COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 76

THE GEOLOGY OF THE BISMARCK MOUNTAINS, NEW GUINEA

BY

D. B. DOW AND F. E. DEKKER

Issued under the Authority of the Hon. D. E. Fairbairn,
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DEPARTMENT OF NATIONAL DEVELOPMENT

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SUMMARY

The Bismarck Mountains rise on the south-western side of the Ramu Valley, about 65 miles west-south-west of Madang, Territory of New Guinea. They have complex topography and extreme relief, and the map area ranges in elevation from 15,400 feet at Mount Wilhelm, to about 700 feet in the Ramu Valley. Most of the area is rugged and bush-covered, and much of it is unpopulated. The total native population is about 20,000, most of whom are very primitive, and have been contacted by Europeans only within the last ten years. Travel within the mountains is generally difficult. Government walking tracks cover only a small part of the area, and many localities could be visited only by cutting tracks through dense bush.

Despite the difficulties of access it was thought that a geological survey would be rewarding for the following reasons:

1. Copper and gold mineralization were known in the area, and it was suspected that there was a large area of ultrabasic rocks near the Ramu Valley which might contain nickel mineralization.

2. The first Triassic rocks known in New Guinea had been found in the area in 1961, but their relationships with other rocks were not known.

3. The structure of the mountains was known to be dominated by large faults, and it was hoped to ascertain the nature of these faults.

The Upper Triassic rocks comprise the Jimi Greywacke and the overlying Kana Formation, a marine unit composed mainly of feldspathic detritus from acid volcanic eruptions. The Bismarck Granodiorite, previously regarded as Palaeozoic, was probably intruded during a moderate orogeny which folded the Upper Triassic rocks in uppermost Triassic or lowermost Jurassic time.

After a short period of erosion, an essentially conformable sequence was laid down between the Lower Jurassic and the lower Miocene. These sediments have been divided into the following units: Balimbu Greywacke (Lower Jurassic), Mongum Volcanics (Middle Jurassic), Maril Shale (Upper Jurassic), Kondaku Tuff (Lower Cretaceous), Kompiai Formation (?Middle Cretaceous), Kumbruf Volcanics (Upper Cretaceous), and Asai Beds (Upper Cretaceous to lower Miocene).

Gabbro and some intermediate differentiates, collectively called Oipo Intrusives, were emplaced probably in Miocene time; the rocks of the Marum Basic Belt, a large gabbro sill intruded by a dunite plug, were probably emplaced at the same time. Small andesite porphyry intrusions are probably Pliocene, and the terrestrial Kirambul Conglomerate was probably laid down during accelerated erosion in the Pleistocene.

The structure of the area is dominated by slightly curved vertical faults, which are concentrated in zones several miles wide. We regard these faults as predominantly transcurrent, and there is evidence that rivers crossing the still-active Simbai Fault have been displaced two miles horizontally.

The survey proved the existence of a plug of dunite, which crops out over an area of about 100 square miles within the Marum Basic Belt. Scout auger holes put down during the survey showed that these rocks are covered by deep nickeliferous soils which warrant further testing. Stream sediments were sampled in conjunction with the geological mapping, but the only anomalous sample was collected near the Yanderra copper deposit.

INTRODUCTION

The geology of the Bismarck Mountains, New Guinea, was mapped in 1962 by a Bureau of Mineral Resources party as part of a programme of regional mapping in the Western Highlands of New Guinea. The main purpose of the survey was to assess the economic potential of the region; also Triassic rocks had been discovered there in 1961 by Dow (1962a), and it was thought that a complete Mesozoic sequence might be exposed. To assist in locating mineral deposits, samples of stream sediments were taken and analysed at the end of the survey by spectrograph.

The 1962 Western Highlands Party, which operated from July to October, consisted of D.B. Dow and F.E. Dekker. R.G. Horne, Resident Geologist at Wau, helped with the mapping for two weeks in July. Results of earlier mapping in the Bismarck Mountains by the Wau Resident Staff (Dow, 1962a; Plane, 1962) have been incorporated in this report.

Location

The geological map (Plate 10) covers about 1200 square miles of country lying between longitudes 144° 30' E and 145° 20' E, and latitudes 5° 10' S and 5° 55' S. It includes parts of the Magin, Musak, Obulu, Kerowagi, and Bismarck one-mile areas of the Ramu 1:250,000 Sheet area.

Air-photographs cover most of the area (index, Plate 10). Provisional planimetric maps of Musak and Kerowagi, produced by the Division of National Mapping Canberra A.C.T., were used to make part of the base map; no maps of Magin and Obulu were available, so an uncontrolled assembly of air-photographs was traced and reduced to the final scale of 1:250,000.

Access

The only road in the map area links Keglsugl with the Goroka/Mount Hagen Road, but there are airstrips suitable for light aircraft at Kol, Mongum, Tabibuga, Keglsugl, Simbai, and Bundi. A wartime airstrip at Faita, and a small airstrip constructed in 1947, by N. Stagg, 4 miles south of Marum Village in the Ramu Valley, are both overgrown.

A network of graded Administration tracks serves the Jimi and Simbai Valleys, and the Bundi Region, but in the northern half of the map area only rare, poorly defined hunting tracks exist.

Population

Native population is confined to the Chim, Koro, Jimi, and Simbai Valleys, and the Bundi Fault Trough between the Marum River and Bundi. The population of the Ramu Valley in the map area is very small and is apparently decreasing as a result of the ravages of disease and the attraction of urban life in Madang.

The northern half of the map area is part of the Madang District, with Patrol Posts at Simbai and Bundi. The Jimi Valley is part of the Western Highlands District, administered from Mount Hagen township with a Patrol Post at Tabibuga, and a native hospital at Kol. The Koro and Chim Rivers are part of the Eastern Highlands District.

Missionaries are active at the Catholic Missions at Bundi, Mongum, and Keglsugl, the Anglican Mission at Simbai, the Lutheran Mission at Kol, and the Nazarene Mission at Tabibuga.

Industry

The local inhabitants practise subsistence agriculture and other local industry is almost non-existent.

J.C. MacKinnon mined alluvial gold at Kumbruf, in the Simbai Valley, from 1954, but work at the prospect ceased about May 1962. The Catholic Mission at Bundi runs a small sawmill for local building, and there are a few, very small, native-run coffee plantations in the Koro River valley.

Climate

Most of the region has a higher rainfall during the north-west monsoon (November to April), than during the south-east monsoon (May to October). The Wilhelm Massif is generally cloud-covered, and its flanks up to about 10,000 feet seem to have a much higher rainfall than the rest of the map area.

The Ramu Valley is hot and humid, but the climate of the Bismarck Mountains between 3000 feet and 7000 feet is quite equable. Most camps above 8000 feet were damp, bleak, and cold.

Field Methods

Most of the area mapped is very rugged and lightly populated, and the success of the survey depended on the party's being mobile and lightly laden. Equipment for each geologist was carried by 16 permanent carriers recruited from Kol, and local natives, where available, were recruited as required. In populated areas, food for the carriers was bought locally, but for the mapping of the Marum Embayment, an area without population, the party was supplied by an airdrop from a DC3 near the mouth of the Marum River. In this way, 3000 pounds of supplies were received without loss.

Fresh exposures are mainly confined to streams, which were traversed where possible. The drainage of the Wilhelm Massif consists of large, widely-spaced rivers which flow through generally impassable gorges (Plate 1, Fig. 1); and traverses had to be spaced more widely there.

Previous Investigations

The first investigation of the area was carried out by F.K. Rickwood (1955), who made a short reconnaissance trip along the Koro river in 1952.

In 1956, Dr E. Reiner, of the C.S.I.R.O. Division of Land Research and Regional Survey, collected boulders of ultrabasic rocks shed from the Bismarck Range into the Ramu Valley. A party of the Bureau of Mineral Resources mapped the area surrounding Bundi in 1957 (MacMillan & Malone, 1960).

D.B. Dow, while Resident Geologist at Wau, completed three reconnaissance trips in the Jimi and Simbai River areas from 1958 to 1961 (Dow, 1962a); the results of his work are incorporated here. M.D. Plane (1962), of the Resident Geological Staff in Wau, made a short reconnaissance of the Lower Simbai region in 1961, the results of which are also included. N. Robinson, of the Department of Lands, Port Moresby, in 1962 investigated native mining in the Jimi watershed.

In 1947, Mr N. Stagg, while prospecting for a private company, constructed an airstrip near the mouth of the Marum River. All his resources were used constructing the airstrip, and when it was found to be too wet for consistent use, the expedition was abandoned.

PHYSIOGRAPHY

The area mapped is one of extreme relief and complex physiography. The two salient features are the Ramu Valley, a flat-floored valley only a few hundred feet above sea level, and the Bismarck Mountains, which culminate in the frost-riven Mount Wilhelm. Almost without exception, the rivers draining the mountains are large and swift-flowing; they are choked with large boulders, and are deeply incised; to cross from one river to the next commonly involves a climb over a ridge 4000 feet to 5000 feet high. These factors make travelling arduous and at times dangerous.

Other physiographic units in the area mapped are: the Schrader Range, the Jimi Valley, and a small part of the Wahgi-Jimi Divide. The spectacular Wahgi Valley, a large intermontane basin, is located just south of the map area (Fig. 1).

Bismarck Mountains

The Bismarck Mountains are a complex horst, and form the watershed between the Jimi River on the south, and the Ramu River on the north: they extend from Mount Wilhelm north-westwards to the Simbai Patrol Post, a distance of 60 miles. The following physiographic units, described later, can be distinguished within the horst: the Bundi Fault Trough, the Marum Embayment, and the Wilhelm Massif.

The range forming the watershed has an average elevation of about 8000 feet, and is dominated by the Wilhelm Massif, which rises to 15,400 feet. The Jimi Gap, near the head of the Mambu River, is the lowest saddle along the range; it is 6000 feet above sea level, and is regularly used by aircraft flying from Madang to the Wahgi Valley.

The northern face of the Bismarck Mountains drops steeply to the Ramu River and is known as the Ramu Fall. The elevation falls from over 14,000 feet at Mount Herbert to less than 2000 feet in the Yemi River, in a horizontal distance of about eight miles. Most of the range is covered by rain forest, but above 10,000 feet snow grass and sub-alpine scrub predominate (Plate 1, Fig. 2).

The Wilhelm Massif (Pl. 2, Fig. 1), part of the range at the head of the Jimi River, covers an area of about forty square miles, most of which is over 12,000 feet high. There is little vegetation above 10,000 feet, and, as the rocks are subjected to frost-action, the ridges are particularly sharp (Pl. 2, Fig. 1). Deep U-shaped valleys, with many cirques at their heads, are evidence of glaciation (Pl. 1, Fig. 2; Pl. 3, Fig. 1; Pl. 4, Fig. 1).

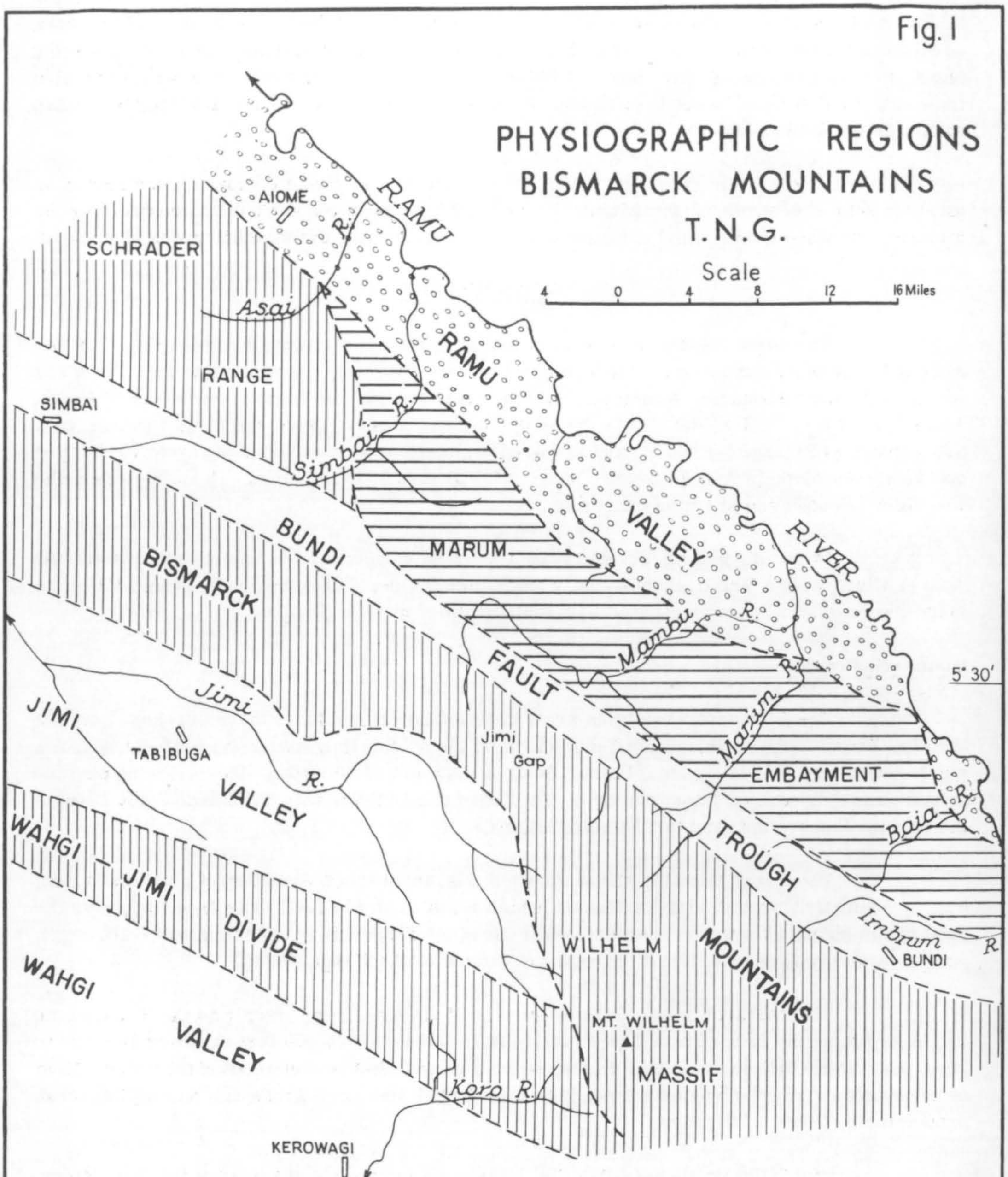


Fig. I
PHYSIOGRAPHIC REGIONS
BISMARCK MOUNTAINS
T.N.G.
Scale
4 0 4 8 12 16 Miles
AIOME
RAMU R.
SCHRADER
Asai
RANGE
RAMU R.
SIMBAI
Simbai
BUNDI
MARUM
VALLEY
RIVER
BISMARCK
Mambu R.
FAULT
Marum R.
5° 30'
Jimi
JIMI
TABIBUGA
Jimi Gap
R.
VALLEY
EMBAYMENT
Baia R.
TROUGH
WAHGI - JIMI
DIVIDE
Imbrum R
BUNDI
WILHELM
MOUNTAINS
WAHGI
VALLEY
MT. WILHELM
MASSIF
Koro R.
KEROWAGI
Bureau of Mineral Resources, Geology and Geophysics. October 1963
145°00'
B55/A5/9

The Bundi Fault Trough is a poorly defined trench along the Ramu Fall of the Bismarck Range. It coincides with the Bundi Fault Zone, and was formed partly by downfaulting, and partly by erosion of the less resistant rocks of the zone. It is about six miles wide near Bundi, and narrows slightly north-westwards to Simbai Patrol Post, where it forms the gap at the head of the Simbai River.

The southern margin of the trough is less well defined than the northern margin, where faulting appears to have taken place more recently. The trough floor has considerable relief, caused mainly by rivers crossing it at right angles from the south. These streams, such as the Baia and Imbrum rivers, flow across in deep valleys to the north side of the trough, where they turn and follow the trough margin for some distance. Farther downstream they turn again at right angles, and break through the range to the north in deep gorges. In the Marum River and Dimba Creek the trough contains alluvium, which has been deposited in valleys dammed by faulting along the trough margin. An example of impending river capture is seen near Bundi, where only a narrow divide about 200 feet high separates the large Baia and Imbrum Rivers.

There is a fairly large native population in the part of the trough between Bundi and the Marum River, and here the vegetation consists mainly of gardens and Kunai grass.

The Marum Embayment, an area of relatively low relief underlain by the Marum Basic Belt, borders the Ramu Valley between the Marum and Simbai Rivers. It forms the foothills of the Bismarck Range in this area, and the larger rivers draining the Bismarck Mountains have cut deep gorges across it. Vegetation is rather sparse, especially on the ultrabasic rocks, and there are no permanent inhabitants in the embayment.

Ramu Valley

The Ramu Valley is the central part of the Sepik-Markham Trough, which extends from Lae in the south-east to the Sepik River in the north-west, a distance of about 250 miles. The alluvium floor of the trough reaches a maximum elevation of about 1400 feet between the Markham and Ramu Rivers. It is probably a graben, but recent alluvium masks the probable faults on the margins. In the map area, the Ramu Valley is about 15 miles wide; the Ramu River meanders north-westwards along the flood-plain about 500 feet above sea level. Cut-off meanders are common on both sides of the river. The larger rivers draining the Bismarck Range emerge from steep-sided gorges, and flow over gently sloping outwash deposits. The smaller streams have built up small, but fairly steeply sloping, alluvial fans where they debouch on to the valley floor. Slopes up to 18^{o} were measured.

Much of the valley is covered with water during the rainy season. Dense rain forest covers most of the valley in the map area, though patches of grassland up to several miles long are common near populated areas.

Jimi Valley

The Jimi Valley is an area of considerable relief, 50 miles long by about 8 miles wide, between the Wahgi-Jimi Divide and the Bismarck Mountains. The valley is occupied by resistant flat-lying or gently dipping greywacke, and the topography consists of very deeply incised rivers separated by broad, flat-topped interfluves. At the eastern end of the valley the interfluves are about 6000 feet above sea level, but they decrease in elevation north-westwards along the valley, and merge with the Lai-Jimi Plain (Dow, 1961).

To the south-east, the Jimi Valley ends abruptly against the Wilhelm Massif. In the massif, the tributaries of the Jimi River are incised as much as 6000 feet below the surrounding ridges, but some distance before reaching the Jimi Valley, they flow along relatively mature valleys, and between Gebal and Tabibuga the Jimi River and its major tributaries are incised 3000 feet to 4000 feet below the surrounding country, but the Jimi River again has a mature profile where it flows over the Lai-Jimi Plain at about 1200 feet above sea level.

The valley has a large indigenous population, and is almost denuded of forest. The vegetation consists mainly of grass, native gardens, and secondary scrub.

Schrader Range

The Schrader Range occupies a small part of the north-western corner of the map area. It is offset about 15 miles north of the Bismarck Mountains, and extends from the Simbai River to the Yuat River west of the map area. Its highest mountain - Mount Aiome, about 8000 feet - is located 5 miles north of Simbai Patrol Post. Like the Bismarck Mountains, the Schrader Range is very rugged and is drained by deeply incised, youthful rivers. The sparse native population has removed the bush cover, and the flanks of the range are covered mainly with grass and native gardens.

Wahgi - Jimi Divide

The Wahgi-Jimi Divide is a straight, narrow range which extends from the Wilhelm Massif to the Baiyer River, west of the map area; it is the main divide, and separates the south-flowing Wahgi River from the Jimi River, which flows to the north coast. The range averages about 8000 feet in altitude, and culminates in the rugged, bare-topped Mount Udon (about 11,000 feet). The flanks of the range are steep, and are drained by short, deeply incised rivers.

Wahgi Valley

The Wahgi Valley is a flat-floored intermontane valley, 40 miles long by about 10 miles wide, immediately south of the map area. It is about 5000 feet above sea level, and is drained by the Wahgi River, which meanders south-eastwards to the end of the valley, where it breaks through the Kubor Range to the south in a magnificent gorge.

STRATIGRAPHY

The stratigraphy of the Bismarck Mountains is summarized in Table 1.

The oldest rocks in the map area belong to the Garoka Formation, which may be partly Palaeozoic. The succession of Mesozoic rocks in the map area is the most complete so far found in New Guinea. Upper Triassic Jimi Greywacke and Kana Formation are separated by an angular unconformity from a full Jurassic sequence comprising Balimbu Greywacke, Mongum Volcanics, and Maril Shale. The Bismarck Granodiorite, previously regarded as Palaeozoic, may have been emplaced in the uppermost Triassic or the lowermost Jurassic, during the folding which caused the unconformity.

TABLE I

STRATIGRAPHY OF THE BISMARCK MOUNTAINS

AGE	FORMATION	LITHOLOGY	THICKNESS	FOSSILS
Recent	Undifferentiated Alluvium	Gravel, sandstone, conglomerate, mudstone		
Pleistocene	Kirambul Conglomerate	Pebble and cobble conglomerate, mudstone, and sandstone	100 feet +	
Tertiary 'e' Stage (L.Miocene) to Upper Cretaceous	Asai Beds	Shale, siltstone, phyllite, with minor quartz sandstone, calcarenite, and pebble conglomerate. Metamorphosed in places.	3350 feet measured but probably much greater.	Foraminifera
Upper Cretaceous	Kumbruf Volcanics	Basaltic agglomerate, pillow lavas, siltstone, tuffaceous greywacke; highly altered in Nondu Creek.	6000 feet.	Belemnites
?Middle Cretaceous	Kompiai Formation	Siltstone and shale in upper half, prominent feldspathic greywacke beds in lower part.	Not measured	Belemnites in upper part.
Lower Cretaceous	Kondaku Tuff	Tuff, basalt agglomerate, tuffaceous greywacke, basalt conglomerate, siltstone, and some basalt.	1000 feet + in Jimi River	
		PROBABLE LOCAL UNCONFORMITY		
Upper Jurassic	Maril Shale	Shale and siltstone with minor greywacke at base. Calcarenite lenses.	3000 feet	*Buchia malayomaorica* *Inoceramus* sp. cf. *haasti*, ammonites.
Middle Jurassic	Mongum Volcanics	Basaltic agglomerate and conglomerate pillow lavas, some greywacke.	850 feet	Brachiopods, ammonites.
Lower Jurassic	Balimbu Greywacke	Fine-grained greywacke and siltstone	950 feet +	Brachiopods, ammonites.
		UNCONFORMITY		
Upper Triassic	Kana Formation	Feldspar arenite, red and purple tuffaceous siltstone, dacite conglomerate.	2000 feet +	Gastropods, pelecypods, and brachiopods.
	Jimi Greywacke	Medium-grained greywacke with some conglomerate and shale.	2500 feet +	Gastropods, pelecypods, and brachiopods.
?Palaeozoic	Goroka Formation	Sericite schist, silicified shale, siltstone, minor marble, phyllite.	Not measured	

The Kondaku Tuff, Kompiai Formation, Kumbruf Volcanics, and Asai Beds were deposited as an almost continuous sequence from the Lower Cretaceous to the lower Miocene. The terrestrial Kirambul Conglomerate was probably deposited during the Pleistocene.

The age of the basic volcanic rocks of Mount Udon is unknown: they may be as old as Lower Jurassic, or as young as Tertiary.

(?) PALAEOZOIC

Goroka Formation

The Goroka Formation was named by McMillan & Malone (1960). The type area is north of Goroka, about 20 miles south-east of Bundi.

Near Bundi, metamorphic rocks intruded by the Bismarck Granodiorite were correlated by McMillan & Malone with the Goroka Formation. These rocks are part of a belt 14 miles long by about one mile wide on the north-eastern margin of the Bismarck Granodiorite. They comprise dark grey biotite-andalusite schist, silicified shale, green altered volcanic rocks, and white marble.

In Korogi Creek, a tributary of the Marum River, steeply dipping silicified shale and marble intruded by the Bismarck Granodiorite are referred to the Goroka Formation (Plate 4, Fig. 2). These rocks are mainly laminated, medium-bedded, silicified shale which contains beds of marble up to six feet thick. The shale was originally calcareous, and has been silicified by the Bismarck Granodiorite. More highly calcareous rocks have been altered to a medium-grained reddish-purple garnetite and garnetiferous marble. A dark blue hornfels was also observed.

Slaty cleavage is developed in most of the rocks, and is generally parallel to the bedding.

The Goroka Formation was correlated by McMillan & Malone with the pre-Permian Omung Metamorphics of Rickwood (1955). However, we believe that metamorphics in the head of the Chim River mapped by Rickwood as Omung Metamorphics are partly Triassic, and the Goroka Formation could therefore be Mesozoic or partly Triassic (see 'Kana Formation' below).

UPPER TRIASSIC

Jimi Greywacke

Jimi Greywacke is the name proposed by Dow (1962a) for Triassic greywacke in the Jimi Valley. The type locality is on the south side of the Jimi Valley between Bubultunga and Gebal. The greywacke crops out in the core of a north-westerly-trending anticline, between the Kanel River and the head of the Mamp River. A thin, faulted wedge crops out in the Bundi Fault Zone between the Yemi River and the Simbai River.

The Jimi Greywacke is overlain, apparently conformably, by the Kana Formation, but its relationship with older rocks is not known, as the base of the greywacke was not seen

Dark, fine-grained greywacke and siltstone are predominant in the lower part of the formation. The rocks are thin-bedded and laminated, and in the head of the Mamp River they have been partly recrystallized by gabbro intruded along the Jimi Fault. Mica schist underlying the Kana Formation half a mile west of Kworu is probably the metamorphosed equivalent of the Jimi Greywacke, but the outcrop is too small to be shown on the geological map (Plate 10).

The most common rock type is highly indurated, medium-grained, dark grey, dark blue, or brown greywacke. It is medium-bedded, and contains thin interbeds of dark grey shale and siltstone. It is commonly calcareous and micaceous, and the coarser beds are generally carbonaceous. Ripple marks are common in the Kanel River, and cross-bedding was noted in boulders shedding into Bombu Creek.

A transition zone near the top of the formation comprises calcareous greywacke and siltstone, similar to that lower in the sequence, interbedded with minor red and purple siltstone and pink feldspathic sandstone very similar to that of the overlying Kana Formation. This transition zone is about 300 feet thick.

Fossils collected in 1961 by Dow (1962a), from the Jimi Greywacke were shown to be Triassic by Dr L.R. Cox (British Museum, pers. comm.). During the 1962 survey, more comprehensive collections were made at the known fossil localities, and several new localities were found. These collections have been described by Skwarko (1963), who recognized the following fauna:

Pelecypoda:

Costatoria sp. nov. aff. C.inaequicostata (Klipstein), 1845

'Myophoria' sp. nov.

'Myophoria' sp. nov. aff 'M' kefersteini Munster, 1928

'Myophoria' sp. nov. aff 'M' microasiatica Bittner, 1891

'Gervillia' sp. nov. aff 'G' mytiloides (Schlotheim), 1820

'Gervillia' sp. nov. aff 'G' rugosa Healey, 1908

Taimyria? sp. nov.

Nuculana sp. cf. N. semicrenulata (Trechmann), 1917

Gastropoda:

Pleurotomaria? sp. nov.

Brachiopoda:

Rhynchonella sp. nov.

Spiriferina sp. cf. S.abich Oppel, 1865

Cephalopoda:

Sirenites sp. aff. S.malayicus Wetter, 1914

Skwarko gives the age of this assemblage as Carnian - Norian.

It was not possible to measure a section of Jimi Greywacke, but the maximum thickness exposed in the type locality, as measured in photographs, is about 2500 feet.

Kana Formation (New Name)

We have given the name Kana Formation to highly feldspathic sediments composed mainly of detritus from acidic eruptions. The formation was originally named 'Herbert Beds' by Dow (1962a), after Mount Herbert, which he assumed was composed of these rocks. However, the mountain is composed mainly of gabbro, and the present name is derived from the Kana River, in which the beds are best exposed.

The Kana Formation crops out on the flanks of the Oipo Anticline along the Jimi Valley between Mount Oipo and the Kana River, and as a narrow south-trending belt flanking the Wilhelm Massif between the head of the Kana River and the head of the Koro River. This belt may extend into the Chim River as part of the Omung Metamorphics of Rickwood (op.cit.).

The formation conformably overlies the Jimi Greywacke, and the base of the formation is marked in most places by a dacite conglomerate. Where the conglomerate is absent, the base of the formation is difficult to define, because it is separated from the Jimi Greywacke by a transition zone, about 300 feet thick, which is mostly dark, calcareous greywacke, and siltstone containing minor pink highly feldspathic beds and red and purple siltstone; under such conditions the base of the formation is taken as the stratigraphic position where the feldspathic beds become predominant.

The Lower Jurassic Balimbu Greywacke unconformably overlies the Kana Formation.

The Kana Formation consists mainly of interbedded feldspar arenite and tuffaceous siltstone.. Massive dacite conglomerate and minor beds of quartz sandstone and calcarenite occur throughout. The feldspathic arenite is fine to coarse-grained, and commonly contains scattered light grey, green, or pink grains of salmon-pink feldspar. It occurs as uniform beds from 3 to 30 feet thick, interbedded with siltstone beds ranging in thickness from six inches to about 20 feet. The thinner beds of arenite are generally laminated, and the thicker ones are only rarely cross-bedded. Scattered, well-rounded pebbles of quartz, dacite, granodiorite, and chert are common in the coarser-grained varieties.

Thin-section examination shows that the arenite is composed of 60 to 80 percent feldspar, the other components being quartz, dacite fragments, and minor chlorite matrix. The feldspar grains are angular to subangular, and comprise plagioclase, quartz-orthoclase intergrowths, and subordinate orthoclase; they are moderately kaolinized. The quartz grains are angular, and many have sharp points.

The siltstone is red and purple, and consists of small, angular grains of probable feldspar and quartz in a highly ferruginous matrix. In places where it has been tightly folded, such as Balimbu Creek, the siltstone has developed slaty cleavage, but generally the beds are massive and structureless. The siltstone was not examined in thin section, but it appears in hand-specimen to be tuffaceous.

Massive beds of pebble and cobble conglomerate crop out near the base of the Kana Formation. The beds range in thickness from a few feet to over 100 feet, and are composed of pebbles of red, green, and purple dacite and dacite porphyry, fine-grained granodiorite, quartz, and hornfels, in a coarse-grained matrix of feldspathic arenite. The beds are massive and lenticular, and contain patches of cross-bedded arenite.

Grey quartz sandstone and lenses of pink calcarenite were seen near Mami Village, but they are only minor constituents of the formation. The quartz sandstone occurs as beds up to four feet thick and grades into quartzite and feldspathic arenite. The calcarenite is composed mainly of shell fragments in a crystalline calcite matrix and contains abundant Bryozoa. It also contains scattered well-rounded quartz grains, and grades into calcareous quartz sandstone.

Boulders of green flow-banded (?) dacite were found in the Kana River, and in a small tributary of the Jimi River, two miles south of Mami Village, but they were not found in situ. They probably come from lava flows within the Kana Formation.

Skwarko (1963) identified the following fossils collected from near Gebal in the Kana River:

Pelecypoda:

Costatoria sp. nov. aff. C.inaequicostata (Klipstein), 1845.

Gastropoda:

Pleurotomaria? sp. nov

Brachiopoda:

Spiriferina sp. cf. S.abichi Oppel, 1865

Scaphopoda

Dentalium sp. indet.

He gives the age as Carnian - Norian.

The formation could not be measured, but it is at least 2000 feet thick. Dow (1962a) tentatively correlated the Kana Formation with the Permian Kuta Group of Rickwood (1955). However, it conformably overlies the Upper Triassic Jimi Greywacke, and fossils collected from the formation prove it to be Upper Triassic.

The Kana Formation was deposited under water, and is composed of detritus from acidic eruptions. The environment of deposition was probably shallow-water and near shore.

Two miles west of Mount Kworu, very highly indurated dacite pebble conglomerate, grey and green feldspar arenite, feldspathic sandstone, and red shale are referred to the Kana Formation. They are underlain by black, fine-grained sericite schist, which is intruded by the Bismarck Granodiorite. The schistosity of these beds trends uniformly 340^{o}, dips steeply east and west, and has completely obliterated the bedding. Near the contact with the Kana Formation, bedding can be distinguished in the schist, and dips steeply south-westwards conformably with the overlying arenites. The black schist is probably the metamorphosed equivalent of the fine-grained upper part of the Jimi Greywacke.

Rocks cropping out in the head of the Chim River ten miles south-east of Mount Kworu were correlated by Rickwood (op. cit., p. 68) with the Palaeozoic Omung Metamorphics. He described these rocks as follows: 'Greenish-grey calcareous slate south of Womkana grades northwards into dark grey slightly micaceous phyllite consisting chiefly of small angular feldspars, some of which are oriented parallel to the cleavage. This grades northwards into about 600 feet of red grit and red ferruginous calcareous shale and finally into purple shale and purple conglomerate with volcanic pebbles up to three inches in diameter'. These beds are probably the south-easterly extension of the Kana Formation, and are therefore probably Triassic; Rickwood states that they are intruded by the Bismarck Granodiorite.

Red shale and volcanic conglomerate crop out in the Walne River about four miles south-east of Kol. The outcrop is not large, and field relationships are uncertain, but the rocks are possibly a fault wedge of Kana Formation.

LOWER JURASSIC

Balimbu Greywacke (New Name)

Greywacke and siltstone of Lower Jurassic age in the Bismarck Mountains are here named Balimbu Greywacke. The type section is in Balimbu Creek, west of Mami Village. The formation unconformably overlies Kana Formation, and conformably underlies Mongum Volcanics.

It crops out on the north flank of the syncline between the head of the Jimi River and the Walne River. Greywacke which crops out near the head of the Koro River also belongs to the Balimbu Greywacke.

The formation consists of black to dark grey calcareous greywacke and interbedded dark siltstone. Outcrop of the greywacke in the type locality is distinctive; resistant greywacke beds between one and five feet thick stand out from the less resistant siltstone beds, whose thickness exceeds five feet (Plate 5, Fig. 1). The greywacke almost invariably contains small dark markings less than 1/4 inch long. These are contorted and finer-grained than the matrix, and are scattered throughout the rock in bands up to 6 inches wide. The rock is possibly a fine-grained intraformational conglomerate. Near the top of the formation there are thin beds of green, silicified, tuffaceous sandstone and agglomerate. The base of the Mongum Volcanics is marked by a basaltic agglomerate bed at least 50 feet thick.

The formation was measured by chain and compass along the track between Mami Village and Mongum Village; it is 950 feet thick in this locality.

Greywacke in the head of the Koro River is a correlative of the Balimbu Greywacke. It occurs as a faulted wedge, and abuts against Kana Formation to the north, and Maril Shale to the south. The predominant rock type is a thin to medium-bedded, fine-grained greywacke, containing interbedded shale, siltstone, and fine-grained pebble beds. The siltstone and some of the greywacke are laminated. Rounded nodules of pyrite are common in the greywacke.

These rocks are underlain, apparently conformably, by greenish-purple vesicular basalt, basalt aggomerate, and dolerite.

The Balimbu Greywacke appears to be considerably thicker in this locality than in the Jimi River. A total thickness of over 5000 feet is indicated, but outcrop is poor, and the beds are probably duplicated by faulting.

Fossils from the formation were described by Skwarko (1963), who recognised the following:

Cephalopoda:

Paltechioceras? Buckman, 1924

Tropidoceras? Hyatt, 1867 (Plate 5, Fig. 2)

Brachiopoda

indeterminate casts

The age is given as Lower Jurassic, so the time-gap represented by the unconformity between the Kana Formation and the Balimbu Greywacke is not great, and the unconformity could, therefore, be of local significance only. However, in the Wahgi Valley, Upper Jurassic Maril Shale rests disconformably on rocks belonging to the Permian Kuta Group (Rickwood, op. cit.), indicating that the depositional break is widespread, and it apparently represents a much greater time gap farther afield.

MIDDLE JURASSIC

Mongum Volcanics (New Name)

'Mongum Volcanics' is the name proposed for basic submarine volcanics which crop out in the head of the Jimi River, on the north flank of the Kol Syncline. The type section is along a small unnamed creek which crosses the Mongum-Mami track, 2 miles south of Mami, and the name is derived from Mongum Village, one mile to the south. The Volcanics conformably overlie the Balimbu Greywacke, and are conformably overlain by Maril Shale. Poorly exposed basic volcanics near Kol are probably Mongum Volcanics.

The formation consists of basaltic agglomerate and pillow lavas interbedded with pebble and cobble conglomerate and tuffaceous greywacke. The basalt is massive and green, and contains vesicles between 1/8 inch and 1/2 inch across, filled with chalcedony and zeolite. Pillow lavas 100 feet thick crop out in Balimbu Creek. The pillows are one foot to three feet in diameter, and the interstices are filled with green chloritic material; they have a glassy margin, inside of which is an inch-wide zone of zeolite-filled vesicles. The agglomerate is green, highly indurated, and consists of angular to sub-rounded basalt fragments in a crystal tuff matrix.

The conglomerate consists of rounded pebbles of silicified greywacke, red and black basalt, and red chert, in a tuffaceous matrix which grades into scoriaceous fine-grained agglomerate. Beds of laminated and thin-bedded greywacke and siltstone up to two feet thick are interbedded with the conglomerate.

The formation was measured by chain and compass in the type area, and is 850 feet thick. Fossils were found in conglomerate in the type section (Locality H908), but they were too poorly preserved to be identified (Skwarko, 1963).

UPPER JURASSIC

Maril Shale

Noakes (1939) measured the section of Mesozoic and Tertiary rocks in the Chim River. He tentatively subdivided this section, and Edwards & Glaessner (1953) proposed the name Maril Shale for the basal unit. Fossils collected in 1939 by Noakes were dated by Glaessner (1945) as Upper Jurassic.

In the Koro River, on the southern margin of the map area, Maril Shale is faulted against Balimbu Greywacke. In the Jimi River, between Kol and Mongum, Maril Shale crops out on the flanks of a north-west-trending syncline. In this locality it is conformably underlain by Middle Jurassic Mongum Volcanics, and overlain, possibly unconformably, by Lower Cretaceous Kondaku Tuff.

In the Koro River, the predominant rock is a fine-grained, thin-bedded, grey and reddish-brown shale. Interbeds of medium-grained grey sandstone occur throughout the formation, and are more common in the upper part. There is a bed of fine-grained, thin-bedded, grey limestone about 200 feet thick near the top of the sequence.

In the head of the Jimi Valley the Maril Shale consists of about 3000 feet of fine-grained, thin-bedded, grey shale and greywacke (Plate 6, Fig. 1). Nodules of recrystallized limestone up to 1 foot in diameter are commonly scattered through the shale.

Some coarse-grained beds occur in the lower part of the sequence. In the Walne River, one mile upstream from Kol, alternating medium-grained greywacke and shale lie about 1000 feet above the base of the formation. A band of thick-bedded, fine-grained greywacke about 150 feet thick forms a prominent ridge on the western side of the Walne Valley. The bed is about 500 feet above the base of the Maril Shale. Carbonaceous plant remains were found in grey-blue, medium-grained sandstone about one mile north of Mongum.

The base of the Maril Shale is marked in places by a thick-bedded, unsorted boulder conglomerate. At least 50 feet of this conglomerate are exposed on the path between Kol and Mans. It consists of well-rounded boulders, up to six inches in diameter, of greywacke, volcanic agglomerate, basalt, black slate, chert, and granodiorite, set in a well-cemented ferruginous matrix.

Buchia malayomaorica and *Inoceramus* sp. cf. *I. haasti* were collected from several localities near Kol, near Mongum, and in the Koro River. These fossils confirm the age of the Maril Shale as Upper Jurassic (Skwarko, 1963).

LOWER CRETACEOUS

Kondaku Tuff

Lower Cretaceous volcanic rocks in the Wahgi Valley were named 'Kondaku Tuff' by Edwards & Glaessner (1953).

In the Jimi Valley about 1000 feet of Kondaku Tuff are preserved as an outlier in the Kol Syncline, where it overlies, probably unconformably, the Maril Shale. The lower half of the formation in the Kol Syncline is composed mainly of basic submarine volcanics, which grade upwards into tuffaceous greywacke. The upper half of the formation, as described by Edwards & Glaessner (op.cit.), is not represented in the map area, and has, apparently, been removed by erosion. The volcanics are crystal tuff, scoriaceous basaltic agglomerate, vesicular basalt, and minor basaltic conglomerate. The greywacke is coarse to medium-grained, and contains cobbles and pebbles of basalt and greywacke. It is thick-bedded, and contains thin bands of laminated shale.

In the Kol Syncline the Kondaku Tuff probably unconformably overlies the Maril Shale. Conglomerate and agglomerate remnants of Kondaku Tuff are exposed on the track between Kol and Mongum, and these truncate Maril Shale beds which dip at about 25°.

The Kondaku Tuff was deposited in a marine environment. No fossils were found in the formation in the Jimi Valley, but its age was given as Lower Cretaceous by Edwards & Glaessner (op.cit).

(?) MIDDLE CRETACEOUS

Kompiai Formation (New Name)

'Kompiai Formation' is the name proposed for predominantly fine-grained sedimentary rocks of probable Middle and Upper Cretaceous age. The type locality is the area surrounding Kompiai Village ($5^{\circ}28'$S, $144^{\circ}39'$E), where the rocks are best exposed in tributaries of the Jimi River. The rocks were originally called 'Genjinji Beds' by Dow (1962a), but exposures in the Genjinji area are poor, and we considered it advisable to change the type locality.

The rocks crop out as a belt about four miles wide, along the north side of the Jimi Valley. They are faulted against Jimi Greywacke and Kana Formation to the south, and to the north they probably conformably underlie Kumbruf Volcanics.

The rocks are complexly folded in most places, and we found it impossible to measure a type section. The upper part of the formation consists of shale and siltstone, containing rare beds of fine-grained greywacke. The lower part is mainly siltstone and contains beds of light-coloured feldspathic sandstone and greywacke.

Dark grey to black siltstone constitutes about 60 percent of the lower half of the formation. Thin-bedding can rarely be distinguished within these fine-grained sediments, and they are generally massive. Light-coloured greywacke makes up the remainder of the lower half of the sequence. It occurs as massive beds, between one foot and five feet thick, in which flow casts, graded bedding, and slump structures are common. Lenses of intraformational conglomerate occur within the greywacke, and bodies of pyrite up to two inches long and half an inch wide were noted in several localities.

The light-coloured greywacke becomes progressively rarer towards the top of the formation, and near Gondeben Village the rocks are almost entirely shale and siltstone. They are dark grey and black, and, rarely, purple and green colour-banded. These rocks mostly appear to be massive but laminae and thin-bedding can generally be distinguished on close examination. The shale almost invariably has a talcose appearance. Beds of dark-grey, fine-grained greywacke occur throughout the sequence; they are indurated, and generally calcareous.

The stratigraphical position of the Kompiai Formation is not known with certainty. In the head of the Simbai River it apparently conformably underlies the Kumbruf Volcanics, but critical contacts are not exposed, and the two formations could be faulted against each other. However, Dow (1962a) found belemnites in Kompiai siltstone in the head of Tunonk Creek, proving that the upper part of the formation is not older than Jurassic and not younger than Cretaceous.

The Kompiai Formation was probably laid down in a geosyncline, which was supplied with abundant arenaceous detritus in the early stages of its development.

(?) UPPER CRETACEOUS

Kumbruf Volcanics

The Kumbruf Volcanics were named by Dow (1962a). The type locality is at Kumbruf Gold Prospect, on the south side of the Simbai Valley, at about $5^{o}20'$S and $144^{o}34'$E. The formation crops out between Simbai Patrol Post and the Sigan River, and also in fault wedges along the Bundi Fault Zone eastwards nearly as far as Bundi Patrol Post. It probably extends to the north-west of the map area, as spilitic volcanic rocks were collected by D.W.P. Corbett in 1958 from the Aunja River, about 12 miles north of Simbai Patrol Post (Corbett, 1962). The formation conformably overlies the Kompiai Formation, and underlies the Eocene Asai Beds, apparently also conformably.

A chain and compass survey was made along Tunonk and Nanoi Creeks, which bound Kumbruf Prospect, and the following section of Kumbruf Volcanics was measured:

Thickness (feet)	Top of Section
200	Basaltic agglomerate, some pillow lavas.
350	Indurated calcareous siltstone with slump structures.
550	Mainly basic pillow lavas with some siltstone interbeds.
600	Black indurated siltstone, tuff, tuffaceous sandstone, and rare basaltic pebble conglomerate.
4400	Mainly basaltic agglomerate with minor lava flows, some basaltic conglomerate, and red banded siltstone.
6100	Total thickness

Products of submarine vulcanism make up about 80 percent of the formation. The agglomerate is green, and highly indurated, and consists of angular to sub-rounded basalt fragments in a medium-grained tuffaceous matrix. The basalt fragments commonly contain spherical vesicles filled with zeolites or calcite, and calcite patches are common throughout the rock. In many places angular and sub-rounded fragments are almost indistinguishable from the matrix. Pillow lavas are common, especially in the upper part of the section. The pillows range in diameter from two to six feet, and the interstices between them are filled either with green or red siltstone, or by an indeterminate white mineral, probably a zeolite.

Medium-grained andesitic tuff and tuffaceous greywacke constitute about 10 percent of the section; these rocks are light-coloured, thin to medium-bedded, and are interbedded with siltstone. The siltstone is dark blue to black and rarely red, and is laminated and thin bedded. Slump structures are common.

Samples of the volcanics were collected by D.W.P. Corbett from the Kumbruf area during a short visit in 1958, and a petrological report on the specimens was made by W.R. Morgan (1960). The basic pillow lavas and agglomerate were, with one exception, classed as spilitic and are mostly porphyritic and amygdaloidal. Phenocrysts of olivine are common, and the amygdales are filled with chlorite, calcite, epidote, and zeolite. A sample of tuff was classified as andesitic crystal tuff.

The only fossils found in the formation occur near its top, in a small tributary of Soi Creek, in boulders of indurated siltstone and fine-grained greywacke; it was not possible to make an adequate collection. The only form recognised was a species of belemnite. About 2000 feet stratigraphically above the top of the formation a limestone member of the Asai Beds contains Eocene microfossils. Field relations indicate a conformable contact with the Asai Beds, so the Kumbruf Volcanics are probably Upper Cretaceous.

Wedges of highly sheared and, in places, mylonitized green and red basalt and agglomerate crop out along the Bundi Fault Zone. In most places the volcanic structures are obliterated by shearing, but remnants of less altered rocks showing pillows, vesicles, and relict agglomerate structures can generally be found. These rocks have been referred to the Kumbruf Volcanics.

The basalt is epidotized and chloritized, and contains many calcite and quartz-epidote veins which are roughly parallel to the shear-planes.

Highly altered submarine volcanic rocks which crop out in the head of the Yemi and Mamp Rivers probably belong to the Kumbruf Volcanics. In the Yemi River they appear to underlie Asai Beds conformably, but the contact, though well exposed, is also sheared, and conclusive evidence is lacking. The rocks are mainly submarine volcanics which contain interbedded phyllite and siliceous siltstone.

The volcanics are a distinctive light green, and comprise agglomerate, volcanic breccia, and pillow lavas. They are highly altered and generally silicified, and volcanic structures have commonly been completely obliterated. Only one rock has been examined in thin section; it is a volcanic breccia consisting of angular to sub-angular fragments of fine-grained basic igneous rocks in a crystal tuff matrix, throughout which are scattered rounded grains of quartz and quartzite. Both the rock fragments and the matrix are almost completely altered to epidote, kaolin, and chlorite.

Black, purple, and green silicified siltstone, and phyllite, constitute about 30 percent of the sequence; they have reacted incompetently to stress, and are very highly contorted. The less silicified rocks have a well developed axial plane cleavage, which in places renders the rock schistose. The silicified siltstone is massive, light green, and very hard.

All the rocks generally contain sparse, scattered crystals of pyrite, and pyrrhotite was noted at one locality in Nondu Creek.

The alteration of these rocks was probably caused by the two large stocks of Oipo Intrusives which crop out nearby.

UPPER CRETACEOUS TO MIOCENE (TERTIARY 'e' STAGE)

Asai Beds

The name Asai Beds was proposed by Dow (1962a) for a sequence of metamorphic rocks cropping out between the Simbai and Ramu Rivers. The name is derived from the Asai River, which drains a large area of these rocks. Rocks similar in lithology crop out within the Bundi Fault Zone, and extend as far east as Bundi.

Rocks in the Bundi area were mapped as Upper Cretaceous, Eocene, and Miocene (Tertiary 'e' stage) by McMillan & Malone (1960) on the basis of contained foraminifera. The rocks here described have a similar lithology, and are indistinguishable from them in the field; they were therefore mapped by us as Asai Beds.

The formation overlies, apparently conformably, the Kumbruf Volcanics in the Simbai River area, and it consists of shale, phyllite, siltstone, calcareous siltstone, fine-grained greywacke, and limestone. North of the Simbai River the rocks appear to grade into fine-grained quartz-sericite schist.

A section of the Asai Beds, 3350 feet thick, overlying the Kumbruf Volcanics was measured in Tunonk Creek, and is tabulated below:

Thickness (feet)	Top of Section
900	Sheared phyllitic siltstone (about 20 percent of the siltstone is calcareous) with minor limestone lenses.
150	Fine-grained recrystallized limestone, generally massive, though laminated and thin-bedded in places. Eocene foraminifera.
200	Calcareous phyllite containing small limestone lenses.
30	Fine-grained marble.
200	Black phyllite, about 50 percent calcareous. Many calcite nodules. Much shearing.
20	Fine-grained marble.
450	80 percent black shale and phyllitic siltstone, 20 percent calcareous, phyllitic siltstone. Sheared, contorted, and brecciated. Pyrite nodules up to three inches in diameter in places.
900	75 percent siltstone and shale, 20 percent calcareous siltstone, 5 percent fine-grained greywacke. Laminated and thin-bedded, and with thin lenses of black siltstone in finer-grained matrix. Finer-grained beds tending towards phyllitic; zones of silicification.
500	60 percent laminated and thin-bedded siltstone, 40 percent calcareous siltstone; calcareous nodules common. Many slump structures.
3350	Total thickness

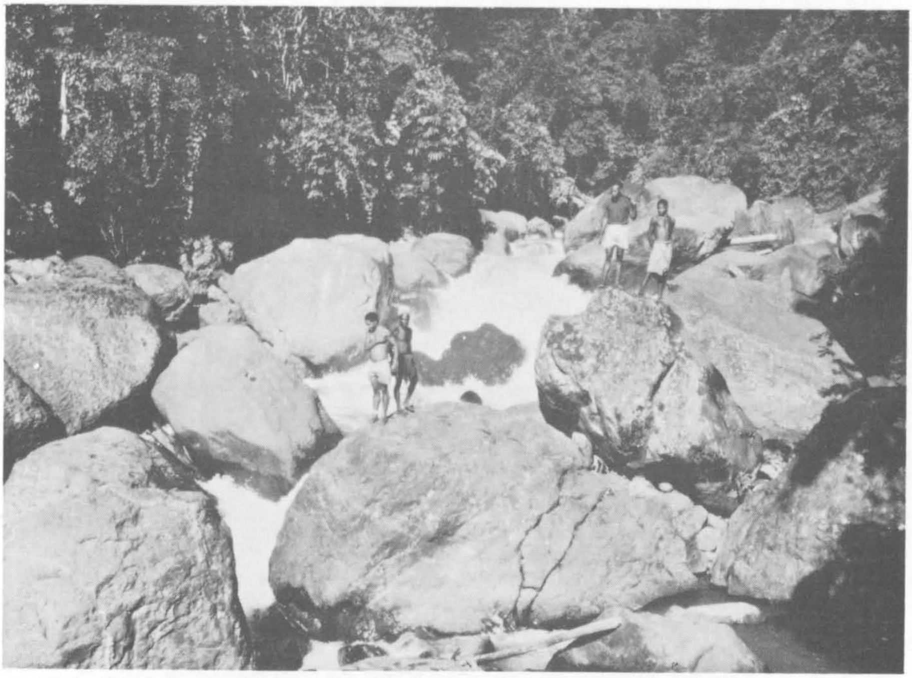


Fig. 1—The Lower Simbai River. The river cannot be forded, and large boulders of Kumbruf Volcanics make travelling arduous and at times dangerous.

Fig. 2—Kworu Tarn, a cirque. Photo taken from the summit ridge of Mount Kworu, looking south.

Fig. 1—Headwaters of the Jimi River, taken from near Mongum, looking eastwards. The peak at the middle top is Mount Kworu (14,500 feet), which is part of the Wilhelm Massif.

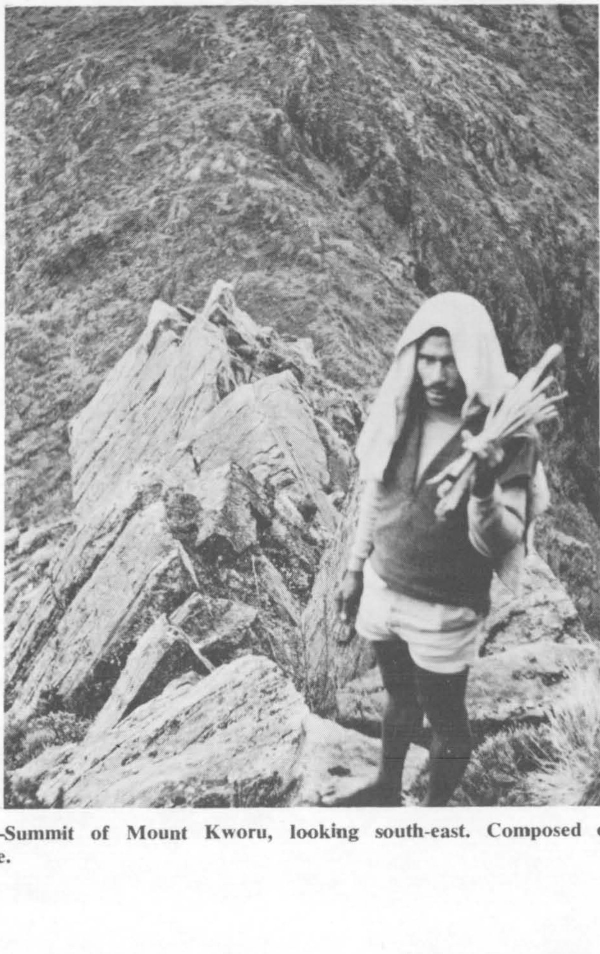


Fig. 2—Summit of Mount Kworu, looking south-east. Composed of frost-riven granodiorite.

Plate 3

Fig. 1—Looking eastwards from Mongum Airstrip. Mount Barangam on the right; U-shaped glacial valley in the middle, notched by later downcutting of the river.

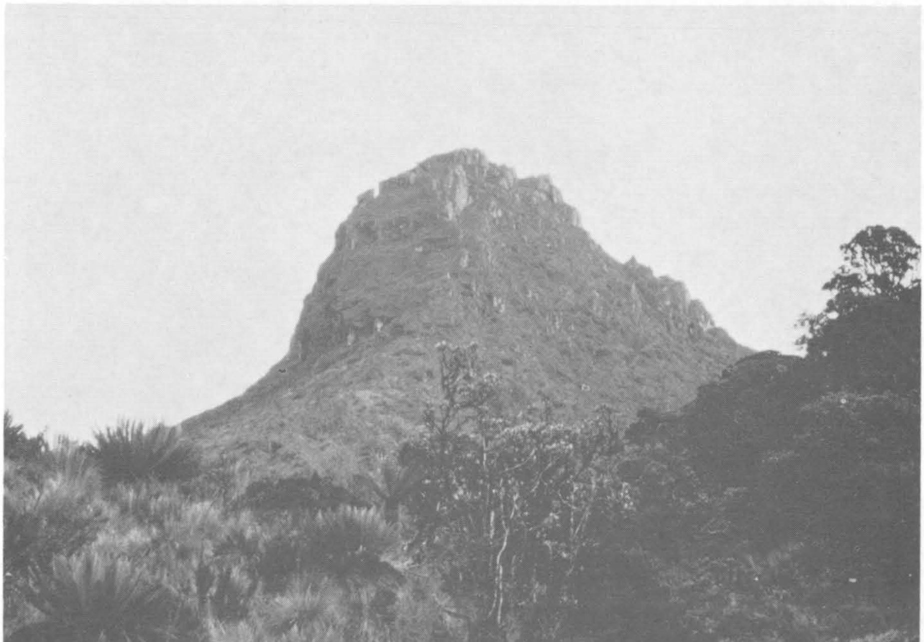


Fig. 2—Mount Kworu (14,500 feet) taken from near the head of the Jimi River. It is composed of granodiorite.

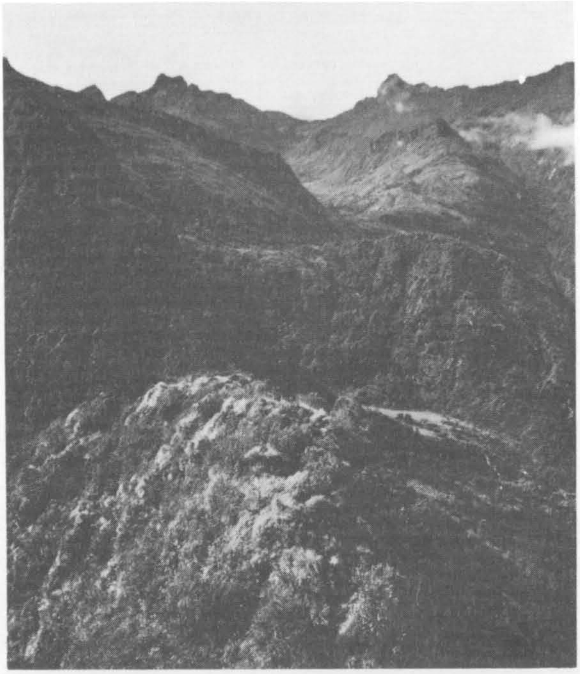


Fig. 1—The head of the Jimi River, taken from Mount Barangam, looking south-eastwards. Shows U-shaped glacial valley (middle background) and a cirque (grassy flat right foreground). Mount Wilhelm (15,400 feet) is the peak in the left background.

Fig. 2—Laminated, silicified siltstone and shale of the Goroka Formation in a tributary of Korogi Creek. Intruded by a porphyry sill related to the Bismarck Granodiorite.

Plate 5

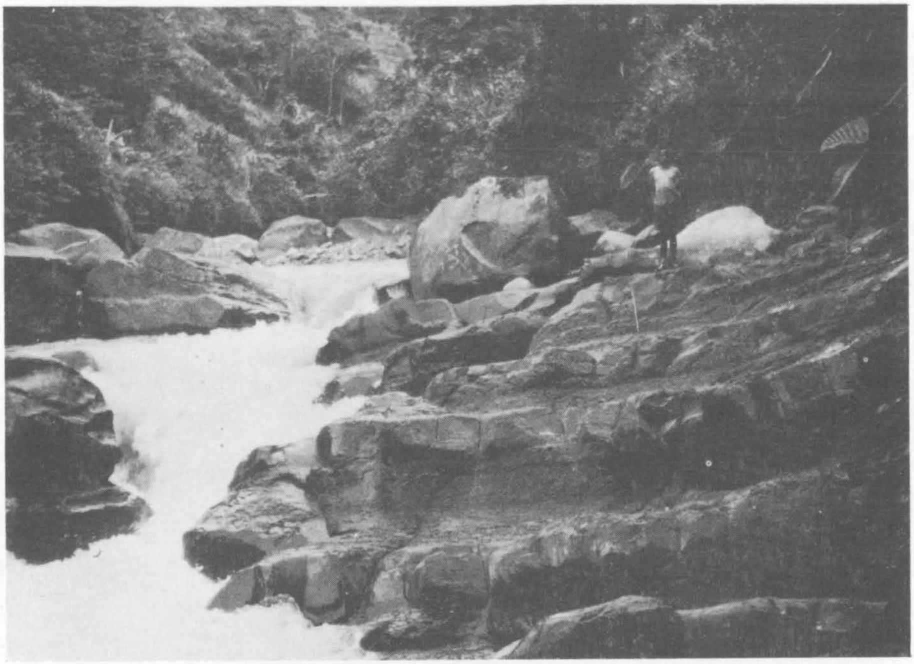


Fig. 1—Fossiliferous Balimbu Greywacke in the Jimi River, two miles north of Mongum. Shows resistant greywacke with less resistant shale interbeds.

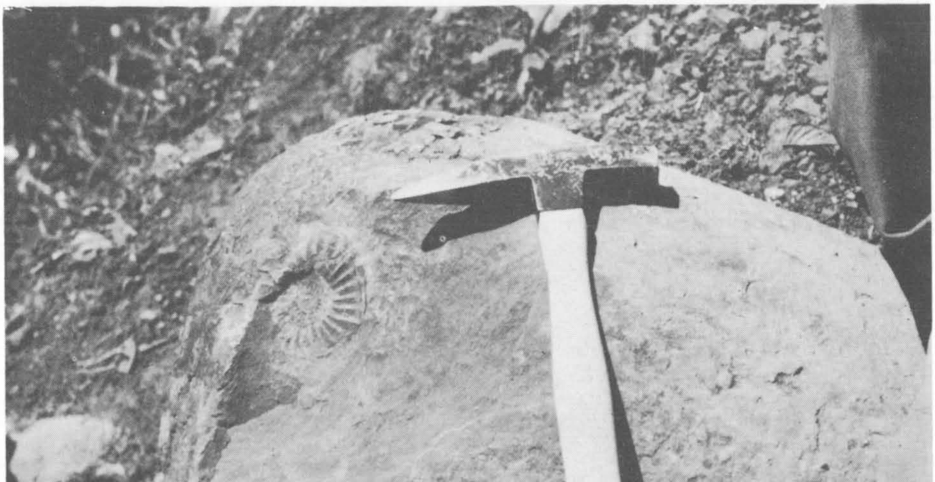


Fig. 2—*Tropidoceras*(?) in Balimbu Greywacke from locality H558, two miles north of Mongum.

Plate 6

Fig. 1—Interbedded fine-grained greywacke and shale near the base of the Maril Shale. The white boulders are granodiorite from the Wilhelm Massif. Photo taken in the Jimi River near Mongum Village.

Fig. 2—Contorted purple and green Asai Beds near the Simbai Fault in the Lower Yemi River.

Plate 7

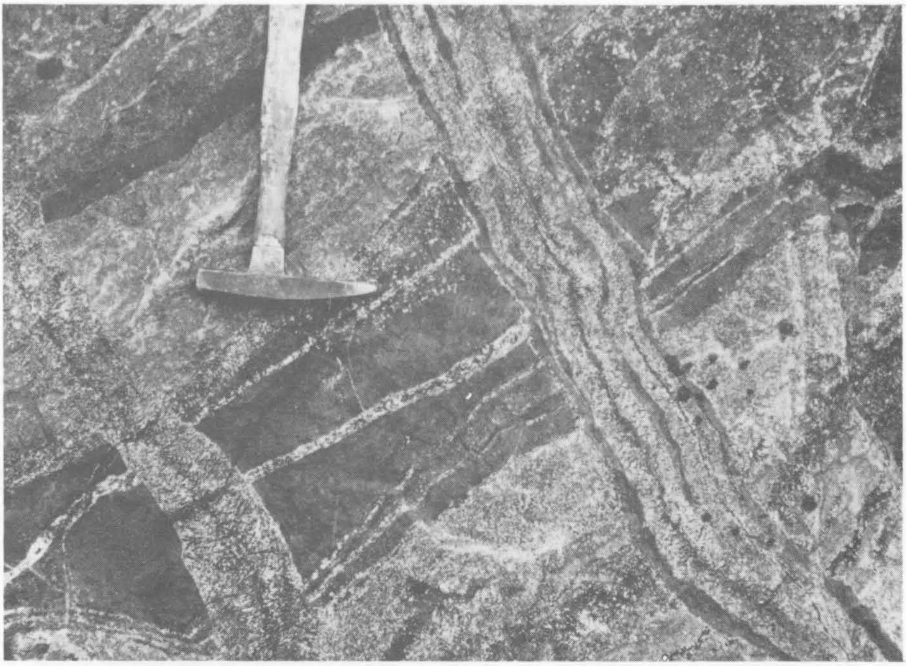


Fig. 1—Complex veining in Oipo Intrusives near Mount Oipo. Veins range in composition from pyroxenite to quartz diorite.

Fig. 2—Stockwork in Oipo Intrusives. Angular fragments are melanocratic gabbro penetrated by veins of (?)anorthosite.

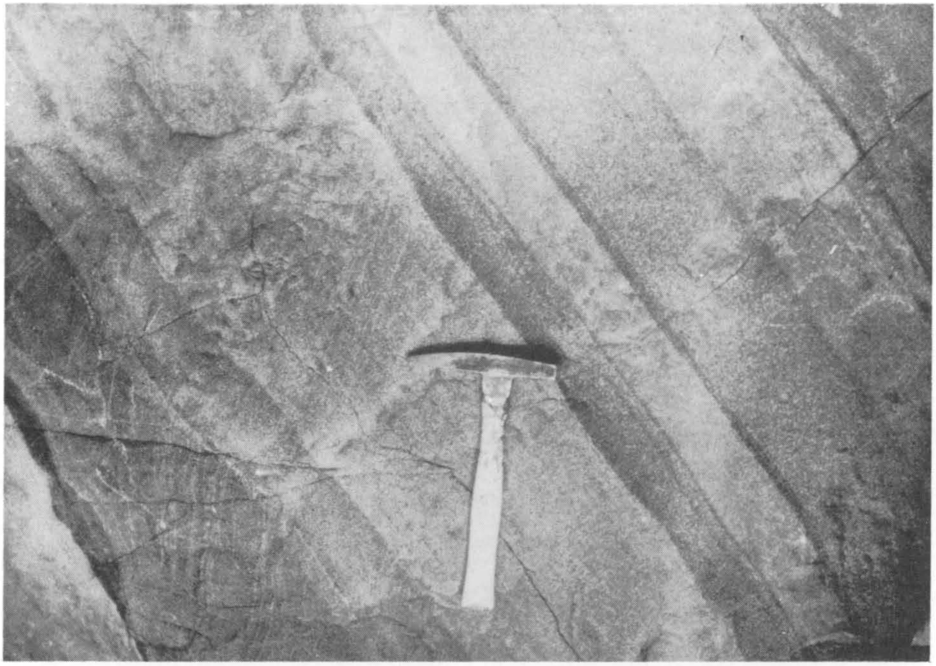


Fig. 1—Banded gabbro of the Marum Basic Belt, Singari River.

The thick limestone lens near the top of the section, though mostly recrystallized, contains thin foraminiferal lenses in which specimens of the Eocene genera Discocyclina and Operculina were determined by Belford (1960).

Two miles north-east of Kumbruf, the Simbai River follows the Simbai Fault, but the Asai Beds are again exposed north of the fault. They are indistinguishable from the rocks south of the fault, and Belford also determined Eocene Nummulites and Discocyclina from a sample of limestone interbedded with phyllitic siltstone.

Most of the rocks north of the Simbai River were called 'sub-schist' in the field. In hand-specimen this rock is fine-grained, black or dark blue, and has a regional schistosity marked by many small, closely-spaced shear-planes. It is difficult to find unsheared fragments of any size, but where they are preserved, they are similar in composition to the phyllitic siltstone at Tunonk Creek. The rocks in this area invariably contain ramifying calcite veins, and the bedding has been obliterated by the schistosity.

Up to 8 miles from the Ramu River, the beds have been metamorphosed to quartz-sericite schist.

Rocks of similar lithology occur as wedges in the Bundi Fault Zone: they are highly contorted and sheared, and their thickness could not be determined. Contacts with other units are generally faulted, but in the Yemi River the Asai Beds are probably conformably underlain by highly altered Kumbruf Volcanics, though here, too, shearing renders field relationships ambiguous.

The Asai Beds in the Bundi Fault Zone are mainly shale and siltstone, which in places have been metamorphosed to phyllite and fine-grained sericite schist. The formation also contains beds of pebble conglomerate, recrystallized limestone, and rare quartz sandstone.

Bedding can generally be distinguished in good exposures: dark blue and dark grey beds, between a quarter of an inch and two inches thick, alternate with thinner, light-grey or cream, slightly coarser-grained siltstone bands. Distinctive purple and green banded shale and siltstone were observed in the Marum and Lower Yemi Rivers (Plate 6, Fig. 2), but they do not appear to be confined to any particular horizon.

Several samples of the siltstone and shale were examined in thin section. They consist of minor angular to subangular silt-size fragments of quartz and plagioclase in a fine-grained matrix. The rocks are generally metamorphosed to some degree; ferromagnesian minerals have been altered to chlorite, feldspars to kaolin, and quartz grains are recrystallized to a mass of interlocking small grains. The matrix is reconstituted in all samples; in one rock, a fine-grained muscovite schist, the matrix has partly recrystallized as fairly large flakes of muscovite.

The metamorphism of the fine-grained sediments to phyllite and schist may have been caused partly by shearing, but contact metamorphism by gabbro dykes was probably the most important factor.

The conglomerate of the Asai Beds occurs as lenses up to 20 feet thick; it is highly indurated, and consists of pebbles of quartz, quartzite, chert, and dolerite, in a dark greywacke matrix. Much of the conglomerate is highly sheared; the matrix is schistose, and the pebbles are flattened or sheared. One mile north of Aindem a sheared calcareous conglomerate consists of flattened pebbles of green chert and black shale in a grey, highly calcareous matrix.

Lenses of limestone from a few inches to about twelve feet thick are found throughout the formation; they are light grey to cream, and are almost invariably recrystallized. Beds of fine-grained sandstone noted in the Marum River are interbedded with dark grey siltstone and range in thickness from a few inches to about two feet.

Quartz veins found throughout the formation are generally parallel to the schistosity. The calcareous sediments contain ramifying calcite veins, and pyrite occurs near gabbro intrusions as disseminations, small veins, and joint linings.

Foraminiferal limestones collected by McMillan & Malone (op. cit.) and Dow (1962a) from scattered localities in the Bundi area, and near Kumbruf, show that the age of the Asai Beds ranges from Upper Cretaceous to Miocene (Tertiary 'e' stage).

PLEISTOCENE

Kirambul Conglomerate (New Name)

'Kirambul Conglomerate' is the name proposed for a gently dipping pebble conglomerate containing mudstone and sandstone bands; the name is derived from Kirambul Village located in the Ramu Valley at 145^{o}7'E., 5^{o}26'S. The formation crops out along the south side of the Ramu Valley between Faita and the Simbai River, and is separated from the Marum Embayment by a mile-wide, alluvium-filled valley.

The conglomerate is deeply weathered, and consists of well-rounded pebbles and cobbles in a clay or sandstone matrix. Only the pebbles most resistant to weathering are now recognisable, and these are indurated greywacke, siltstone, and dolerite. Bands of weathered sandstone, mudstone, and carbonaceous siltstone, up to two feet thick, are interbedded with the conglomerate.

The formation is characterized by fine dendritic drainage, which shows plainly on the airphotos. Viewed from a distance, the surface of the formation is seen to dip away from the Bismarck Range at about 3^{o}; the surface of the formation is about 80 feet above the level of the Ramu flood-plain near the Marum Embayment and merges with the flood-plain near the Ramu River.

The formation is similar to Recent alluvium being deposited by the larger streams draining the Bismarck and Schrader Ranges, but it is deeply weathered and dissected, and is therefore considerably older. Its limited outcrop near rivers draining the Wilhelm Massif could be explained by local uplift, but we prefer the explanation that the formation is an outwash fan resulting from accelerated erosion during glaciation of the Wilhelm Massif.

RECENT

Alluvium:

The flood-plain of the Ramu River is composed mainly of siltstone and mudstone which contain lenses of pebble conglomerate up to five feet thick. The streams draining the Bismarck Mountains have deposited alluvial fans, composed of gravel and conglomerate, which merge with the flood-plain.

Small patches of gravel and conglomerate have been formed where small tributaries have been impounded by recent movements on the Bundi Fault Zone. Examples are seen at Marum Village, Simbai Patrol Post, and Dimba Creek. The auriferous gravels which cap the prospect ridge at Kumbruf were deposited as a result of a similar, but older, movement of the Simbai Fault.

UNKNOWN

Basic Volcanic Rocks of Mount Udon

Mount Udon is composed of basalt, agglomerate, and dolerite of unknown age. To the north-west the volcanics are probably faulted against Mongum Volcanics, but contacts with other rocks are in inaccessible country on the flanks of Mount Udon.

The upper part of Mount Udon consists of a sequence which has about 2000 feet of massive dolerite near its base, and which grades upwards into 2000 feet of basalt and agglomerate. Only one thin section of the dolerite was examined: it is a medium-grained, sub-ophitic variety, consisting of augite and (?) oligoclase in nearly equal proportions. The rock is not greatly altered; interstitial chlorite constitutes about 30 percent of the rock, and the feldspar is moderately altered to kaolin. Minor (?) andesite was noted within the dolerite, but it was not examined in thin section.

The volcanics consist of altered basalt, basalt agglomerate, greywacke, and siltstone. Only one specimen, called 'fine-grained agglomerate' in the field, was examined in thin section. It is an augite basalt consisting of inclusions of vesicular basalt and rare quartzite in a trachytic groundmass. The conglomerate consists of rounded to sub-rounded basalt pebbles in a tuffaceous greywacke matrix. The siltstone is dark-grey, and massive and occurs as beds between six inches and four feet thick.

In the head of the Walne River the volcanics overlie a small outcrop of possible Balimbu Greywacke, but other evidence of age is lacking. The volcanics could, therefore, be correlatives of the Mongum Volcanics (Jurassic), but they could be as young as Tertiary.

INTRUSIVE ROCKS

(?) LOWER JURASSIC

Bismarck Granodiorite

The Wilhelm Massif is composed almost entirely of granodiorite, which was first examined by Noakes (1939). He realised that the granitic rocks were part of a large batholith which he referred to as the Wilhelm Granite. Rickwood (1955) named these rocks the Bismarck Granodiorite: he mapped them as forming the Jimi-Wahgi Divide, but the 1962 survey has shown that the batholith does not extend north-westwards beyond Mount Herbert.

The batholith is 30 miles long by about 11 miles wide; its long axis trends north-west, and the granodiorite crops out between Mount Herbert and the Asaro Valley to the south-east of the map area.

Seven samples of the granodiorite taken from between Mount Kworu and Yokwagi Village were examined in thin section. The most common rock type is light-grey hornblende-biotite granodiorite, which grades with decreasing quartz content into hornblende-biotite tonalite. The plagioclase is in the oligoclase-andesine range, and iron oxide, sphene, and apatite are present as accessory minerals. In most of the samples relict crystals of augite, partly replaced by green hornblende, are common. Veins of aplite consisting of quartz, albite, and accessory biotite, sphene, and iron oxide, occur sparsely throughout the granodiorite. They are generally between six inches and several feet thick. Slight kaolinization of the feldspar was the only alteration noted.

The granodiorite is foliated in places, notably in the Marum River, where the constituent minerals are aligned parallel to the contact with the (?) Goroka Formation; the foliation was probably caused during intrusion, by flow near the margin of the batholith.

The granodiorite and tonalite in the map area are almost identical with samples of Bismarck Granodiorite, described by McMillan & Malone (1960), from near Yanderra and from the south-eastern end of the batholith.

The summit ridge of Mount Wilhelm is mainly gabbro (McMillan & Malone, op.cit.), very similar in composition to that on the north-western end of the batholith near Mount Herbert. McMillan & Malone did not differentiate the two, but we mapped the gabbro separately as a correlative of the Oipo Intrusions.

The age of the Bismarck Granodiorite is in dispute. McMillan & Malone (op.cit.) correlated it with the pre-Permian Kubor Granodiorite of Rickwood (1955), because they are very similar in composition. However, east of Mount Kworu and south of Keglsugl, the granodiorite intrudes sediments correlated by us with the Upper Triassic Kana Formation. If this correlation is sound, then the Bismarck Granodiorite is post-Triassic. Further evidence of age is seen east of Mami Village, in the Jimi River, where the Kana Formation is commonly silicified, and contains veins of quartz and pyrite, and some disseminated pyrite. This mineralization was probably introduced by the Bismarck Granodiorite. By contrast, the overlying Jurassic rocks are not mineralized; thus the granodiorite was probably intruded during the folding in the uppermost Triassic or lowermost Jurassic time. The Kana Formation is composed mainly of detritus from acidic eruptions which may have preceded the intrusion of the granodiorite.*

(?) MIOCENE

Marum Basic Belt

From work done before 1962 it was suspected that the area north of the Bundi Fault Zone was one of extensive basic and ultrabasic intrusion. In 1957 McMillan & Malone had mapped a large gabbro mass in the Imbrum River, two miles east of Bundi. Dr E. Reiner, of the C.S.I.R.O. Division of Land Research and Regional Survey, had, in 1957, collected boulders of ultrabasic rocks from streams draining country to the north-west of the map area, and M.D. Plane (1962), had mapped a large body of gabbro near the mouth of the Simbai River. We have established that basic and ultrabasic rocks form a belt about 50 miles long and about 8 miles wide, between the Simbai River and the Marea River, which is 9 miles east of the Imbrum River. We have named this belt the Marum Basic Belt, and have taken the name from the Marum River, which crosses the middle of the belt.

The Marum Basic Belt is bounded by the Simbai Fault to the south, and the Ramu Valley to the north. At its western end it has a complex, faulted, and possibly intrusive

*Footnote: The age of a sample of Bismarck Granodiorite collected by M. Plane from near Yanderra has recently (Nov. 1963) been determined by M. Bofinger, using the Rubidium/Strontium method, as 194 million years i.e. early Upper Triassic. The result is preliminary only, and results from other samples could cause it to be amended slightly (M. Bofinger, pers. comm.).

contact with the Tertiary Asai Beds, and at its eastern end it is cut off by convergence of the Bundi Fault Zone and the alluvium cover of the Ramu Valley. The feldspathic rocks of the belt near the Marum River are less resistant than other rocks in the area, and they form the Marum Embayment, an area of subdued topography (see Physiography).

The belt consists of two main rock types - feldspathic basic rocks, and ultrabasic rocks - which were mapped separately. The feldspathic rocks crop out over an area of about 300 square miles on both ends of the belt, and ultrabasic rocks cover an area of about 100 square miles in the middle of the belt between the Baia River and the Marum River. Serpentinite intruding Asai Beds north of the Simbai River belongs to the Marum Basic Belt, and the large gabbro intrusions in the same area are shown on the Geological Map (Plate 10) as part of the Marum Basic Belt, though they could belong to the Oipo Intrusives.

Ultrabasic Rocks. Only two traverses were made across the ultrabasic rocks, one parallel to the Marum River, and the other parallel to the Baia River. The rocks are dunite or serpentinite, except for a small outcrop of pyroxenite found near the mouth of the Marum River. Pyroxenite boulders were found in streams draining the ridge between the Singari River and the Yemi River, but the rock was not found in place.

The dunite is light brown where fresh, and consists of olivine and scattered euhedral crystals of chromite. It is generally serpentinized, but all grades from fresh dunite to serpentinite were seen. The pyroxenite is brown and coarse-grained, and consists almost entirely of hypersthene and accessory chromite.

Boulders of pyroxenite and dunite were found in Wendink Creek, but the rocks were not found in place. The pyroxenite consists of enstatite, augite, and accessory hypersthene; the dunite is fractured and slightly serpentinized, and consists of olivine and accessory chromite. Black serpentinite occurs within the large shear-zone in the gabbro along Wendink Creek, and the ultrabasic rocks in this locality have probably been emplaced along the shear-zone.

Basic Rocks. Both ends of the Marum Basic Belt are composed mainly of basic rocks. These rocks were not mapped in detail because most of the area is almost inaccessible, but representative samples were examined in thin section. Most of these are gabbro; one is norite. Anorthosite and gabbro pegmatite occur as veins within the gabbro.

In thin section the gabbro is seen to consist of plagioclase ranging in composition from labradorite to anorthite (30% to 70% of rock), augite (up to 55%), hypersthene (up to 10%), and accessory ilmenite, magnetite, and chromite, each of which may rarely constitute up to 10 percent of the rock. The gabbro is generally fresh, but in some specimens the feldspar has been kaolinized, and the pyroxene has commonly been partly converted to hornblende. The norite is fine-grained, and consists of saussuritized anorthite (An_{92}), hypersthene, and accessory clinopyroxene. One sample examined proved to be olivine gabbro.

Banding is common in the gabbro at the north-western end of the belt, but is rare at the south-eastern end. With few exceptions it strikes slightly north of west, parallel to the Simbai Fault, and dips both north and south at 20° to 30°. Dark, highly mafic bands alternate with more feldspathic, lighter-coloured bands (Plate 8, Fig. 1). The bands are two to four inches thick, and rarely exceed twelve inches; the lighter-coloured bands are generally thicker than the dark ones. The bands are fairly uniform in composition and grain-size.

In thin section, the dark bands are seen to be pyroxenite which grades, with increasing plagioclase content, into gabbro or norite. The pyroxenite consists of hypersthene and subordinate augite, and contains small amounts of plagioclase. The lighter bands are gabbro and rarely norite. The contacts between the bands are quite sharp, and the bands were probably formed by convection and crystal settling.

Banding observed five miles south of the airdrop site is probably of different origin. Contacts between successive bands are sharp, and commonly slickensided, and the long axes of the grains of ferromagnesian minerals in the gabbroic bands are aligned roughly parallel to the banding: this banding has possibly resulted from shearing stress at a late stage of crystallization of the magma, as suggested by Bowen (1928, pp. 168-170). In the same locality, a light-coloured, olivine-rich gabbro contains thin dark bands formed by alteration of the ferromagnesian minerals to serpentine and magnetite along parallel fractures in the rock.

The ultrabasic rocks are exposed as an irregular body which transects the banding in the basic rocks. Five miles south of the airdrop site a dyke of relatively fresh dunite, 30 feet wide, intrudes the gabbro. The ultrabasic rocks were therefore emplaced, probably as a plug, after the gabbro had crystallized.

Thin-section examination of the dunite supports this conclusion, because all rocks examined showed evidence of strong deformation. The olivine grains are crystallographically aligned, and many of them show strain-lamellae. In one section stringers of spinel are aligned parallel to the long axes of olivine crystals. Dr D.H. Green, who examined these thin sections, concluded (pers. comm.) that these features were the result of recrystallization of the olivine caused by strong deformation at high temperatures. He also examined the thin sections of the gabbro from the basic belt, and concluded that a few show igneous textures but many have a 'granulitic texture', probably caused by recrystallization under stress at high temperature.

The age of the Marum Basic Belt is not known. Field relationships are uncertain, as critical contacts were not exposed in the areas visited. However, its boundary on the north-western end is irregular, and the rocks could have intruded the Asai Beds. Other evidence is inconclusive: the large gabbro plugs north of the Simbai River could be related to the rocks of either the Marum Basic Belt or the Oipo Intrusives, and the serpentinite north of Terengi Village was probably emplaced in the solid state after the intrusion of the rocks of the main belt.

Oipo Intrusives

Oipo Intrusives was the name proposed by Dow (1962a) for gabbro and granodiorite which intrude the sedimentary rocks of the Bismarck and Schrader Ranges. The name is taken from Mount Oipo, a prominent mountain on the Jimi-Simbai Divide, about seven miles east of Tabibuga.

These rocks crop out mainly along the Bundi Fault Zone, and there are six large intrusions between the Wilhelm Massif and the Simbai Patrol Post. In addition to the intrusions shown on the geological map (Plate 10), there are a great many altered gabbro dykes along the Bundi Fault Zone which are too small to show on the map.

The larger intrusions range in composition from pyroxenite to granodiorite, gabbro and granodiorite being predominant, but relationships between the various rock-types have not been worked out.

The granodiorite is generally medium-grained to fine-grained and light-coloured. It rarely contains biotite, and thin sections show that the most common variety is hornblende-actinolite granodiorite containing plagioclase of oligoclase-andesine composition. There is a complete range in composition from granodiorite through tonalite and diorite to gabbro. The gabbro is generally coarse-grained and dark.

The Mount Oipo Stock is exceptionally complex, and consists of a network of dykes which range from less than an inch to several feet in thickness (Plate 7, Figs 1 and 2). Textures range from fine-grained to pegmatitic, and the following rock types were recognised in hand specimen: pyroxenite, pyroxene pegmatite, gabbro, dolerite, granodiorite, and (?) lamprophyre. These rocks have not been examined in thin section.

The dykes cropping out along the Bundi Fault Zone are fairly uniform in composition, and most were given the name of 'spotted gabbro' in the field. The rock is coarse-grained to medium-grained, and has an almost vitreous appearance. It contains dark blebs or spots which are between 1/4 inch and one inch in diameter. In hand specimen these blebs appear to be altered pyroxene crystals; the rocks have not been examined in thin section.

Sulphide mineralization is widespread throughout the Oipo Intrusives, particularly in the gabbro, and it occurs mostly as disseminations of fine-grained pyrite and pyrrhotite. Disseminated chalcopyrite was found in gabbro in the Marum River, three miles south-west of Marum Village (see Economic Geology).

The Oipo Intrusives intrude Asai Beds, and are therefore younger than Tertiary 'e' stage. Tertiary 'f' 1-2 stage was a time of widespread basic and intermediate vulcanism and intrusion, both in the Upper Ramu River (Dow, 1962a), and between Kompiai and Wabag, 35 miles west of the map area (Dow, 1961), and it is possible that the Oipo Intrusives were intruded during this period.

(?) PLIOCENE

Intermediate Porphyry

Small bodies of porphyry are intruded along faults south of Kol and west of Bundi. Near Yanderra the rocks are porphyritic microdiorite and quartz-biotite andesite porphyry, and they intrude Bismarck Granodiorite (McMillan & Malone, 1960); they appear to have introduced the gold and copper mineralization of that area (M.D. Plane, pers. comm.). The intrusions near Kol are leucocratic quartz andesite porphyry which grades into dacite porphyry.

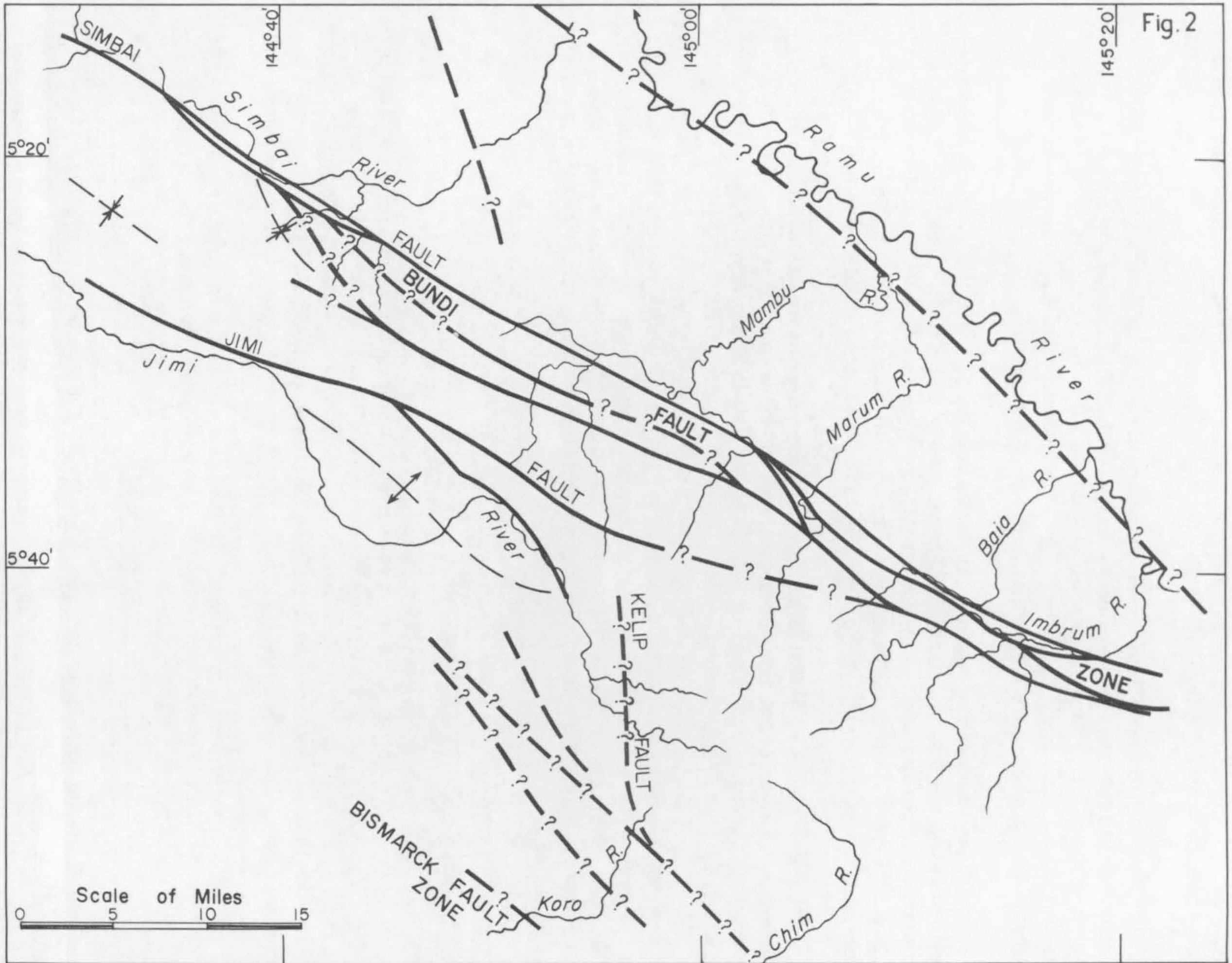
These intrusions are probably of the same age as the Ga Intrusives mapped by Rickwood (1955) in the Wahgi Valley, and are therefore probably Pliocene.

STRUCTURE

Major faulting dominates the structure of the Bismarck Mountains. The Jimi Fault is probably the oldest fault in the area, and it appears to have been active as early as Upper Triassic; it probably influenced the environment of deposition in Upper Cretaceous and Lower Tertiary time.

Two major fault-zones are recognized in the map area - the Bismarck Fault Zone (Rickwood, 1955), and the Bundi Fault Zone (Fig. 2). These are younger than the Jimi

Fig. 2



STRUCTURAL SKETCH MAP
BISMARCK MOUNTAINS
T. N. G.

REFERENCE

Fault
Inferred fault
Anticlinal axis
Synclinal axis

Bureau of Mineral Resources, Geology and Geophysics *October, 1963* B55/A5/12 JVF

Fault, and the Bundi Fault Zone is still active. The recent movement on the latter appears to be mainly transcurrent, and it is probably confined to the Simbai Fault, which is the northernmost fault of the zone. The Ramu Valley is probably a graben, but evidence of faulting on its southern margin is masked by recent alluvium from the Bismarck Mountains.

Folding is subordinate to the faulting, and most of the rocks have been openly folded along horizontal axes which are parallel to the major fault zones. The incompetent Asai Beds are highly contorted within the Bundi Fault Zone.

Jimi Fault

The Jimi Fault branches off the Bundi Fault Zone in the head of the Baia River, and trends west-north-west along the north side of the Jimi Valley (Fig. 2). It brings Middle Cretaceous Kompiai rocks to the north, against Jimi Greywacke to the south, an apparent downthrow to the north of 14,000 feet.

The fault was seen at only two places. It is best exposed in the head of Wau Creek, where sub-horizontal Jimi Greywacke is separated from steeply-dipping Kompiai siltstone and shale by a zone of shearing and gabbro intrusion about 600 feet wide. There are many ramifying calcite veins, and plentiful disseminated pyrite, within the fault zone. One of the few stream-sediment samples containing anomalous molybdenum collected during the survey was taken a short distance downstream from the fault. In the head of the Mamp River the fault is marked by a zone, several hundred feet wide, of contorted and silicified Kumbruf Volcanics, intruded by many gabbro and porphyry dykes.

Erosion has obliterated the fault trace, but the fault marks the boundary between the Jimi Valley and the Bismarck Mountains. The throw on the fault is down to the north, and the valley must have been formed by removal of the less resistant Jurassic and Cretaceous rocks which overlay the massive Triassic formations. There was probably little movement on the fault during this erosion. The fault is almost certainly an ancient one, because a branch of it does not displace Lower Jurassic rocks near Mongum (see below).

The Jimi Fault may have controlled sedimentation in Upper Cretaceous and Lower Tertiary times, because sediments of this age south of the fault were deposited in a shelf environment (Rickwood, op.cit.), and those to the north are eugeosynclinal sediments.

A splay fault branches south-eastwards from the Jimi Fault in the head of the Kana River, and follows the Jimi River as far as Mami Village. In the Kanel River, Jimi rocks are up-faulted to the north at least 500 feet. The vertical movement on the fault cannot be determined in the Jimi River, but it is probably much less than 500 feet. Dow (1962a) cites evidence of transcurrent movement on the fault seen near Mami Village. The fault may continue upstream from Mami, but it is not exposed. Certainly, it does not disrupt the overlying Jurassic strata, showing that movement on the fault had ceased by the Lower Jurassic.

Bismarck Fault Zone

The system of faults between the Wahgi Valley and the Jimi River was named the 'Bismarck Fault Zone' by Rickwood (op. cit.). During the 1962 survey two major faults were recognized where the fault-zone crosses the southern margin of the map area. The southernmost of these, in the Koro River, was mapped by Rickwood, and brings Upper Jurassic Maril Shale against Lower Jurassic Balimbu Greywacke. The other one, named here the 'Kelip Fault', after Kelip Creek, a tributary of the Jimi River, forms the western margin of the Wilhelm Massif. It strikes north-south in the head of the Jimi River, and swings rather sharply south-eastwards in the head of the Koro River, and probably joins a fault mapped by Rickwood in the Chim River. The Jurassic and Cretaceous sediments to the west have been thrown down against Triassic Kana Formation of the Wilhelm Massif.

A lineation seen on the air-photographs between the head of the Koro River and the Walne River is the trace of a splay fault of the Kelip Fault. The fault brings Upper Jurassic and Cretaceous sediments to the north against Middle and Lower Jurassic sediments to the south. The north face of Mount Udon is steep and straight, and is possibly a fault scarp.

In no place were these faults seen in outcrop, so their dip is unknown. However, they have straight or slightly curved traces which do not appear to be appreciably affected by relief, so the faults must be vertical or steeply dipping. There is insufficient information to determine the total movement on these faults. Rickwood (op.cit.) states:... 'the faults in the Bismarck Fault Zone are high-angle overthrust faults', but gives no evidence to support this contention. Vertical movements on the faults are obvious, but as the fold axes are parallel to the faults in most places, extensive transcurrent movement could have taken place, leaving little record of its magnitude. Thus, the possibility that the faults may be predominantly transcurrent cannot be ignored.

Bundi Fault Zone

McMillan & Malone (op.cit.) mapped a group of faults near Bundi, and named two of them, the 'Bundi' and 'Imbrum' Faults. Dow (1962a) mapped the Simbai Fault in the Upper Simbai River, and recognized it as predominantly transcurrent. These faults are part of a system of faults named here the 'Bundi Fault Zone'. The name 'Simbai Fault' has been retained for the largest fault of the zone.

The Bundi Fault Zone has been mapped from the Imbrum River east of Bundi, north-westwards to Simbai Patrol Post, a distance of 70 miles; it is about 8 miles wide between Bundi and the Lower Simbai River, but it narrows sharply in the Simbai River, and is only about half a mile wide near Simbai Patrol Post. It is expressed physiographically by a striking feature, the Bundi Fault Trough, which has been formed by a combination of down-faulting and erosion of the highly sheared rocks within the zone. The deepest part of the trough is on the northern side of the zone, which is the region of the active faulting.

The fault-zone separates the Marum Basic Belt from the Mesozoic rocks of the Bismarck Range, and consists of many slightly curved anastomosing faults. Many areas of poor outcrop within the zone probably conceal faults, and the structure is undoubtedly more complex than shown on the geological map (Plate 10). Each of the established faults shown on the map has been observed in at least one place as a wide shear-zone, but the lateral correlation of some of these zones is uncertain because of poor exposure in critical areas. The faults shown on the map as inferred, or partly inferred, were mapped on the basis of juxtaposition of formations of different ages.

The faults within the zone are either straight or slightly curved, and where seen, consist of vertical shear-zones up to 1200 feet wide.

The Simbai Fault is the best exposed, and it was examined at five localities, viz., the Simbai River at the mouth of Tunonk Creek, the Simbai River north of Monde Village, the lower Yemi River, the middle Marum River, and the Imbrum River north of Bundi. In these five localities, the fault is marked by a vertical zone of shearing about 1200 feet wide. Large blocks of limestone in the Tunonk Creek locality have been caught up in the fault, and have been drawn out horizontally into marble lenses up to six feet wide and 100 feet long. Carbonaceous siltstone and shale within the fault have been slightly recrystallized, and are now phyllitic. Where the Kumbruf Volcanics have been involved in the shearing, they are largely mylonitized, and only rarely can relict volcanic structures be found in them.

We believe that movement on the Simbai Fault is largely transcurrent, for the following reasons:

1. Eocene foraminifera were collected from limestone on both sides of the Simbai Fault near Tunonk Creek, so very little vertical movement can have taken place in this locality.

2. The courses of some of the rivers crossing - and partly following - the Simbai Fault appear to have been displaced by fairly recent clockwise transcurrent movement on the fault, as elaborated below.

The elevation of the country north of the Simbai Fault averages about 2000 feet above the Bundi Fault Trough, and the only outlets for drainage off the northern front of the Bismarck Range are five deep gorges, the Imbrum, Baia, Marum, Mambu, and Simbai Gorges. These gorges are probably ancient features, and have controlled the drainage of the range for a considerable time.

Both the Imbrum and Baia Rivers flow south-eastwards along the fault for about four miles before breaking through the Marum Basic Belt; where these rivers are closest to each other, they are separated by a low saddle only about 1300 feet wide (Fig. 3). It is possible that the head of the Imbrum River was originally a tributary of the Baia River, and has been captured by the Imbrum River. We think this unlikely, however, because near the saddle, the Imbrum River is vigorously downcutting, and is well below the level of the Baia River, hence the rest of the headwaters of the Baia River could hardly have escaped capture.

Another explanation is that the southern block containing the headwaters of the Imbrum and Baia Rivers has moved horizontally north-westwards along the Simbai Fault relative to the Marum Basic Belt. Similar evidence for transcurrent movement on the Owen Stanley Fault was given by Dow & Davies (1964).

The other large rivers which cross the Simbai Fault - the Mambu, the Yemi, and the Marum - follow anomalous courses at the fault, but they do not conform to the simple pattern described above. It is suggested that in these cases river capture has removed evidence of transcurrent movement.

The other faults of the zone are similar to the Simbai Fault, and they are also regarded as predominantly transcurrent.

The Bundi Fault Zone, with its many curved anastomosing faults, is very similar to the Waria Graben (Dow & Davies, op. cit.) 180 miles to the south-east. The geology of both areas is also very similar: basic and ultrabasic rocks to the north and Mesozoic and older rocks to the south, are separated by imbricate and tightly folded Upper Cretaceous and Lower Tertiary sediments and volcanics.

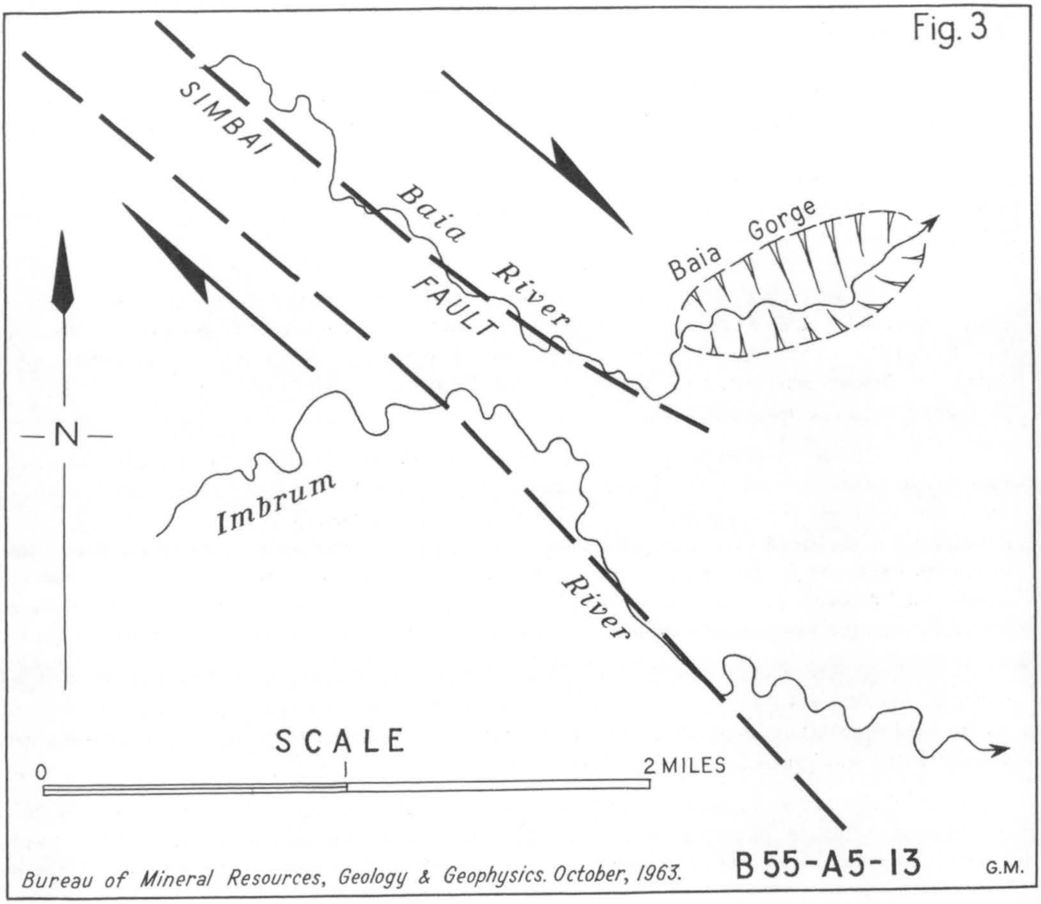


Fig. 3
SIMBAI
FAULT
Baia River
Baia Gorge
Imbrum
River
N
SCALE
0
1
2 MILES
Bureau of Mineral Resources, Geology & Geophysics. October, 1963.
B55-A5-13
G.M.

In the Waria Graben there is good evidence that the most active fault, the Owen Stanley Fault, is predominantly transcurrent, and has moved at least 14,000 feet in an anticlockwise sense since the major river valleys were formed (Dow & Davies, op. cit.).

Plane (1962) mapped a fault in the Lower Simbai River trending north-north-west, which crosses the Simbai River near Maule Creek, and brings Marum gabbro against Asai Beds. There is a thin wedge of sheared and altered volcanics along the fault, and these rocks have been tentatively correlated with the Kumbruf Volcanics. In its upper reaches Wendink Creek follows a zone of shearing, and this is possibly the south-eastern extension of the fault, and it is probably a splay fault of the Bundi Fault Zone.

Folding

Along the Bundi Fault Zone the incompetent Asai Beds are highly contorted, sheared, and intruded by many gabbro dykes (Plate 7, Fig. 1). South of the Simbai Fault, near Kumbruf, the Asia Beds dip consistently north-eastwards, and this was the only locality where a section of these rocks, albeit incomplete, could be measured.

In the Schrader Range the Asai Beds have been metamorphosed to sericite schist, and the bedding has been completely obliterated. The schistosity trends within 30^{o} of north, and dips east and west between 30^{o} and 70^{o}.

The more competent Kumbruf and Kompiai rocks have been deformed into large, fairly open, symmetrical folds. The fold axes are generally horizontal, and are parallel to the Bundi Fault Zone. The chaotic structure of the Kompiai Formation near Kwima Village, 8 miles north of Tabibuga, may have been caused by intrusion of the gabbro stock immediately to the north.

The Jimi Greywacke and the Kana Formation are massive, competent units, and they have reacted to stress mainly by block-faulting accompanied by tilting of the blocks. One large, open fold, called here the 'Jimi Anticline', trends parallel to the Jimi Fault along the Jimi Valley. It is symmetrical, and has a horizontal axis, and its flanks dip very regularly between 35^{o} and 40^{o}.

The overlying Jurassic rocks in the head of the Jimi Valley are openly folded along north-north-west-trending axes. The fold axes are horizontal, and the flanks rarely dip at more than 30^{o}.

GEOLOGICAL HISTORY

Evidence of two major periods of tectonic movement is found in the area. These have been preceded by long periods of marine deposition, under relatively stable conditions, in narrow, elongated, and probably fault-controlled troughs.

The pre-Mesozoic history of sedimentation in New Guinea is obscure because the rocks are generally contorted and highly sheared. The Goroka Formation, which is probably partly Palaeozoic, is predominantly fine-grained, and the presence of limestone lenses throughout the formation indicates that the sequence was deposited in a reef environment. Subsequent tight folding and intrusion by the Bismarck Granodiorite have metamorphosed the formation.

The fossils in the Upper Triassic Jimi Greywacke indicate a shallow-water, off-shore environment. Acid eruptions provided detrital material for the feldspathic and tuffaceous Kana Formation, which was deposited under similar conditions. This eruptive phase probably heralded the intrusion of the Bismarck Granodiorite.

Intrusion of the Bismarck Granodiorite late in the Triassic or early in the Jurassic was accompanied by uplift and erosion; it was followed by a period of almost uninterrupted marine deposition from Lower Jurassic to Middle Tertiary.

Sediments of the Lower and Middle Jurassic are known only in the Jimi Valley and the Koro River. The Lower Jurassic Balimbu Greywacke was deposited on eroded Kana rocks, probably in a narrow eugeosyncline which had its axis along the north side of the Wahgi Valley, where the sediments are thickest. To the south, the Kubor Range was land (Rickwood, op.cit.), and supplied detritus for the Balimbu Greywacke. In the Middle Jurassic one thousand feet of submarine basic volcanics were laid down in the area where the head of the Jimi Valley is now situated, but they are not known elsewhere.

The Upper Jurassic was a time of widespread marine transgression in the Western Highlands area of New Guinea, and resulted in the deposition of the Maril Shale, which has a fairly constant thickness and a remarkably uniform lithology over a large area. The area now occupied by the Kubor Range was submerged at this time, and the Maril Shale rests disconformably on Permian sediments. Buchia malayomaorica and Inoceramus haasti are common in the formation, and show that it was deposited in fairly shallow water. A remote, low-relief source of detritus is postulated to account for the fine grain of the sediments.

The Lower Cretaceous rocks are composed mainly of basic volcanic detritus. Edwards & Glaessner (op.cit.) suggested that a zone of island arcs lay to the north, and that the volcanic debris was deposited in a miogeosynclinal environment in the map area. A probable unconformity at the base of the Lower Cretaceous in the Jimi valley indicates that warping and erosion may have occurred in that area at the end of the Jurassic. Outside the map area the Cretaceous succession appears to be conformable (Rickwood, op.cit.).

In the Middle Cretaceous and Upper Cretaceous, the Kompiai Formation and the Kumbruf Volcanics were laid down in a eugeosyncline north of the Jimi Valley. The Chim Group (Rickwood, op.cit.) was laid down to the south, probably in a miogeosynclinal environment. The Jimi Fault appears to be the dividing line between the two environments, and it could have been the main factor controlling their locations. While the Kumbruf Volcanics were being laid down, there was a marked shallowing of the seas to the south, and the upper part of the Chim Group is composed mostly of coarse-grained sediments (Rickwood, op. cit.).

There was uninterrupted marine deposition in the map area from the Upper Cretaceous to the lower Miocene. The Bismarck Mountains apparently continued to be the site of a narrow eugeosyncline in which the Asai Beds were laid down. The sediments of the Wahgi Valley were deposited in a shelf environment, as shown by the predominance of reef limestone and coarse clastics in this area. It is remarkable that the fine-grained Asai Beds were laid down so close to the abundant supply of coarse-grained detritus in the Wahgi Valley. A barrier reef may have existed near the edge of the shelf, thus trapping the coarse detritus.

Widespread basic intrusion occurred north of the Jimi Valley, probably in the upper Miocene, when both the Oipo Intrusives and the rocks of the Marum Basic Belt were emplaced.

Correction

Page 35, 5th line from bottom:

"Woi Creek" should read "Soi Creek".

The faulting which probably controlled the environment of deposition from the Jurassic to the lower Miocene became more active in the Miocene and Pliocene and the major physiographic units of the Bismarck Mountains were formed by graben and horst faulting.

The Wilhelm Massif and Mount Herbert were glaciated in the Pleistocene, and supplied abundant detritus which was deposited in the Ramu Valley as the Kirambul Conglomerate.

ECONOMIC GEOLOGY

One of the main purposes of the survey was to assess the mineral potential of the Bismarck Mountains. The only recorded mineral production from the area is a small quantity of alluvial gold from the Kumbruf Gold Prospect, which was discovered by the first Government patrol into the Simbai River in 1954. Native miners have produced a very small, unrecorded quantity of alluvial gold from streams draining the Yanderra Copper Prospect, which has been known since pre-World War II days.

Minor quantities of alluvial gold are known to occur in the headwaters of the Mamp River (N. Stagg, pers. comm.), but this gold has no commercial significance.

The area north of the Simbai Fault was suspected to comprise mainly basic and ultrabasic rocks. Air-photographs showed that the area was one of moderate relief, and there was a possibility of economic concentration of nickel in overlying soils. Five auger holes were put down in soils overlying the ultrabasic rocks to test for the presence of nickel.

Most of the larger streams in the map area were panned for gold, and systematic sampling of stream sediments was carried out in conjunction with the regional mapping.

GOLD

Kumbruf Gold Prospect

Gold was first discovered in a tributary of the Simbai River by D. Leahy, who accompanied a Government patrol early in 1954. J.C. MacKinnon visited the area in September 1954, and first pegged a lease in April 1956. Total production from the prospect was 677.8 fine ounces of gold valued at £10,591. The gold from the prospect ranges in fineness from 877 to 900.

The prospect is a remnant of an elevated and weathered auriferous terrace which caps the ridge between the Tunonk and Soi Creeks in the Simbai Valley. The terrace was probably formed by blocking of the ancestral Tunonk Creek by movement along the Simbai Fault, which crosses the mouth of Tunonk Creek.

Tunonk and Soi Creeks have progressively cut down through the auriferous gravels, and have left a series of terraces down the side of the ridge, some of which the lessee has worked for gold. The beds of the two creeks and Nanoi Creek, a tributary of Woi Creek, were also worked.

Gold is at present shedding from the vicinity of porphyritic microdiorite intrusions in the head of Tunonk Creek, and it is undoubtedly this source which supplied the gold in the terrace. However, the source is neither rich nor extensive, and recent testing on the terrace

(Dow, 1962b) shows that it is not an economic proposition. A forty-foot-deep section of the terrace from the bottom of the old channel of Tunonk Creek was tested, and gave an average value of fourpence per cubic yard. The younger terraces were enriched by the flanking creeks, cutting down through the older terraces, but most of these were worked out at the time of Dow's latest visit, and work on the deposit ceased in May 1962.

Traces of alluvial gold were found at four localities:

Kunun and Pint Rivers

The porphyry intrusions at the head of Tunonk Creek extend to the headwaters of the Kunun and Pint Rivers, which are tributaries of the Jimi River. Dow (1962a) confirmed the presence of gold in these rivers, but the values are poor. A recent terrace of the Pint River, which was considered the most likely prospect, was tested (Dow, 1962a) by means of a portable sluice box, but the results were disappointing, and only 0.01 ounce of gold was recovered by four labourers for one day's boxing. The gold from both this terrace and Kumbruf Prospect is between 870 and 900 fine.

Upper Jimi River

The Kana and Upper Jimi Rivers both contain gold which appears to be derived mainly from feldspathic sandstone and conglomerate of the Kana Formation. The Bismarck Granodiorite has possibly also contributed some of the gold, but no gold was found in the head of the Upper Jimi River, which contains many granodiorite boulders. The Jimi River has a fairly flat gradient below the junction with the Kana River, and the recent terraces in this locality may carry sufficient gold to warrant working by the local natives.

Headwaters of the Mamp River

Traces of gold were found in the Mamp, Yemi, and Yigile Rivers, but because the streams are steep there are no extensive alluvial terraces, and the possibility of an economic concentration of gold is remote. The most promising occurrence is in the head of the Yigile River, where three natives produced about half a pennyweight of gold, reputedly in two days, by means of ground-sluicing. We did not visit the locality, but were shown the gold, which was fairly well worn, and of high fineness.

The gold in these localities was probably introduced during the intrusion of the more acid phases of the Oipo Intrusives.

Yanderra

Cupriferous calcite veins in the Bismarck batholith near Yanderra, sampled by McMillan & Malone (op.cit.), assayed 4 pennyweight of gold per ton. Natives have worked streams in the area for gold, but there is no record of the production.

COPPER

Copper mineralization at Yanderra has proved to be fairly widespread, but so far generally low-grade (M.D. Plane, pers. comm.). The primary mineralization consists of disseminated chalcopyrite and cupriferous calcite veins in the Bismarck Granodiorite and the younger andesite porphyry. A prospecting lease has been taken out over the area of mineralization, and investigation by private company is continuing.

Chalcopyrite was found in gabbro in three localities in the map area, but the mineralization was either very low-grade, or else of small extent. Probably the most important of these localities is in the Marum River, four miles south-south-west of Marum Village, where gabbro of the Oipo Intrusives contains scattered grains of chalcopyrite. A sample assayed only 0.06 percent copper but the mineralization appeared to be fairly widespread, and the area warrants further examination. A boulder of gabbro containing disseminated chalcopyrite was found in a stream draining the Marum Basic Belt, three miles north of Bundi. It assayed 0.11 pei cent copper. Only one cupriferous boulder was found and the deposit is probably of only small extent.

Boulders of gabbro containing veins of chalcopyrite and pyrrhotite were found in the Singari River, in the Marum Basic Belt. They come from a small shear-zone which is only about 18 inches wide, and contains small irregular patches of sulphide; selected samples assayed 3.45 percent copper. The deposit is too small to be commercial.

A small pebble of quartz containing malachite and galena was found in Wendink Creek, Lower Simbai area, but its source was not traced. Boulders of granodiorite containing small quartz-chalcopyrite veins less than a quarter of an inch wide were found in a tributary of Korogi Creek, four miles south of Marum Village. Pebbles of quartz containing galena, (?) molybdenite, sphalerite, and chalcopyrite were found in the same tributary.

GEOCHEMICAL SAMPLING

To assist in locating mineral deposits, samples of stream sediments were taken in main streams and small tributaries thoughout the area, and were later analysed by spectrograph in the Bureau of Mineral Resources laboratory at Canberra for nickel, copper, cobalt, vanadium, molybdenum, and lead. Tin and beryllium were sought but were not detected in any sample.

Stream sediments with anomalously high metal contents may have been enriched in metals by dispersion downstream from a mineralized area, and analyses of these sediments may help to reveal economic mineralization. Since high rainfall and steep slopes prevail in the Bismarck Mountains, the stream sediments contain only small clay fractions; consequently, the adsorption of metallic ions on clay particles probably contributes little to the metal contents of the stream sediments. We believe that in these mountains, metallic anomalies in stream sediments mostly result from the incorporation of small fragments of mineralized rock or vein material carried in the streams.

In the Bismarck Mountains, stream sediments were taken from the beds of main streams and small tributaries generally from fine-grained sediments deposited by eddies. In rugged country geological traverses were widely spaced, and many streams were not sampled (Pl. 9). The wet samples were sieved by a shaker consisting of a metal cylinder with 80-mesh nylon stretched across it. A suspension of sediment and water was placed in a plastic mug which was clamped on one end of the cylinder, and the contents were shaken into an empty mug on the other end. The samples were put into small plastic bags, and analysed by spectrograph in the Bureau of Mineral Resources laboratory at Canberra at the end of the season.

The locations of the 147 samples assayed are shown on Plate 9 and the results are given in Appendix 1. Few anomalies were found and the results are discussed below.

Copper Anomalies

Most of the stream sediments contain between 10 and 30 ppm copper: streams draining Kumruf Volcanics and gabbro are exceptional, and their sediments commonly contain 50 ppm copper.

Taking into account the rock types drained by the streams tested, only four samples are regarded as anomalous and three of these were taken from streams draining the northern part of the Bismarck Granodiorite. A sample taken 2 miles downstream from the Yanderra Copper Prospect contains 300 ppm copper, the highest anomaly found. The stream has a steep gradient, and most of the sediment collected was silt size, so it is likely that the high copper value is due to detrital material transported from the mineralized area, and not to adsorption of copper by clay. This anomaly suggests that copper mineralization can be detected up to 2 miles downstream from the deposit in the area of high rainfall and steep streams.

The other anomalous sample, containing 150 ppm copper, is in a small stream draining Asai Beds seven miles north-west of Bundi. The source of the anomaly is probably gabbro which intrudes the Asai Beds in this area. Disseminated chalcopyrite was found in gabbro four miles north of Bundi. Sediments taken from Korogi Creek and the head of the Imbrum River, both of which drain Bismarck Grandiorite, contain 50 ppm copper, a value equalled only by stream sediments derived from gabbro and the Kumbruf Volcanics.

Molybdenum Anomalies

Molybdenum was notably absent in all but five samples. Two of the anomalous samples were collected from streams draining the Bismarck Granodiorite, and are probably related to the source of the anomalous copper in the area. Two are in the head of the Yemi River which drains altered volcanics, and the fifth is in the head of Wau Creek, where gabbro intrudes Jimi Greywacke along the Jimi Fault.

Nickel and Cobalt

High nickel and cobalt values were found in the lower part of the Baia River in streams draining dunite and serpentinite. Almost identical values were found by Davies & Ives (op.cit.) in streams draining ultrabasic rocks.

Vanadium

The vanadium content of the samples was high, mostly between 100 ppm and 500 ppm, but the values could not be related to rock-types.

NICKEL SAMPLING

Scout auger holes, shown on Plate 9, were drilled to test the thickness of soil over different types of ultrabasic rocks, but none reached the bottom of the soil. Representative samples were taken over every interval of five feet, and were assayed for nickel by J.R. Beevers, of the Bureau of Mineral Resources. The results are given in Table 2 below.

TABLE 2

Results of Auger Drilling, Marum Basic Belt

Hole	Depth in feet	Soil derived from:	% Nickel
1.	0 - 5	pyroxenite	0.30
2.	0 - 5	pyroxenite	0.30
3.	0 - 5	pyroxenite	0.28
	5 - 10		0.29
	10 - 15		0.24
	15 - 20		0.30
	20 - 22		0.19
4.	0 - 5	dunite	0.59
	5 - 10		1.00
	10 - 15		0.60
	15 - 20		0.72
	20 - 25		0.83
	25 - 30		1.31
5.	0 - 5	serpentinite	0.83
	5 - 10		0.94
	10 - 16		0.63

SUMMARY OF PROSPECTS

Two areas worthy of further prospecting were delineated by the survey: the ultrabasic part of the Marum Basic Belt, and the northern part of the Bismarck Granodiorite west of Bundi.

The ultrabasic rocks cover 100 square miles, and are mostly dunite and serpentinized dunite: the overlying soils proved to be at least 30 feet thick in places, and they contain up to 1.31 percent nickel. Relief is subdued over most of the ultrabasic rocks, and the weathering conditions are similar to those at Kota Baru, West Irian, where economic concentrations of nickel have been proved in soils overlying ultrabasic rocks.

Further exploration of the ultrabasic rocks would be worthwhile, and it is suggested that detailed geological traverses be made at one-mile intervals across the ultrabasic part of the belt so that the composition of these rocks can be better determined. A systematic programme of auger drilling could be conducted concurrently with the geological work.

The area between Yanderra and Yokwagi is one of proved copper mineralization. Little is known of the extent or grade of the Yanderra Prospect, but geochemical soil sampling and costeaning are warranted. Copper mineralization in the Marum River, and the geochemical anomalies found in the area, suggest that a detailed stream sediment sampling programme between Bundi and Yokwagi should be undertaken.

ACKNOWLEDGEMENTS

We wish to thank the officers of the Department of Native Affairs in the Western Highlands and Madang districts - in particular, Patrol Officers Jack Edwards and Frank Martin from Tabibuga and Bundi, respectively - for the considerable and varied assistance received during the survey.

The hospitality of Father Michael of Bundi Roman Catholic Mission, and of John Crawford of Kol Medical Aid Post, was very much appreciated after the rigorous conditions experienced while on traverse. The senior author also wishes to thank Jim MacKinnon of Kumbruf for his hospitality, when he visited the prospect between 1958 and 1961.

The skilful execution of the airdrop by John Downie, senior pilot for Ansett-MAL in Madang, was a novel experience for both us and our native carrier line, and did much towards raising our morale when we were in the unpopulated Ramu Valley.

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APPENDIX 1

RESULTS OF SPECTROGRAPHIC ANALYSIS OF STREAM SEDIMENT SAMPLES

by

E.J. Howard

(Results in parts per million)

Sample No.	Ni	Co	Cu	V	Mo	Pb
H33	20	5	30	70	a*	10
H69	50	10	50	100	a	20
H77	20	10	10	500	a	10
H78	10	10	30	150	a	10
H93	5	10	30	100	a	10
H94	5	20	50	300	a	10-
H95	5-[x]	5	300	30	5	10
H98	150	30	10	100	a	10-
H102	70	30	10	700	a	10-
H103	100	50	20	300	a	10-
H105	70	30	20	500	a	10-
H106	100	50	20	300	a	10-
H109	150	70	20	200	a	10-
H112	50	20	30	150	a	10
H113	70	30	30	200	a	10-
H115a	70	30	30	150	a	10-
H115b	150	50	20	300	a	10-
H115c	150	70	10	300	2	10-
H121	150	50	10-	150	a	10-
H122	30	20	30	150	a	10-
H122	30	10	10	150	a	10-
H123	70	30	10	500	a	10-
H124	20	10	30	150	a	10
H125	20	10	20	150	a	20
H127	30	20	30	150	a	10
H130	5	5	20	100	a	20
H131	5-	10	20	100	a	10-
H133	10	10	30	70	a	20
H136	5-	10	20	300	5	10-
H141	5-	5	20	70	a	10-
H142	5	5	30	100	a	10-
H143	5-	10	20	100	a	10-
H144	5	10	20	100	a	10-
H144	20	10	50	100	2	30
H149	5	10	10	150	a	10
H150	5-	5	10	100	a	10-

[x] 5- means less than 5 ppm.
* a means sought but not detected

Sample No.	Ni	Co	Cu	V	Mo	Pb
H153	5-	5-	10	100	a	10
H156	5-	5	10	100	a	20
H157	5-	10	20	100	a	10-
H158	5	5	20	100	a	10-
H164	5	5-	20	70	a	10
H165	5	5	20	70	a	10
H166	5-	5	10	100	a	10
H169	5	5	10	70	a	20
H173	5	5	10	50	a	10
H174	5	5-	10	50	a	10
H179	5-	5	20	70	a	10
H180	5-	10	20	150	a	10
H181	5-	5	10	70	a	10
H184	5	10	30	100	a	10
H185(1)	5	10	20	100	a	10
H185(2)	5-	5	10	100	a	10-
H185(3)	5	5	10	70	a	10
H187	5	10	20	70	2	10
H192(a)	5-	5-	10	50	a	100
H192(b)	10	10	20	100	a	20
H194	10	10	30	100	a	20
H195	5-	5	20	300	a	10-
H196	5-	5	20	500	a	10-
H197	5-	20	10	300	a	10-
H198	5-	10	20	100	a	20
H209	5	10	20	100	a	20
H213	50	20	30	150	a	10
H214	50	10	30	150	a	10-
H215	70	30	50	200	a	10-
H216	70	30	30	200	a	10
H217	100	30	50	300	a	10-
H218	70	20	50	100	a	10-
H219	70	30	30	200	a	10-
H220	70	30	30	150	a	10-
H222	200	30	20	100	a	10
H224	200	30	30	150	a	10
H227	70	30	30	200	a	10-
H229	20	20	30	200	a	10
H230	5	10	20	70	a	10
H234	5	20	30	100	a	10
H237	5-	10	20	200	a	10-
H238a	5-	10	20	150	a	10
H238b	5-	10	20	150	a	10-
H240	5-	10	20	150	a	10-
H241	5-	5	10	150	a	10
H242a	5-	5	10	100	a	10

Sample No.	Ni	Co	Cu	V	Mo	Pb
H242b	10	10	30	150	a	30
H532	5-	5	20	150	a	10-
H533	5	5	20	200	a	10-
H553	20	10	30	70	a	10-
H554	5	5	20	200	a	10-
H596	5-	5	20	150	a	20
H610	5-	5	20	200	a	10
H627	5-	10	30	150	a	10-
H629	5-	20	30	500	a	10-
H640	5-	10	20	70	a	10
H641	5	20	30	150	a	10
H644	5-	5-	20	150	a	10-
H650	5-	5-	30	300	5	10
H656	150	50	20	200	a	10-
H658	No result for this sample					
H677	500	20	10	100	a	10-
H680	700	70	10-	70	a	10-
H687	300	70	10	100	a	10
H689	300	150	10-	150	a	10-
H691	150	30	150	100	a	20
H695	20	30	70	150	a	10
H697	70	20	50	150	a	20
H701	70	70	50	200	a	10
H703	20	30	50	200	a	20
H707	70	10	50	150	a	20
H711	10	10	30	100	a	20
H713	30	10	30	100	a	10
H715	5-	10	20	500	a	10-
H717	70	20	30	300	a	10-
H725	10	10	30	100	a	20
H728	5	5	20	70	a	10
H736	5	20	50	200	a	10-
H746	10	20	20	500	a	10-
H748	5-	5	10	100	a	10
H749	5-	10	10	100	a	10-
H753	5-	10	20	150	a	10
H755	5-	10	10	100	a	10-
H757	5-	10	10	100	a	10
H762	5-	10	10	150	a	10-
H765	5	5	20	100	a	20
H766	5	10	20	100	a	10
H768	5	10	20	70	a	10
H775	5	10	20	70	a	20
H776	5	5	20	70	a	10
H787	10	5	10	150	a	10-
H788	5-	5	20	100	a	10

Sample No.	Ni	Co	Cu	V	Mo	Pb
H792	5	5	10	150	a	10
H793	20	1 10	20	150	a	10
H799	150	20	50	100	a	10-
H801	5-	10	10	150	a	10-
H802	5	20	10	300	a	10
H804	5	10	10	70	a	20
H809	5-	5	20	100	a	30
H813	5-	5	20	200	a	10-
H815	5-	10	50	150	a	10
H815	5-	10	20	500	a	10-
H819	5-	10	20	200	a	20
H822	5-	10	20	100	a	30
H823	10	10	20	100	a	20
H824	5	5	20	70	a	20
H832	150	50	20	150	a	10-
H837	70	30	30	200	a	10-
H838	100	20	20	150	a	10-
H840	100	30	20	300	a	10-
H841	150	70	10	150	a	10-

Tin and beryllium were also sought, but neither was detected. A trace of phosphorus was found in samples H815 and H813.

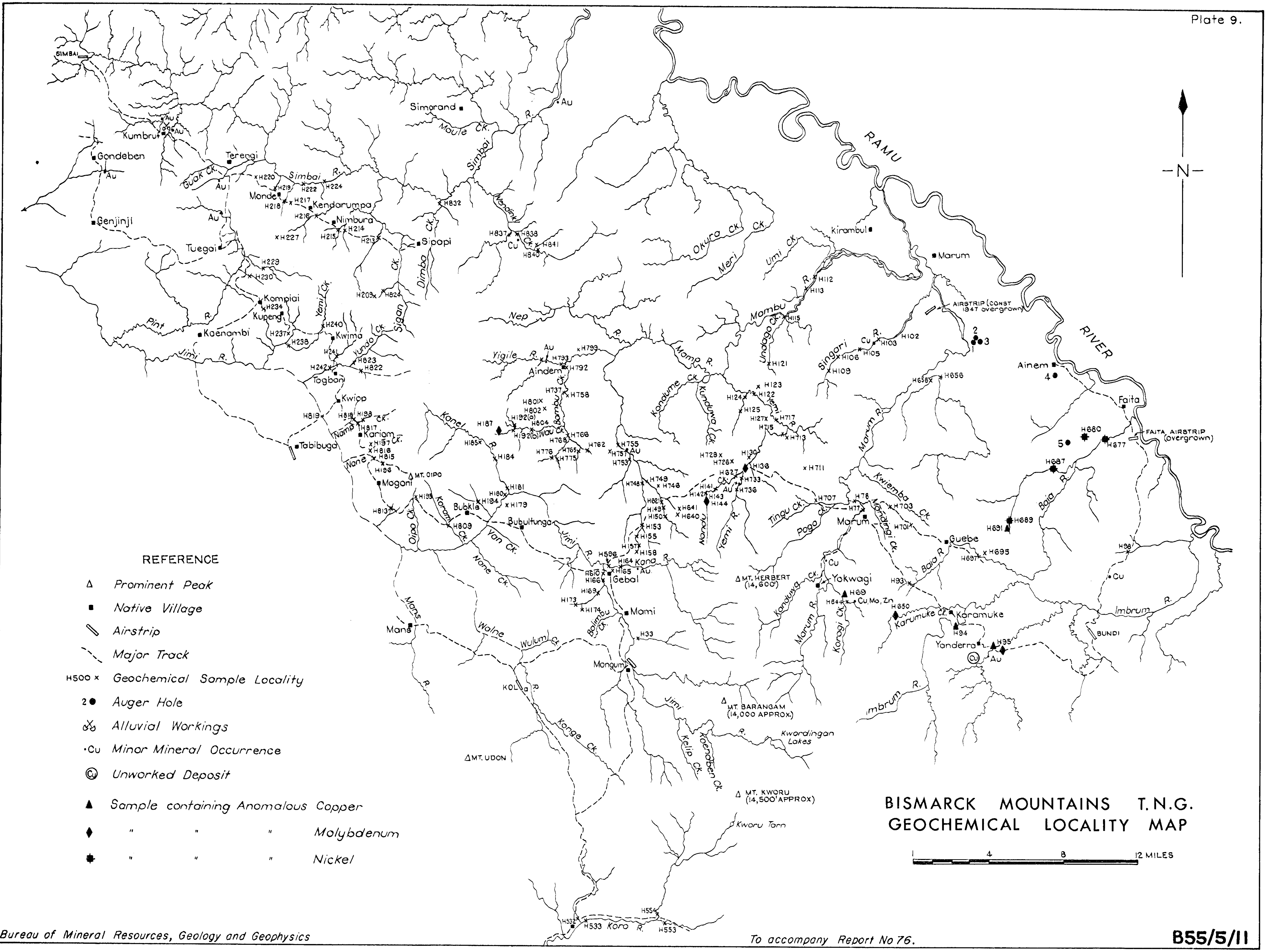
Plate 9.
BISMARCK MOUNTAINS T.N.G.
GEOCHEMICAL LOCALITY MAP
REFERENCE
Prominent Peak
Native Village
Airstrip
Major Track
H500 × Geochemical Sample Locality
2● Auger Hole
Alluvial Workings
·Cu Minor Mineral Occurrence
Unworked Deposit
Sample containing Anomalous Copper
" " " Molybdenum
" " " Nickel
12 MILES
N
RAMU RIVER
MT. HERBERT (14,600')
MT. BARANGAM (14,000 APPROX)
MT. KWORU (14,500' APPROX)
MT. UDON
MT. OIPO
Jimi R.
Simbai R.
Bureau of Mineral Resources, Geology and Geophysics
To accompany Report No 76.
B55/5/11

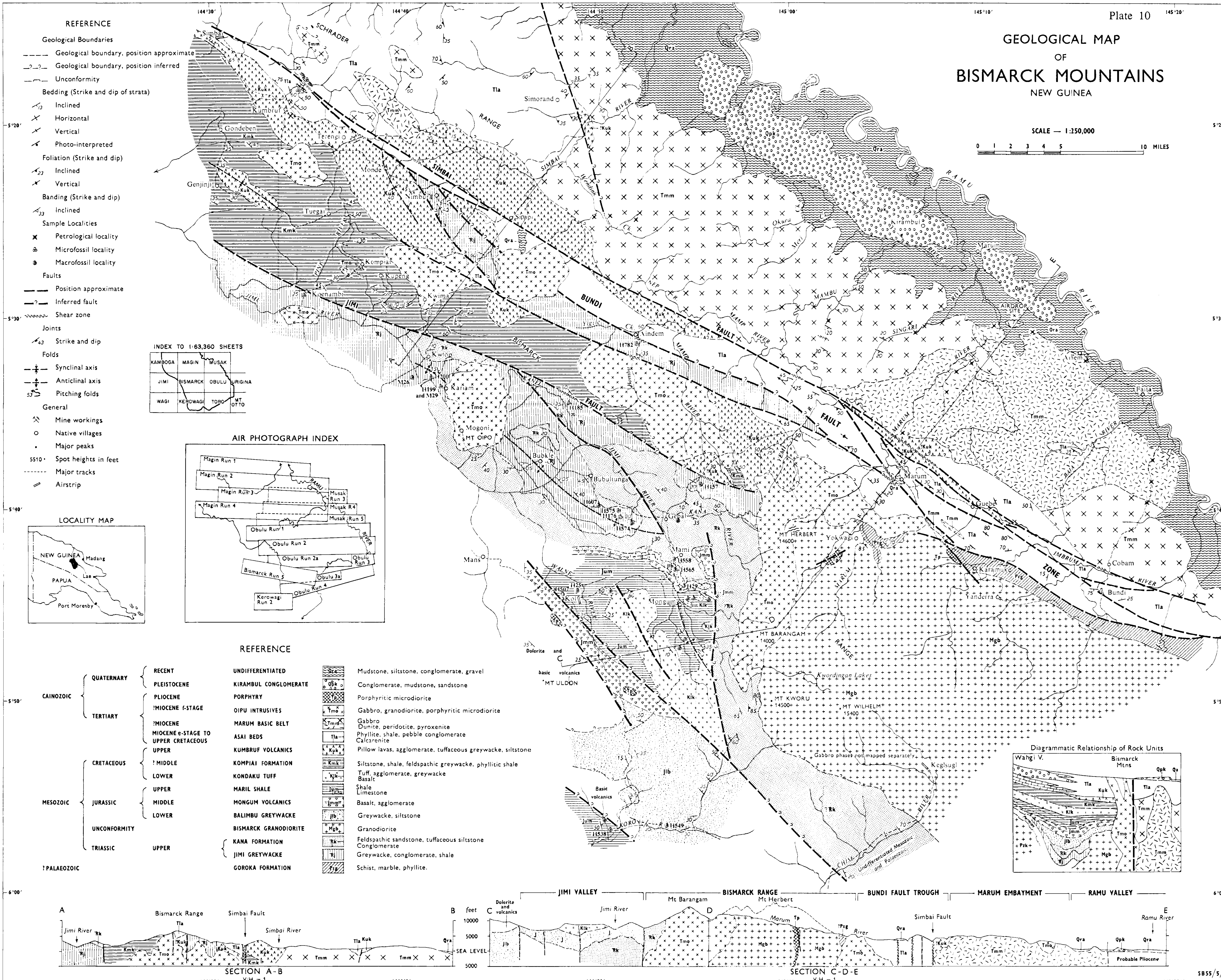
Plate 10
GEOLOGICAL MAP
OF
BISMARCK MOUNTAINS
NEW GUINEA
SCALE — 1:250,000
0 1 2 3 4 5 10 MILES
REFERENCE
Geological Boundaries
Geological boundary, position approximate
Geological boundary, position inferred
Unconformity
Bedding (Strike and dip of strata)
Inclined
Horizontal
Vertical
Photo-interpreted
Foliation (Strike and dip)
Inclined
Vertical
Banding (Strike and dip)
Inclined
Sample Localities
Petrological locality
Microfossil locality
Macrofossil locality
Faults
Position approximate
Inferred fault
Shear zone
Joints
Strike and dip
Folds
Synclinal axis
Anticlinal axis
Pitching folds
General
Mine workings
Native villages
Major peaks
Spot heights in feet
Major tracks
Airstrip
INDEX TO 1:63,360 SHEETS
KAMBOGA MAGIN MUSAK
JIMI BISMARCK OBULU URIGINA
WAGI KEROWAGI TORO MT OTTO
AIR PHOTOGRAPH INDEX
Magin Run 1
Magin Run 2
Magin Run 3
Magin Run 4
Musak Run 3
Musak R4
Musak Run 5
Obulu Run 1
Obulu Run 2
Obulu Run 2a
Obulu Run 3
Obulu 3a
Obulu Run 4
Bismarck Run 5
Kerowagi Run 2
LOCALITY MAP
NEW GUINEA
Madang
PAPUA
Lae
Port Moresby
REFERENCE
CAINOZOIC QUATERNARY RECENT UNDIFFERENTIATED Qra Mudstone, siltstone, conglomerate, gravel
PLEISTOCENE KIRAMBUL CONGLOMERATE Qpk Conglomerate, mudstone, sandstone
TERTIARY PLIOCENE PORPHYRY Tp Porphyritic microdiorite
?MIOCENE f-STAGE OIPU INTRUSIVES Tmo Gabbro, granodiorite, porphyritic microdiorite
?MIOCENE MARUM BASIC BELT Tmm Gabbro Dunite, peridotite, pyroxenite
MIOCENE e-STAGE TO UPPER CRETACEOUS ASAI BEDS Tla Phyllite, shale, pebble conglomerate Calcarenite
MESOZOIC CRETACEOUS UPPER KUMBRUF VOLCANICS Kuk Pillow lavas, agglomerate, tuffaceous greywacke, siltstone
? MIDDLE KOMPIAI FORMATION Kmk Siltstone, shale, feldspathic greywacke, phyllitic shale
LOWER KONDAKU TUFF Klk Tuff, agglomerate, greywacke Basalt
JURASSIC UPPER MARIL SHALE Jum Shale Limestone
MIDDLE MONGUM VOLCANICS Jmm Basalt, agglomerate
LOWER BALIMBU GREYWACKE Jlb Greywacke, siltstone
UNCONFORMITY BISMARCK GRANODIORITE Mgb Granodiorite
TRIASSIC UPPER KANA FORMATION Rk Feldspathic sandstone, tuffaceous siltstone Conglomerate
JIMI GREYWACKE Rj Greywacke, conglomerate, shale
?PALAEOZOIC GOROKA FORMATION Ptg Schist, marble, phyllite.
Diagrammatic Relationship of Rock Units
Wahgi V.
Bismarck Mtns
SCHRADER RANGE
SIMBAI
BUNDI FAULT
BISMARCK FAULT
JIMI RIVER
RAMU RIVER
IMBRUM ZONE
BISMARCK RANGE
MT HERBERT 14600
MT BARANGAM 14000
MT KWORU 14500
MT WILHELM 15400
MT OIPO
MT ULDON
Kwordingan Lakes
Gabbro phases not mapped separately
Undifferentiated Mesozoic and Palaeozoic
Simbai
Kumbruf
Gondeben
Genjinji
Tuegai
Kompiai
Koenambi
Kwima
Aindem
Kariam
Mogoni
Bubkle
Bubulunga
Gebai
Mami
Mongum
Mans
Marum
Gueba
Yokwagi
Karamuke
Yanderra
Cobam
Bundi
Koglsugl
Simorand
Kirambul
Airdrop site
Ainem
Faila
Dolerite and basic volcanics
Basic volcanics
JIMI VALLEY
BISMARCK RANGE
BUNDI FAULT TROUGH
MARUM EMBAYMENT
RAMU VALLEY
Bismarck Range
Simbai Fault
Simbai River
Jimi River
SEA LEVEL
feet
10000
5000
5000
Mt Barangam
Mt Herbert
Marum River
Ramu River
Probable Pliocene
SECTION A-B
V/H = 1
SECTION C-D-E
V/H = 1
144°30'
144°40'
144°50'
145°00'
145°10'
145°20'
5°20'
5°30'
5°40'
5°50'
6°00'
Bureau of Mineral Resources, Geology and Geophysics, 1963
SB55/5/14
RJP