLEISTOCENE — Punam Limestone — Czp — Chalky limestone, foraminiferal calcarenite, coralline calcirudite
UPPER MIOCENE — Rataman Formation — Tmr — Andesitic and dacitic crystal – lithic tuff, volcanolithic arenite and lutite, foraminiferal marl and limestone
LOWER MIOCENE TO PLIOCENE OR PLEISTOCENE Upper Te to Th* — Lelet Limestone — Tmpl — Algal and coralline calcarenite and calcirudite; minor foraminiferal biomicrite
MIDDLE MIOCENE — Tm — Limestone
PRE-MIDDLE MIOCENE — Tv — Volcanics, including alkali–olivine basalt and andesite
LOWER TO MIDDLE MIOCENE Upper Te to lower Tf* — Surker Limestone — Tms — Chalky limestone, clayey calcarenite and calcirudite; minor arenaceous limestone; rare calcareous and volcanolithic sandstone
LOWER MIOCENE Upper Te* — Lossuk River Beds — Tml — Siltstone, calcirudite, pebbly feldspatho-lithic labile sandstone and conglomerate
LOWER OR MIDDLE OLIGOCENE AND MIDDLE MIOCENE — Lemau Intrusive Complex — Toma — Granodiorite, tonalite, trondhjemite
Tomb — Gabbro, norite, diorite (mostly leucocratic), rhyodacite plugs
LOWER TO MIDDLE (OR EARLY UPPER) OLIGOCENE Tc to Td or lower Te* — Jaulu Volcanics — Toj — Porphyritic andesitic lapilli tuff and agglomerate; minor welded ash-flow tuff, amygdaloidal and pillow lava, tuffaceous limestone
Limestone lenses
* Tertiary letter stage
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS
Unconformity
Sections
SCHLEINITZ RANGE
LELET FAULT
ANDALOM FAULT
LELET PLATEAU
RAMAT FAULT
WATAKAN FAULT
WEITIN FAULT
HANS MEYER RANGE
VERRON RANGE