DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/57

EXPLANATORY NOTES ON THE RAMU GEOLOGICAL SHEET

by

J.H.C. Bain and D.E. Mackenzie

RECORD 1974/57

EXPLANATORY NOTES ON THE RAMU GEOLOGICAL SHEET

by

J.H.C. BAIN AND D.E. MACKENZIE

PLEASE NOTE:

1:250 000 geological map of Ramu was included in record 1974/58 (Explanatory Notes on the Karimui Geol. Sheet) and should be used in conjunction with this record 1974/57. (EXPLANATORY NOTES ON THE RAMU GEOL SHEET.)

Thank you

EXPLANATORY NOTES ON THE RAMU GEOLOGICAL SHEET

Compiled by

J.H.C. Bain & D.E. Mackenzie

The Ramu 1:250,000 Sheet area is bounded by latitudes 5° and 6° S, and longitudes 144° and 145°30' E. It covers 17 600 km^2 of some of the most rugged country in Papua New Guinea, and includes the highest peak, Mount Wilhelm (4509m), and a large area of flat swampy ground near sea level in the Ramu valley.

The main town and administrative centre in the area is Mount Hagen, headquarters of the Western Highlands District. Sub-district headquarters of Minj, Tabibuga (Western Highlands District), Kerowagi, and Gembogl (Chimbu District), and patrol posts at Baiyer River (Western Highlands District), Simbai, Bundi, and Usina (Madang District), and a number of mission stations are the focal points of a largely subsistence rural population of about 300 000, including about 2000 Europeans. The population is concentrated in the Baiyer-Wahgi valley area, the Chimbu and Asaro valleys, and parts of the Jimi valley. Very few people live in the mountainous areas.

Mount Hagen (Fig. 1) is linked by an all-weather road via Goroka (Karimui 1:250 000 Sheet area) to Lae on the coast, and by regular airline flights to Port Moresby, Lae, Goroka, and several other towns. All-weather roads also link Mount Hagen with Baiyer River, Minj, Banz, and Kerowagi, and with Ialibu, Mendi, and Wabag southwest and west of the Sheet area. Many kilometres of secondary road in the Wahgi and Baiyer valleys in the southwest give access to patrol posts, missions, and plantations. A road to Tabibuga was completed almost entirely without the use of machinery in mid-1970. Many secondary roads become difficult or impassable during the October to April wet season, and some, such as the Tabibuga road, are only passable in 4-wheel-drive vehicles or light trucks at any time. Most airstrips are served by scheduled or charter flights from either Mount Hagen or Madang.

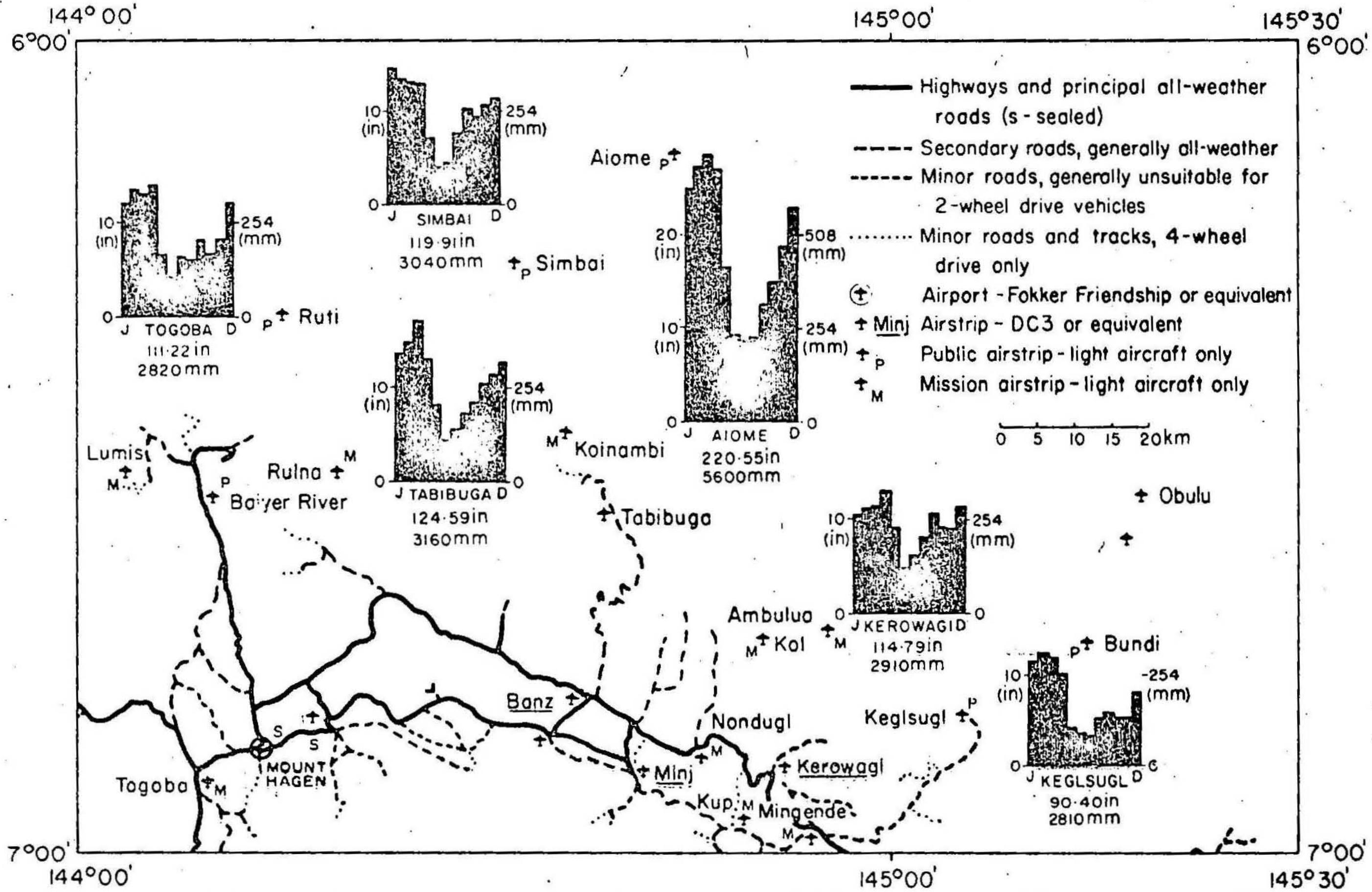


Fig.1, Rainfall at main recording centres. Average monthly distribution and annual totals. Roads and airstrips.

855/45/47

EXPLAN. NOTES RAMU J. BAIN

Walking tracks are numerous, but are closely spaced only in the more populous area. However, no area is totally devoid of tracks. The only means of access to most areas not crossed by roads or tracks is helicopter. Landings can be made on river-gravel banks, and in villages, gardens, and clearings.

Food and most other supplies are available at Mount Hagen, and at Goroka just southeast of the Sheet area. Lae and Madang are the nearest coastal supply centres.

Local labour is readily available, and indispensable for survey work in areas away from roads.

The weather in the area is dominated by the northwest trade winds which bring rain during October to April. Rainfall (Fig. 1) is greatest on the highest mountains and on the windward slopes. Mount Hagen receives about 2500 mm of rain per year which is about average for the Sheet area. Extremes range from about 2000 mm in the Asaro valley to over 5500 mm in the northwestern part of the Ramu Plains for example 5600 mm at Aiome (Fig. 1). Cloud cover over Mount Hagen averages about 80 percent; early morning cloud generally thins by 9 or 10 a.m., and then builds up again during early to mid-afternoon (Table 8. McAlpine, 1970). These conditions are typical of the whole Sheet area. Relative humidity at Mount Hagen averages 88 percent at 9 a.m. and 67 percent at 3 p.m., and is slightly higher in the dry than in the wet season (Table 7. McAlpine, 1970). Diurnal variation ranges from between 21^{o} and 32^{o}C in the Ramu plains to below 0^{o} and about 18^{o}C on the summit of Mount Wilhelm where frost is common and snow falls occasionally. In Mount Hagen town (1600 m above M.S.L.) the diurnal temperature range is between 13^{o} and 24^{o}C. Temperatures are alightly higher in the southeast along the Wahgi valley, and at Baiyer River 45 km to the north they are about 3^{o}C higher. The climate of the area is further discussed in the Explanatory Notes to the Karimui 1:250 000 Geological Series Sheet.

Much of the Sheet area is covered by tropical rainforest, low montane and montane forest, generally with a two-layered canopy. Varieties of beech (mainly Nothofagus) and oak predominate in the more hilly country, with some scattered patches of conifers; Pandanus palm is common above 2200 m. The Ramu valley is mainly grassland and low scrubby forest with areas of larger trees and swampy areas. Many valleys in the Imbrum-Marum Rivers area are partly cultivated, and there are areas of secondary growth. Many areas in the Jimi valley and most of the Chimbu River and Asaro River valleys are extensively cultivated, and areas of secondary growth and Casuarina groves are common. The Wahgi River and Baiyer River valleys are partly grassy and partly cultivated with numerous stands of conifers and some eucalypts around the gardens, particularly in the Mount Hagen and Asaro areas. Areas of alpine tussock, moss, bracken, and lichen occur on the highest peaks such as Mounts Wilhelm, Kworu, Herbert, Udon, Hagen, and Sigul Mugal. The highest parts of these peaks are mainly bare rock, or rock covered by lichen and moss; frost-shattering has affected a large area on Mounts Wilhelm and Kworu.

These notes and the accompanying map are based on field work carried out by BMR geologists from 1956 to 1970. The geology of the area northeast of the Ramu River has been taken from maps prepared by the Continental Oil Company of Australia Ltd. in 1970, supplemented by airphoto interpretation at BMR.

The topographic base map for that part of the Sheet area south of 5°45'S was prepared for Division of National Mapping 1:63 360 planimetric series preliminary edition maps enlarged to 1:50 000 scale. A small area around Mount Hagen is covered by a surveyed and contoured Army map at 1:50 000 scale. The extreme northwest corner of the map is based on an uncontrolled side-looking radar imagery mosaic. The Ramu River area is based on a poorly controlled Army Survey Corps 1:250 000 base map, corrected in places by information from aerial photographs. The remainder of the Sheet area was compiled by BMR at 1:50 000 scale from semi-controlled aerial photograph slotted template assemblies and some radar imagery.

Most of the Sheet area is covered by aerial photographs taken by Adastra, QASCO, STOL, and the RAAF. The QASCO photographs were taken from a height of 4500 m with a 152-mm focal length lens; the remainder from 7600 m. Photographs are generally of good quality though some of the Adastra photos taken in 1957 show few of the roads and other cultural details now present. Geological interpretation and base map preparation are impaired by the presence on the photographs of patches of clouds, scale differences in areas of high relief (up to 2000 m), and variation in the flight altitude. A large part of the northwestern quarter of the Sheet area, and a small area in the Jimi-Wahgi divide are covered by side-looking airborne radar imagery flown by Westinghouse-Raytheon for the Department of the Army in 1970.

Previous geological investigations

The first geologist to visit the Ramu Sheet area was E.R. Stanley who, in 1920, sailed up the Ramu River as far as Aiome, and noted pebbles of plutonic metamorphic, and sedimentary rocks (Stanley, 1922)*. N.H. Fisher, Government Geologist for the Territory of New Guinea, visited the Mount Hagen area in 1937 to inspect the gold prospect area at Kuta. K. Washington Gray collected fossils at Mingende in 1939, and in the same year Noakes (1939) made a geological reconnaissance of the Wahgi valley and measured a section in the Chimbu River and adjacent Wahgi River. A geological reconnaissance of the Mount Hagen area was made by Ward (1949), and in the same year, G.A.V. Stanley, K.M. Llewellyn, and M.F. Glaessner visited the Kubor Range Wahgi valley area (Stanley, 1950). Edwards & Glaessner (1953) made a petrological study of specimens collected by Fisher, Noakes, Stanley, Llewellyn, and Glaessner.

F.K. Rickwood surveyed the Wahgi valley, the lower slopes of the Kubor Range and the Mount Wilhelm/Jimi/Wahgi divide area, and the Mount Hagen/Baiyer River area from December 1950 to March 1951 and from December 1952 to March 1953. Mapping was done with the aid of chain, compass, and abney level, or pace and compass, as there were no base maps or aerial photographs. With the aid of work by Noakes and Edwards & Glaessner, Rickwood established the basic stratigraphy of the area (Rickwood, 1955).

* Geologists of Island Exploration Co. Pty. Ltd. in 1937 & 1938 mapped in the area between the Ramu River and Madang

Regional mapping by BMR started in 1956 in the headwaters of the Asaro River and the Mount Otto area (McMillan & Malone, 1960). D.B. Dow (1961, 1962) reconnoitred the Sau River and Jimi River areas in 1961-62, and Dow & Dekker (1964) mapped the upper Jimi valley in 1962. In 1966 a BMR field party led by Dow visited the Yuat River area by jet boat. In 1967 J.H.C. Bain made a geological reconnaissance of part of the Schrader Range in the north (Bain, 1967), and in 1967 Bain and R.J. Ryburn mapped an area around Tabibuga. The area south of 5°45'S was mapped in detail by Bain and others (Bain et al., 1970), and the remainder of the Sheet area - the Jimi-Wahgi divide, Baiyer River, and upper Yuat River areas - was mappedin 1970 (Mackenzie & Bain, 1972).

Reiner (1960) described glacial features on Mount Wilhelm. Further work on the samples examined by Edwards and Glaessner (1953) was published by Crook (1960) who discussed diagenesis in the Wahgi valley Mesozoic sedimentary sequency. CSIRO conducted a survey of land systems, soils, vegetation, and geology of the Wabag-Tari area in 1960-61 (CSIRO, 1965). This area included part of the western side of the Ramu Sheet area. A similar survey by CSIRO in 1968-69 covered the Wahgi, Baiyer, and Asaro valleys, the northern Kubor Range, and part of the Wahgi-Jimi divide (CSIRO, 1970).

Geologists of the Continental Oil Company of Australia Ltd mapped the area northeast of the Ramu River in the course of petroleum exploration (1965-1969).

Jakes & White (1969) published analyses of five specimens from the Mount Hagen volcanic complex, and their conclusions as to the origin of the Hagen Volcanics were questioned by Johnson et al. (1970, 1971).

Specimens from the Kubor Granodiorite, Kimil Diorite, Bismarck Intrusive Complex, the Lower Jurassic unamed intrusives (Jlu; previously called Urabagga Intrusives), and the Yaveufa Formation (previously called Daulo Formation) have been isotopically dated by R.W. Page (Page, in prep; Page & McDougall, 1970 a, b).

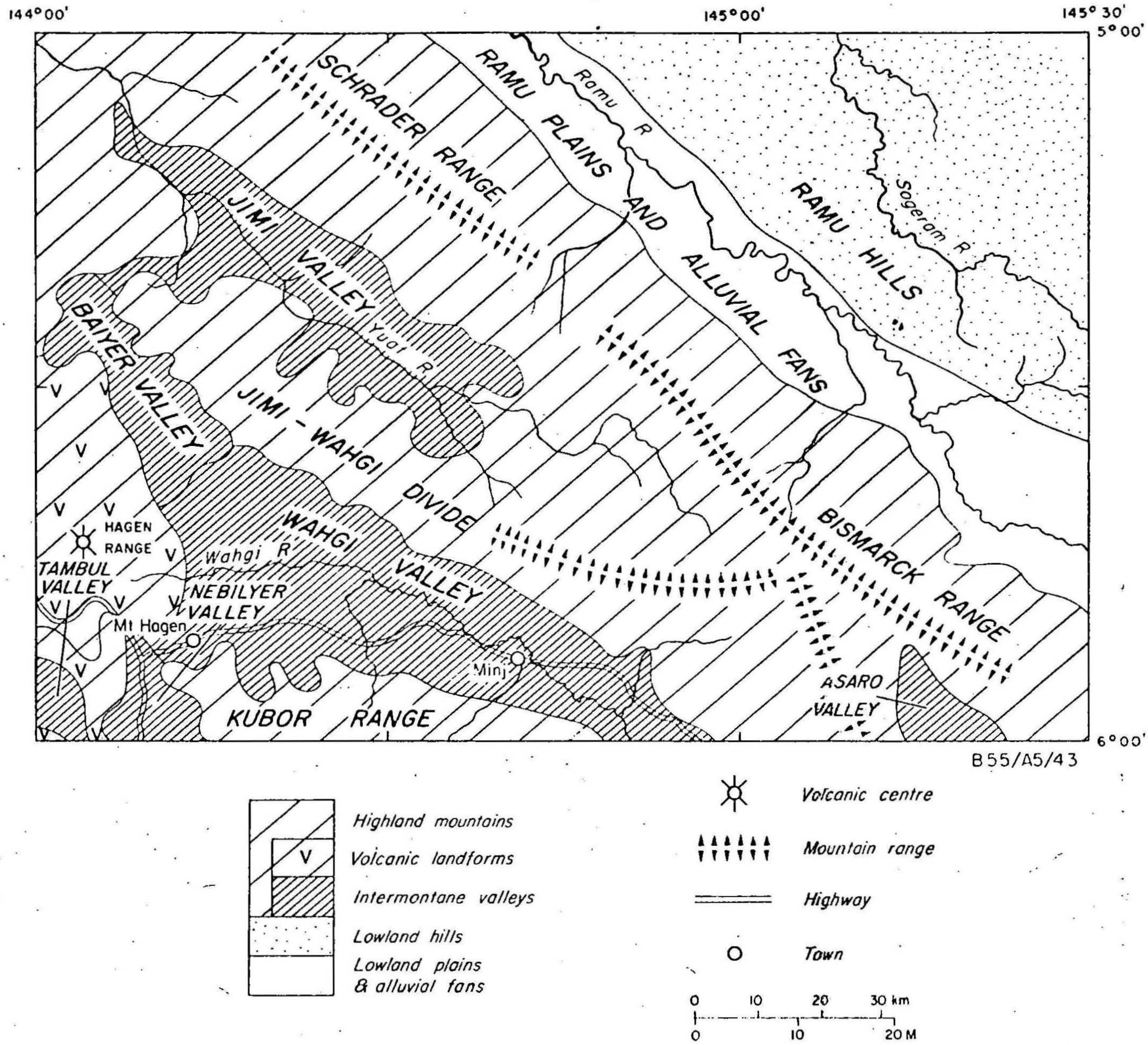


Fig. 2 Expl. Notes RAMU J. Bain PHYSIOGRAPHIC DIVISIONS

PHYSIOGRAPHY

Relief

The main physiographic divisions are shown in Figure 2. Most of the Sheet area lies within the central mainland cordillera and has an elevation of 1500 to 3000 m with several peaks reaching 3500 to 4500 m above sea level. The southwestern edge of the Ramu Plains at about 50-100 m above sea level, defines the northern limit of the cordillera. The low hills northeast of the Ramu Plains are the northwestern end of the Saruwaged-Finisterre Mountains block east of the Sheet area (Madang 1:250 000 Sheet area).

The Ramu Sheet area may be divided into the following physiographic divisions:

1. Highland Mountains
   a) Kubor Range
   b) Jimi-Wahgi divide
   c) Bismarck and Schrader Ranges
   d) mountains south of the Yuat River
   e) intermontane valleys
   f) volcanic landforms
2. Lowland Hills
3. Lowland Plains & Alluvial Fans

Highland Mountains

Most of the area is above 1000 m and consists of rugged and extremely rugged mountains with no single characteristic drainage pattern, and a diversity of landforms. Most of the area consists of rugged low mountains and hills with irregular branching ridges and a deeply incised close dendritic pattern of V-shaped valleys. In some areas there are well developed strike ridges and dipslopes and a structurally controlled rectilinear pattern of valleys. Slit gorges and waterfalls are common.

The Kubor Range in the south is an anticline of rugged mountains rising to rocky peaks up to 4000 m above sea level; these are developed on resistant residual patches of Triassic Kana Volcanics and the underlying granitic and metamorphic core of the Kubor Anticline. The foothills are dominated by prominent dipslopes of Jurassic and Lower Cretaceous sediments.

The Bismarck Range and its northwestern extension the Schrader Range are dominant topographic features. The southern limit of the Bismarck Range is marked by the Chimbu Limestone scarp bordering the Wahgi valley. North of the scarp a series of northwesterly-trending limestones strike ridges rises to over 3000 m and merges into the Wilhelm Massif and the lower plateau-like mountain block to the east of Mount Wilhelm. A large part of the summit area of Mount Wilhelm has been glaciated, leaving well developed cirques, U-shaped valleys, tarns, moraines, and ragged rocky peaks. The fall from Mount Wilhelm to the Ramu Plains is steep, dropping from 4509 to about 300 m in 30 km. From the Wilhelm Massif, the Bismarck Range extends along the southwestern side of the Ramu valley to the northern boundary of the Sheet where it swings to form the Schrader Range which divides the Jimi and Sepik valleys. The range is rugged, heavily wooded, and cut by large fault-controlled valleys trending northwest (Bundi Fault Zone, etc.)

The Jimi-Wahgi divide extends from near Mount Wilhelm west to the Mount Hagen-Baiyer valley area. It consists of moderately deeply dissected mountains up to 3500 m (Mount Udon), and includes several low passes (about 2300 m) which afford access from the Wahgi valley to the Jimi valley. On the northern side, the divide drops gradually to the Jimi valley, and is characterized by rounded bifurcating ridges, rounded hills, dip-slopes, and fault-controlled valleys. The southern side drops steeply to the Wahgi valley and, with the northwestern side, is characterized by prominent north-dipping dip-slopes and large valley-forming faults striking west-northwest.

The low <u>mountains south of the Yuat River</u> are rugged and have a dominant dendritic drainage pattern developed on the Maramuni Diorite, which forms the core of the range. Some dip-slopes are developed in the folded Mesozoic sediments on the northern and southern sides.

The <u>intermontane valleys</u> include the Wahgi, Baiyer, Nebilyer, Tambul, Asaro, and Jimi valleys. The Wahgi, Baiyer, and Tambul valleys are broad, flat-floored, grassy, and flanked by hummocky volcanic rocks which separate them from the Hagen volcanic complex. The lower (southeastern) part of the Wahgi valley is largely covered by thick alluvial fan deposits which have been deeply dissected by the Wahgi River and its tributaries. Its upper (western) end is covered by volcanic and lacustrine sediments through which partly buried hills of Mesozoic and older rocks protude.

The floor of the Baiyer valley is covered by lacustrine and alluvial sediments which, over most of the valley, overlie volcanic debris and lava from Mount Hagen. Apart from the Baiyer River gorge, which cuts through volcanic rocks at the northern end of the valley, the Baiyer valley is flat and grassy, with slightly entrenched meandering streams. The Nebilyer valley, like the western end of the Wahgi valley, is floored by moderately to deeply dissected volcanic rocks sloping gently south away from the Hagen Range.

Only a small part of the northern end of the Asaro Valley falls within the Ramu Sheet area; it has been almost entirely cleared of forest and is floored by moderately dissected alluvial fan deposits which slope gently to the south. The Jimi valley is a large area of subdued relief between the Jimi-Wahgi divide and the Schrader Range. The topography is dominated by northwesterley-trending valley-forming faults (especially the Jimi Fault Zone). Damming and subsequent infilling of the valley by Hagen Volcanics caused flattening of its northwestern end.

<u>Volcanic landforms</u> are superimposed on the Highland Mountains. The Hagen Range volcanic complex and the hills to the north and south form the

western margin of the Baiyer, Nebilyer, and Wahgi valleys. To the south, a prominent limestone scarp marks the western margin of the Nebilyer valley and to the north are rounded hills of a large Mesozoic-Tertiary inlier in Hagen Volcanics.

Lowland Hills

In the northeast corner of the Sheet area are the Ramu Hills, characterized by a dense dendritic drainage pattern developed on soft, very gently folded sediments. These hills, though only 30 to 250 m high, are steep and rugged. Streams meander across some broad flat alluvium-filled valleys.

Lowland Plains and Alluvial Fans

The northwestern margin of the Bismarck-Schrader range is an abrupt fault-controlled change in topography. Dissected alluvial terraces and alluvial fans flank the range and extend northeast to the flat alluvial flood plains of the Ramu River.

Drainage

The southern part of the Ramu Sheet area (Wahgi valley, Nebilyer valley, southeastern Hagen Range, Kubor Range, and southern fall of the Jimi-Wahgi divide) is drained by the Wahgi and Nebilyer Rivers into the Purari systems of the Karimui Sheet area to the south. The remainder of the area is drained to the northwest via the Yuat River into the Sepik system and north via the Ramu River to the sea. The main tributaries of the Yuat River are the Baiyer, Lai, and Jimi Rivers. The Imbrum, Marum, Simbai, and Asai Rivers are the main tributaries of the Ramu River. Drainage of the low hills northeast of the Ramu River is eastward and northward to the sea via the Gogol, Sogeram, Wanang, and other rivers. The northern fall of the Schrader Range drains into the Sepik River.

Deeply incised radial drainage characterizes the Hagen Range and extends south into the Nebilyer valley and east into the upper Wahgi valley. Farther east the middle reaches of the Wahgi River meander along the flat-floored valley and the lower reaches are alightly incised. Drainage in the upper and middle Jimi valley is irregular or follows faults or bedding in deep-V-shaped valleys. The lower reaches of the Jimi River are alightly to moderately incised with some meanders entrenched into alluvium and volcanic material. Drainage is mainly dendritic in the area between the Lai and Yuat Rivers farther west. In the southern Bismarck Range, much of the drainage is controlled by faults and joints of the Bismarck Intrusive Complex. Farther north in the Bismarck Range and in the Schrader Range, large fault zones control much of the drainage.

The Ramu River meanders over an alluvial plain, and to the northeast, streams have a fine dendritic drainage pattern grading into entrenched meanders downstream.

Most streams in the Sheet area (apart from the Wahgi, Baiyer, and lower Jimi valleys), especially those flowing northeast into the Ramu River, are steep, fast-flowing, and boulder-strewn. They are generally deeply incised into valleys with sides sloping at 25^{o} to 60^{o}.

STRATIGRAPHY

The stratigraphy is summarized in Table 1.

PALAEOZOIC

UPPER PALAEOZOIC

Omung Metamorphics

The age of the Omung Metamorphics is unknown because the rocks are unfossiliferous and have not been dated isotopically. However, they must be older than the intruding Kubor Granodiorite which has been isotopically dated at 244 m.y.

UPPER PERMIAN

Kubor Granodiorite

The Kubor Granodiorite is unconformably overlain by the fossiliferous Permian-Triassic Kuta Formation. Although a large number of isotopic age determinations by the K-Ar method indicate an age of 215-220 m.y., the Rb-Sr age of 244 m.y. seems more probable.

UPPER PERMIAN TO LOWER TRIASSIC

Kuta Formation

The Kuta Formation consists of remnants of reef limestone resting unconformably on granitic and metamorphic basement. The limestone is characteristically dark grey, slightly recrystallized and silicified, and therefore very hard and tough in places.

MESOZOIC

Goroka Formation

The Goroka Formation consists of low to moderate grade (low pressure) regional metamorphic rocks of unknown age. It is probably the metamorphic equivalent of some, or all, of the Mesozoic formations exposed on the flanks of the Kubor Anticline. For example, rocks in the Asaro valley, especially near Asaro village (Karimui Sheet area) are similar to the sheared Upper Triassic Kana Volcanics in the Chimbu valley and are intruded by Lower Jurassic granitic stocks (180-190 m.y.). Other parts of the formation are similar to the Upper Cretaceous to Eocene Asai Shale. Structural and petrological properties of the metamorphics (McMillan & Malone 1960) indicate that there have been at least two periods of metamorphism. Preliminary Rb-Sr data indicate that metamorphism occurred about 20-35 m.y. ago (Page, in prep.). However a pre-middle Eocene metamorphism must also have occurred because outside the Sheet area the formation is unconformably overlain by unmetamorphosed middle Eocene and younger sediments.

MIDDLE TO UPPER TRIASSIC

Yuat Formation

The formation is well exposed only along the Yuat River in the Wabag and Ambunti Sheet areas. It is faulted against Lower Cretaceous Kumbruf Volcanics and apparently unconformably overlain by possible Lower Jurassic

Balimbu Greywacke. The younger (Carnian-Norian) part of the formation is of the same age as the Jimi Greywacke about 100 km to the southeast in the headwaters of the Jimi River.

UPPER TRIASSIC

Jimi Greywacke

According to Dow & Dekker (1964), the greywacke is medium-bedded and contains thin interbeds of dark grey shale and siltstone. It does not crop out in the Kubor Anticline and it is presumed that it does not extend southwards beyond the Jimi-Wahgi divide.

Kana Volcanics

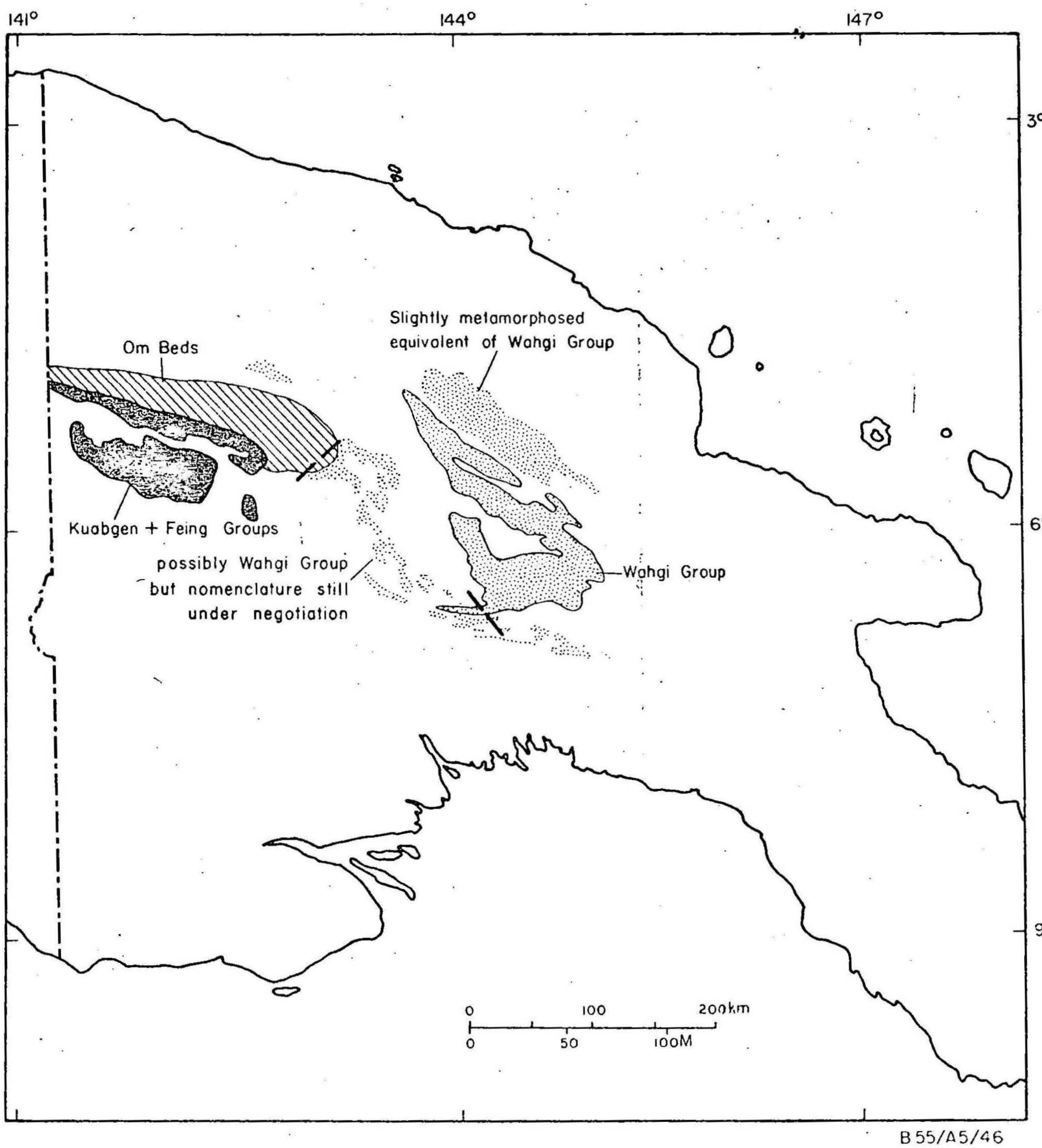
The Kana Volcanics crop out along the Jimi-Wahgi divide from the headwaters of the Jimi River to the Sai River and along the Jimi and Yuat Rivers. Less extensive outcrops are present 4 km west of Baiyer River and in the Black Hill area north of Mount Hagen. The sedimentary rocks are most common in the headwaters of the Jimi River and in the Chimbu valley near Gembogl where the type section is located. The formation attains its maximum thickness of about 2500 m in the Jimi-Wahgi Divide. To the northeast and southwest the formation thins and is only 600 m thick in the Kubor Range.

LOWER JURASSIC - UPPER CRETACEOUS

Wahgi Group

Up to 7300 m of shale, siltstone, sandstone, and subordinate volcanics and limestone were deposited in the Kubor Range area after erosion of the Kana Volcanics. These rocks have been divided into five formations each of which thickens outwards from the core of the Kubor Anticline, which was emergent from Triassic time onwards.

The five formations are nowhere seen together in stratigraphic order, owing to the structural complexity of the area. Observable sequences above the Triassic Jurassic unconformity are shown below:



B 55/A5/46

DISTRIBUTION OF JURASSIC-CRETACEOUS GROUPS

Fig 3.

[illegible] Fig. 3

	Kol Syncline	Kubor Anticline	Lower Jimi valley
Upper Cretaceous		Chim Formation	
Lower Cretaceous	Kondaku Tuff	Kondaku Tuff	
Upper Jurassic	Maril Shale	Maril Shale	Maril Shale
Middle Jurassic	Mongum Volcanics		
Lower Jurassic	Balimbu Greywacke		Balimbu Greywacke

The apparent absence of Maril Shale between the Balimbu Greywacke and Kondaku Tuff in the syncline 10 km northeast of Banz is probably due to the paucity of data in that area.

Correlatives of the Wahgi Group are the Feing and Kuabgen Groups (Blucher Range Sheet area) and the Om Beds (Wabag and Blucher Range Sheet area). Other formations or beds that are wholly or partly equivalent to the various constituent formations are discussed below (Fig. 3).

Although there are ammonites of Sinemurian - Pliensbachian age at several localities in the Balimbu Greywacke, notably in the type section in Balimbu Creek, west of Manu village (Kol Syncline), the greater part of the formation is unfossiliferous and thus of uncertain age. Mapping of Balimbu Greywacke along the Jimi-Wahgi divide and north of the Lai River is based solely on lithological and stratigraphic corrections.

The ?Middle Jurassic Mongum Volcanics appear to be restricted to the vicinity of the Kol Syncline.

The Upper Jurassic Maril Shale rests unconformably on the Omung Metamorphics, Kubor Granodiorite, Kuta Formation, and Kana Volcanics in the Kubor Anticline. Elsewhere it is conformable on Balimbu Greywacke or Mongum Volcanics. The weathered surfaces of the calcareous shale and siltstone tend to disintegrate into small angular chips resulting in characteristic hummocky, crumbling outcrops. Another distinctive feature is the two well developed sets of joints at a high angle to bedding and to each other. Diagenetic mineral assemblages characteristic of the Kondaku Tuff are mostly absent, probably because of the high $CaCO_3$ content. Although the type section is along the Wahgi River south of Kundiawa (Karimui Sheet area) the beds are more accessible and more easily studied in the Maril River area.

The Lower Cretaceous Kondaku Tuff overlies the Maril Shale with local slight unconformity and transgresses it in the Kubor Anticline. The base of the formation is taken as the first major sandstone, greywacke, or volcanolithic bed above the Malayomaorica beds. Those parts of the volcanolithic sediments that have been buried to depths of 4500 m or more contain prehnite, pumpellyite, zoisite, and calcium zeolites. The formation grades upwards into the Upper Cretaceous Chim Formation. In the Ramu Sheet area the formation is confined to areas near the Kubor Anticline and the Lai valley west of Baiyer River. In the Karimui Sheet area to the south, the formation is much more extensive. Ammonities and other macrofossils are present, as well as Foraminifera.

LOWER JURASSIC?

Unnamed granitic intrusives that intrude the Goroka Formation near Urabagga Hill and Asaro village (Karimui Sheet area) have been isotopically dated by the Rb-Sr method at 180-190 m.y. (Page in prep.).

UPPER JURASSIC?

Kompiai Formation

Phyllitic and schistose fine-grained calcareous sediments, of the Kompiai Formation are correlated with the Upper Jurassic Maril Shale. Fossils are scarce and indeterminate. However, ammonities indicate a Mesozoic age and brachipod moulds resemble the Upper Jurassic Malayomaorica malayomaorica. Stratigraphic relations are not clear, but it appears to conformably underlie Kumbruf Volcanics, and is faulted against Triassic beds, and intruded by the Miocene Oipo Intrusives.

LOWER CRETACEOUS?

Unnamed Intrusives

Dykes and sills up to 30 m thick intruding Maril Shale in the area northeast of Mount Hagen town may be related to the middle Miocene Kimil Diorite, or they may be contemporaneous with the Kera Sill (Karimui Explanatory Notes) which is possibly Lower Cretaceous.

Kumbruf Volcanics

The Kumbruf Volcanics may be correlated on lithological similarities with the Lower Cretaceous Kondaku Tuff which lies to the south. Alternatively it may be Upper Cretaceous. There are no identifiable fossils.

MESOZOIC - CAINOZOIC

UPPER CRETACEOUS TO EOCENE

Asai Shale

Although the Asai Shale is predominantly Upper Cretaceous to Eocene, fault-bounded beds of Oligocene to lower Miocene age (Te stage) are present at two localities in the Bundi Fault Zone northwest of Bundi; they have been mapped as Asai Shale, but on the basis of lithological similarity and possibly similar age they may be correlatives of the Wulamer Beds to the northwest. Numerous acid to basic intrusives cut the Asai Shale, but only the larger bodies are shown (Oipo Intrusives). The beds are contorted and strongly faulted.

CAINOZOIC

MIDDLE EOCENE TO LOWER OLIGOCENE (Ta_3 to Tc)

Nebilyer Limestone

The Nebilyer Limestone contains only sparse undiagnostic planktonic foraminifera, but can be confidently correlated with the Chimbu Limestone. It unconformably overlies the Chim Formation and is conformably overlain by the Miocene Aure Beds.

Chimbu Limestone

The Chimbu Limestone forms prominent fault-bounded hogbacks southeast of Kerowagi. It overlies the Chim Formation unconformably (para-conformably);

it is overlain unconformably by the Movi Beds. Within the Sheet area the limestone is tightly folded and strongly faulted into a number of subparallel ridges, but to the southeast (Karimui Sheet area) only one strike ridge of limestone is present.

OLIGOCENE? to LOWER MIOCENE?

Unnamed beds Tlm (referred to as Mena and Mebu groups in various oil exploration reports) are the oldest exposed beds in the Ramu Basin. They comprise marine sediments and subordinate volcanics.

OLIGOCENE?

Wulamer Beds

The Wulamer Beds are correlated with the older part of the unnamed Oligocene? to lower Miocene? beds northeast of the Ramu River. They are contorted, metamorphosed up to greenschist facies, and strongly faulted, but a regional dip to the northeast is clearly discernible.

UPPER OLIGOCENE to MIDDLE MIOCENE (Te to Tf)

Aure Beds

The Aure Beds paraconformably overlie the Nebilyer Limestone and are extensively overlain by Quaternary volcanics, especially Holocene? ash. The beds are discussed further in the Karimui Explanatory Notes.

LOWER to MIDDLE MIOCENE (Upper Te to lower Tf)

Movi Beds

In the Sheet area the Movi Beds are confined to the Bismarck Fault Zone and are strongly faulted. In the Karimui Sheet area they are much thicker and more extensive (see Karimui Explanatory Notes). They are correlated with the upper Te to lower Tf part of the shallow-water clastic sediments of the Aure Beds.

MIDDLE MIOCENE

Yaveufa Formation

The lavas of the Yaveufa Formation range in composition from highly potassic undersaturated olivine basalts to high-potassium hornblende-pyroxene andesites. The formation contains Lower Tf foraminifera in limestone lenses, and samples of lava have been dated isotopically at 12.5 to 15 m.y. (Page, 1971).

Maramuni Diorite

The large area of intrusive rocks in the northwest corner of the sheet area is part of a large batholith, which together with several other large plutons west of the sheet area was named Maramuni Diorite by Dow et al. (In press). Within the sheet area, the batholith is composed of granodiorite, monzonite, and gabbro, cut by minor dolerite, andesite, and porphyritic diorite and micriodiorite dykes.

Within the Ramu Sheet area Maril Shale is the youngest formation intruded by the Maramuni Diorite which has been isotopically dated as middle Miocene (Page in prep.).

Kimil Diorite

In several places, notably in the headwaters of Banz Creek, the Kimil Diorite is extensively altered to chlorite, actinolite, potash feldspar, and prehnite. It intrudes Maril Shale and several older formations, and has been isotopically dated as middle Miocene. This age agrees with the age inferred from the similarity between Kimil Diorite and Oipo Intrusives, which intrude Asai Shale, and with the tectonic setting of the intrusions (Bain et al., 1970).

Iron and copper sulphide minerals occur widely in the Kimil Diorite, notably in Apin and Marramp Creeks, tributaries of the Tsau River, where they are associated with molybdenite and gold. Gold also occurs in Banz Creek.

Bismarck Intrusive Complex

The large batholith in the southwest corner of the Sheet area consists of gabbro, diorite, and mangerite in its western and northeastern portions, granodiorite tonalite and rare granite elsewhere. Ultramafic rocks, including pyroxenite hornblendite, peridotite, dunite, and anorthosite occur on Mount Wilhelm (McMillan & Malone, 1960). The batholith is characterized by a strong joint pattern easily discernible on aerial photographs. The dominant joint set trends southwest, parallel to the regional tectonic strike. Complementary sets strike north-northeast and north-northwest.

The complex intrudes Goroka Metamorphics, Kana Volcanics, Jimi Greywacke, Kumbruf Volcanics, and Asai Shale. Sulphide minerals, mainly pyrite, chalcopyrite, and some molybdenite are sparsely disseminated through the basic rocks in the Mount Wilhelm area, and form significant disseminated and fissure-filling in the Yanderra area.

Oipo Intrusives

Like the Kimil Diorite, the Oipo Intrusives crop out as a number of small stocks, with associated dykes, in the Jimi valley and northern Bismarck Mountains. Rock types, which were described by Dow & Dekker (1964), are complexly interrelated with several generations of dykes of different rock types cutting the original intrusion which, in the case of Mount Oipo stock, has been almost completely obscured.

In one area the Oipo Intrusives intrude Asai Shale, which is Upper Cretaceous to Eocene and possibly Te stage, and the intrusives have been isotopically dated as middle Miocene. Hence they are probably genetically related to the Bismarck Intrusive Complex and Kimil Diorite.

Disseminated pyrite and pyrrhotite are common, especially in the gabbro; disseminated chalcopyrite occurs in the Marum River, 5 km southwest of Marum village.

Marum Basic Belt

A large mass of gabbroic and ultramafic rocks on the western side of the Ramu valley was mapped and named by Dow & Dekker (1964). The northern half and southernmost parts of the mass consist of hypersthene augite gabbro and lesser norite, veined by anorthosite and gabbro pegmatite. Olivine occurs in some parts of the gabbro, and chromite is a common accessory mineral. Banding is conspicuous in some parts of the gabbro. Ultramafic rocks crop out in the Marum River Baia River area. All gradations from fresh dunite to serpentinite, and pyroxenite are the only rock types described from this area. The dunite contains chromite, and the pyroxenite is made up of either hypersthene and chromite, or enstatite, augite, and hypersthene.

The Marum Basic Belt is bounded on its western side by the Simbai Fault, and on its eastern side by Pleistocene to Holocene alluvium of the Ramu valley. It intrudes Kumbruf Volcanics and Asai Shale at its northern end, and in the Marum River Baia River area. The age of emplacement is probably middle Miocene.

Apart from disseminated chromite, lateritic nickel deposits developed over a large part of the ultramafic body are the only features of economic importance.

UPPER MIOCENE

Benembi Diorite

A small stock of Benembi Diorite intrudes Kondaku Tuff 7 km southeast of Mount Hagen town; it may be related to dykes in the Kuta area to the east which have produced gold mineralization in the Kondaku Tuff. The Benembi Diorite is thought to be related to the upper Miocene Michael Diorite (Bain et al., 1970), or perhaps to the middle Miocene Kimil Diorite.

Unnamed Intrusives (Tmuy)

In the Yanderra area, 10 km of Bundi on the northeast side of the Bismarck Intrusive Complex, middle Miocene granodiorite and tonalite are intruded by a large number of mineralized stocks and dykes of upper Miocene age. Intrusive relations are complex, with most types intruding one another. There has been considerable alteration and potash metasomatism along fractures in the porphyries and their host rocks; disseminated and fissure-filling copper molybdenum and other base metal sulphides are associated with this alteration.

PLIOCENE (Tpo)

Ouba Beds

The Ouba Beds are extensive in the Ramu Basin and are correlated with similar Pliocene beds in the Sepik Basin (Torricelli Mountains). Gas seepages occur along several folds and fractures in the beds. The beds are the subject of continuing petroleum exploration.

QUATERNARY

PLEISTOCENE

Unnamed poorly consolidated marine sediments (Qp) conformably overlie the Ouba Beds in the Ramu Basin.

Giluwe Volcanics

Most of the floor of the Tambul valley in the south west corner of the Sheet area is covered by debris from Mount Giluwe, 12 km to the west-southwest. The debris consists mainly of basaltic to andesitic agglomerate and derived sediments, and is interbedded with and overlain by the Tambul lake beds and alluvium of the Kaugel River. Mount Giluwe is Pleistocene to Holocene in age (Blake & Löffler, 1971; D.H. Blake, pers. comm. 1971); some activity may have taken place as recently as 1000 years ago.

Hagen Volcanics

The Mount Hagen Range is a composite stratovolcano which consists of eroded calderas in the southern and central parts, and a smaller, younger composite cone in the north. The northern cone has a summit crater which has its western side eroded away, and a smaller crater on its northern side. The rocks are dominantly lava, agglomerate, and ash in the Range itself; and tuff, ash agglomerate, massive lahar deposits and volcanic breccia, and derived sediments in the surrounding aprom. The deposits which extends north, along the Yuat River are massive, coarse to extremely coarse volcanic breccia.

The lavas are massive, some with vesicular or fragmented tops, and range from high-K olivine basalt (shoshonite) to high-K high-Al basalt, high-K andesite, and dacite.

Volcanic rocks from the Hagen complex are interbedded with lake beds and alluvium in the Wahgi and Baiyer valleys. Tuff, probably from Mount Hagen, has been found in a bog on Mount Wilhelm (G. Hope, ANU, pers. comm. 1971). This evidence, the state of preservation and the fact that Mount Hagen has been glaciated in the Pleistocene (CSIRO, 1965; Löffler, 1972) indicate a Pleistocene to Holocene age. Unconsolidated moraine and fluvioglacial gravels (Qm) are confined to the glaciated areas of Mount Wilhelm and Mount Hagen.

Partly dissected unconsolidated lake sediments (Ql) form extensive flat areas in the intermontane valleys; Tambul, Baiyer, and Wahgi (Ramu Sheet area) and Goroka (Karimui Sheet area). The sediments interfinger with extensive alluvial fans (Qf) which are also present in the Jimi and Ramu valleys. The fans formed at the base of mountainous terrain during a short period of accelerated erosion during the Pleistocene. However, many are still active aggradational landforms and both lake sediments and alluvial fans are partly veneered with Holocene alluvium. Only the largest scree deposits (Qs) have been mapped; they consist of rock-fall debris mixed with soil beneath limestone cliffs and landslip and outwash rubble at the base of steep slopes.

Holocene

Alluvium (Qa) consisting of clay sand, silt, gravel, and some peat and soil is present throughout the Sheet area, but is most extensive in the Ramu and Wahgi valleys. It forms river terraces, flood plains, valley fill and alluvial plains over lacustrine sediments.

STRUCTURE

There are three main structural elements within the Sheet area; the Kubor Anticline in the southwest, the New Guinea Mobile Belt in the centre, and

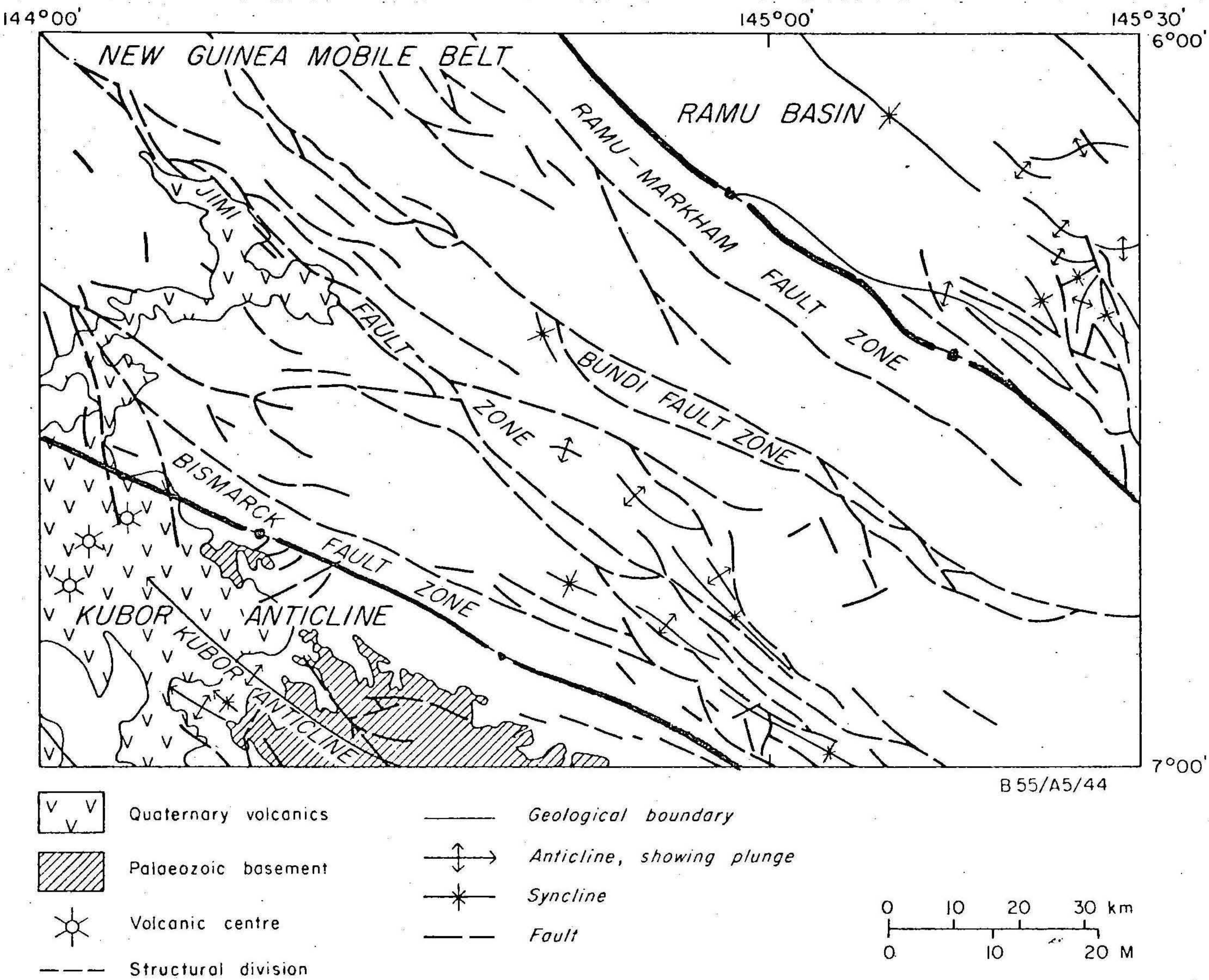


Fig. 4. Ramu Explanatory Notes. J. Bain.

To 60 %

the Ramu Basin in the northeast (Fig. 4).

Kubor Anticline

The Kubor Anticline is a broad gentle arch 140 km long and 65 km wide at its widest point, and is the largest exposure of Palaeozoic basement in Papua New Guinea.

It lies southwest of a fault zone, which trends southeast, and is colinear with the Bismarck Fault Zone (Dow et al., 1968; Bain et al., 1970) and the Maramuni Fault Zone in the Ambunti Sheet area (Dow et al., in press), i.e. the Bismarck-Maramuni Fault Zone. Within the Sheet area the anticline is cut by two, or possibly three, major northerly-trending splays of this fault zone. It is extensively covered by Quaternary Hagen Volcanics which have been extruded from centres that lie on or near the intersection of these faults with the trend of the axis of the Kubor Anticline.

In the hills within the Bismarck Fault Zone, Triassic and Jurassic beds dip northeasterly at 20 to 50^{o} off the Kubor Granodiorite, and are cut by small-displacement normal faults oriented radially to the anticlinal axis. These faults, as well as the major northerly trending splay faults, have step-faulted the northern flank of the anticline (west side up).

New Guinea Mobile Belt

New Guinea Mobile Belt is 50 to 100 km wide and 1600 km long, and contains most of the major high-angle faults, and almost all the intrusive ultramafic and metamorphic rocks of Mesozoic or younger age in mainland Papua New Guinea. The Mobile Belt may be regarded as the Tertiary zone of interaction between opposing crustal plates, the Australian plate to the south and the Pacific plate to the north.

This structural element is characterized by large well defined anastomosing fault zones (e.g. Bismarck-Maramuni Fault Zone, Jimi Fault Zone, Bundi Fault Zone - Fig. 4) and numerous small shears and fractures, all with a general northwesterly trend (see also Karimui Explanatory Notes).

The Bismarck Fault Zone (the main branch of the Bismarck-Maramuni Fault Zone) is a clearly delineated, topographically recognizable break between beds of different age and rock type. However, the numerous similarly trending small shears and fractures in the beds and intrusions immediately north of the main fault indicate that the fault zone is considerably wider than indicated on the map. In fact most of the area of Kana Volcanics and Kimil Diorite in the Jimi-Wahgi divide can be regarded as lying within the Bismarck Fault Zone.

The Jimi Fault Zone is a 2 to 5 km-wide shear zone which follows the line of the Yuat and lower Jimi Rivers, in part separating Triassic and Cretaceous beds. In the centre of the Sheet area near Bokapai, it splays into two arms, the southern arm merging with the Bismarck Fault Zone near Mount Udon, and the northern arm trending towards the Bismarck Intrusive Complex. Estimates of the magnitude and nature of the movements that have taken place along the Jimi Fault Zone are hampered by its complexity.

The existence of a major fault along the northeastern slope of the mountain ranges, which mark the side of the Ramu Valley, is indicated by the topography and by the presence of strong deformation. Another major fault about 7 km to the northeast marks the other side of the valley. Although Cainozoic formations are truncated by the fault on the northeastern valley side, there is no marked escarpment. These two parallel faults and the area between them constitute the Ramu-Markham Fault Zone which extends the length of the Ramu and Markham Valleys and brings lower Tertiary and Mesozoic rocks in the south against upper Tertiary and Quaternary sediments in the north. The true nature of the zone has not been determined because it is partly covered by Quaternary alluvium. However, it is apparent that vertical movements of more than 1 km, and possibly considerable horizontal movements have occurred along the fault zone.

Rocks in the Schrader Range are either extensively sheared (e.g. Asai Shale) or broken by normal faults with vertical displacements in the order of 600 to 1000 m (e.g. Wulamer Beds). All faults and shears trend northwest.

Penetrative faulting throughout the New Guinea Mobile Belt has broken most large folds, of which only remnants remain.

The Yaveufa Syncline, a Tertiary structure subparallel to the eastern end of the axis of the Kubor Anticline, has been strongly affected by the Bismarck Fault Zone. Deformation north of Kundiawa (Karimui Sheet area) has been so intense that the original synclinal form has been almost entirely obliterated, but the synclinal form is preserved down-plunge to the southeast.

However, it is apparent that the south side has moved upwards some 2000 m or more relative to the north side. On the southern, Tsau River splay of the fault zone, the movement appears to have been in the opposite sense. Horizontal movements may have occurred on this and other major fault zones such as the Bismarck Fault Zone (Dow et al., in press), but no evidence was found within the map area to support or discount this possibility.

A 30 km wide parallel-sided horst block composed almost entirely of northeasterly dipping Triassic and Jurassic sediments and volcanics intruded by Miocene acid to intermediate plutons lies between the Bismarck-Maramuni and Jimi Fault Zones. The horst has been uplifted about 2000 m relative to the adjacent blocks.

The Bundi Fault zone, a 3 to 7 km wide system of anastomosing faults, extends from the Ramu Valley 30 km east of Bundi to at least the northern edge of the Sheet area, and is clearly marked by a succession or a zone or hill-and-valley relief or block-faulted land and hill-and-valley relief block-faulted landscape. This topographic feature has been called the Bundi Fault Trough by Dow & Dekker (1964). The faults within the zone are either straight or slightly curved and, where seen, consist of shear zones up to 350 m wide.

The presence of Eocene foraminiferal limestone lenses on both sides of one of the major faults in the zone (near Tunonk Creek) suggests that very little vertical movement has occurred at this locality. Farther southeast along the fault, recent clockwise transcurrent movement is indicated by the displacement of the Baia and Imbrum Rivers. Dow & Dekker (1964) believed that this type of displacement is predominant in the Bundi Fault Zone. However, only 20 km to the southeast the fault zone contains a 135 km^2 block of Upper Triassic Jimi Greywacke faulted on both sides against Cretaceous and Jurassic? formations. In this case vertical movements must have been greater than 2000 m.

There are several large open folds in the headwaters of the Jimi River - most are symmetrical and have horizontal axes that trend parallel to the predominant faults.

The Ramu Basin

The Ramu Basin covers an area of 7500 km^2 and contains up to 2000 m of unconsolidated and poorly consolidated Quaternary marine and terrestrial clastic sediments overlying 2000 to 4000 m of lower Tertiary sedimentary rocks.

The simple undeformed appearance of the Ramu Basin is misleading. When examined at small scale numerous small faults, tight folds, and vertical and overturned beds are recognized. Even Quaternary sediments are locally folded and faulted. Most fold and fault trends are parallel or subparallel to the Ramu-Markham Fault Zone and are clearly related to it.

The Banam Anticline is about 75 km long and 13 km wide, with a culmination 14 km long and 3 km wide. It plunges to the northwest beneath the alluvium of the Ramu River. To the southeast it becomes lost in an area of strong faulting. At least three cross-faults cut the axis and flank faults occur on both limbs. Dips are generally steep on both flanks but drop to 15° on the north flank 6 km from the axis. The axis is faulted (vertical dips are present within the culmination), though the movement may only be minor.

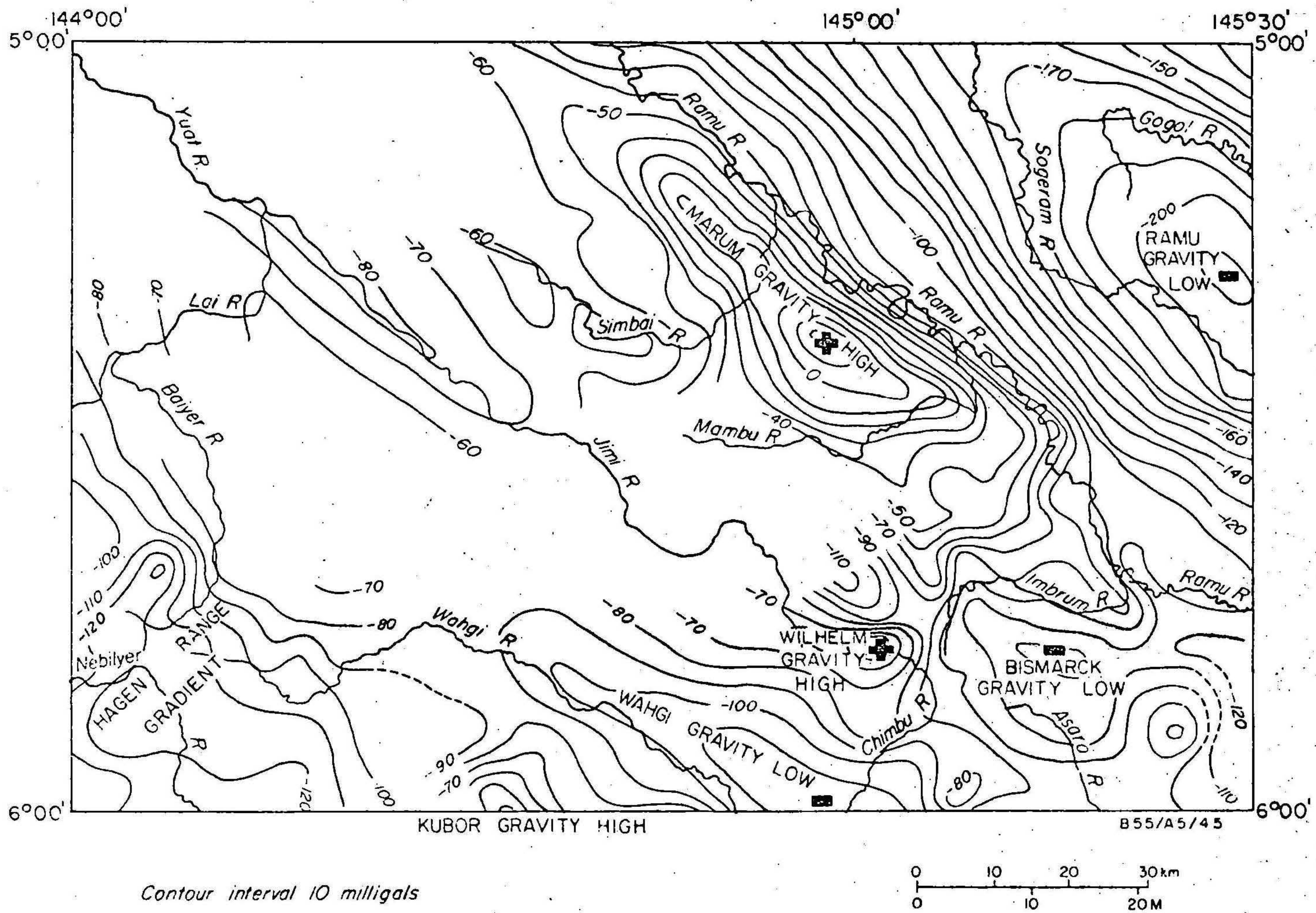

144°00'
145°00'
145°30'
5°00'
6°00'
Yuat R.
Ramu R
Sogeram R
Gogol R
RAMU GRAVITY LOW
MARUM GRAVITY HIGH
Lai R
Simbai R
Baiyer R
Jimi R
Mambu R
Imbrum R
Wahgi R
WILHELM GRAVITY HIGH
BISMARCK GRAVITY LOW
WAHGI GRAVITY LOW
Chimbu R
Asaro R
Nebilyer
HAGEN RANGE GRADIENT
KUBOR GRAVITY HIGH
B55/A5/45
Contour interval 10 milligals
0 10 20 30 km
0 10 20 M

Fig 5.

Little is known about the Gogol Fault which cuts across the northeastern corner of the Sheet area. However, it is probably a major fault as the Miocene sediments do not extend across it.

Gravity

Gravity data was obtained in 1968 (Watts, 1969) and 1970 (Zadorosnj & Coutts, 1973) by BMR helicopter-supported gravity surveys using the cell method of traversing described by Vale (1962) and Hastie & Walker (1962). There are no gravity stations in the rugged country either side of the Jimi River, but there are sufficient data in the southern and eastern parts of the Sheet area to define several large gravity features (Fig. 5). Terrain corrections have been applied only to the data in the southern half of the Sheet area.

The Ramu and Wahgi Gravity lows correspond to sedimentary basins; the Bismarck Gravity Low lies entirely within the Bismarck Intrusive Complex. By far the largest and strongest high, the Marum Gravity High, corresponds to and is presumably caused by the Marum Basic Belt. The small but intense Wilhelm Gravity High corresponds to an area of basic and ultrabasic rocks within the Bismarck Intrusive Complex. The Kubor Gravity High appears to correspond to the Omung Metamorphics which are more dense than the adjacent Kubor Granodiorite. Small highs elsewhere in the southeastern part of the Sheet area are probably related to the presence of small gabbroic intrusions or metamorphics of high density. The Hagen Range Gradient is probably due to variations in crustal thickness, whereas the more pronounced but unnamed gradient between the Marum Gravity High and the Ramu Gravity Low coincides with the Ramu-Markham Fault zone.

MINERAL DEPOSITS AND OCCURRENCES

Except for several small alluvial gold workings there is no recorded mineral production and no economic mineral deposits are known. However, two large low-grade mineral deposits - the Yanderra Copper Prospect and the Marum Nickel Prospect initially recommended for detailed exploration by BMR geologists in 1962 (Dow & Dekker, 1964) are currently under investigation by mineral exploration companies. Apart from evaluation of these prospects, metalliferous mineral exploration to date has consisted mainly of regional and local stream-sediment sampling and analysis; only very small copper-molybdenum deposits and geochemical anomalies of dubious economic significance have been detected.

Petroleum exploration in the Ramu Basin has been carried out intermittently since about 1938, but no bores have been drilled. Within the Sheet area exploration has been confined to geological mapping and despite the existence of several gas seepages current interest in the area is low.

The quarrying of aggregate for road, dam, and building constructions is likely to increase rapidly as the region progresses economically. Already roadside quarries are common in the highlands. The exploitation of small alluvial gold deposits is also likely to increase as a result of increasing gold prices and a growing awareness by the local inhabitants of its widespread distribution.

Gold

Kuta: Auriferous gravel deposits near Kuta, 8 km south of Mount Hagen were discovered by the Leahy brothers in 1932 while accompanying the first Government Patrol into the area. Between 1935 and 1949, 87 085 g 753 fineness gold valued at $71 366 were produced (Ward, 1949). Production has now all but ceased. The main workings extended more than 1 km along the eastern bank of Kunimo Creek; other workings in Ambi, Ewunga, and Kuan Creeks were less extensive. The auriferous wash rests on tuffaceous sandstone, and contains pebbles and boulders of andesite, quartz, limestone, and sandstone. Its thickness ranges from about 10 cm to 2.4 m, and it is overlain by soil and unconsolidated volcanic ash. Ward (1949) suggested that the gold may have been derived from stringers and veinlets of quartz associated with small diorite dykes and sills that intrude the Kondaku Tuff near Kuta (see Benemi Diorite).

Kumbruf: Alluvial gold in a tributary of the Simbai River near Kumbruf was also discovered by Leahy whilst he accompanied a Government Patrol in 1954. Between 1958 and 1967 about 28 000 g 877 to 900 fineness gold valued at about $31 000 was produced from the Kumbruf deposit. The prospect is a remnant of an elevated weathered suriferous 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 Soil 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 have been worked for gold. The beds of the two creeks and Nonoi Creek, a tributary of Soi Creek, have also been worked.

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

Minor occurrences: Small patches of auriferous river gravel in the Jimi Valley north of Banz provide a subsistence income (about 100 g gold per month) for a small group of people. The gold is thought to have been derived from the Kimil Diorite. Gold has also been shed southwards from the Kimil Diorite into the Wahgi valley; the alluvial deposits in streams draining the southern side of the Jimi-Wahgi divide near Banz contain some gold.

Streams in the Yanderra area have been worked for gold by the local inhabitants, but there is no record of the production.

Traces of alluvial gold have been found in the headwaters of the Mamp River, the upper Jimi River, and in the Kunnum and Pint Rivers. There have been unsubstantiated reports of gold from the Minj River, south of Minj.

Lode gold is known only at Yanderra (see below) and in an area of intrusive and metamorphic rocks in the extreme southwestern corner of the Sheet area. Here, small pyritic quartz veins assay about 4 to 8 g gold per tonne.

Copper and Molybdenum

Yanderra Copper Prospect *: An extensive (greater than 20 km^2) but low-grade copper deposit 10 km west of Bundi Patrol Post has been the scene of almost continuous exploration and evaluation since 1965. Detailed geological, geochemical, and geophysical studies, together with information obtained from several diamond-drill holes and numerous pits and costeans, indicate that the deposit is of the porphyry copper type. It lies within part of the Bismarck Instrusive Complex (Tmb) intruded by a large number of upper Miocene porphyry dykes and veins (Tmuy). The porphyry constitutes about 30 percent of the wall and mineralized rocks - the remainder are granodiorite. The copper minerals are mostly confined to small shears and fractures in the granodiorite and porphyry; some are disseminated close to the fractures. The primary sulphide minerals are bornite, chalcopyrite, molybdenite, sphalerite, galena, and pyrite. Pyrite makes up about 2 percent of the rock in the mineralized zones and locally up to 10 percent. Sphalerite and galena are rare. Malachite and chrysocolla are common on rock surfaces in many stream beds, and secondary copper minerals (chalcocite and covellite) are extensive and may represent a zone of secondary enrichment. Also associated with the mineralized fractures are quartz veinlets and some silicification and clay sericite alteration; less commonly limonite coatings, micaceous hematite, and gold **.

---

* Information and geological maps generously provided by K.E.A.

** Cupriferous calcite veins sampled by McMillan & Malone (1960) assayed 4 dwt gold per ton.

Molybdenite appears to be an important part of the mineralization and could be a major economic factor in any mining operation.

At present the area is extremely isolated and exploration expensive. However, the projected Mount Hagen to Madang Highway and the Ramu Hydro-electric Scheme could greatly reduce development and production costs.

Other occurrences: There is a large number of other copper-molybdenum occurrences and geochemical anomalies thoughout the Bismarck Mountains/Jimi-Wahgi divide. Most notable is the small but high-grade copper-molybdenum skarn in Korogi Creek, a tributary of the Marum River. The deposit is in a small roof pendant of metamorphosed sediments (including limestone) within the Bismarck Intrusive Complex. Minerals present are chalcopyrite, bornite, malachite and chacocite, molybdenite, and rare galena.

Molybdenite and chalcopyrite with traces of secondary copper sulphides and sphalerite are also present in small shear zones near granite/volcanics contacts in the Apin and Marram Rivers in the Jimi valley. There are two known copper-molybdenum geochemical anomalies in the watershed between the headwaters of the Mai and Asaro Rivers.

Sparsely disseminated chalcopyrite is commonly present in gabbroic rocks of the Oipo Intrusives and Marum Basic Belt. Selected samples from a shear zone in Marum Basic Belt gabbro assayed 3.45 percent copper (Dow & Dekker, 1964).

Nickel

Marum Lateritic Nickel Prospect: An extensive area of nickeliferous laterite overlying ultramafic rocks of the Marum Basic Belt was discovered and initially tested by BMR geologists in 1962. Subsequent work has established that soil depths are 30 to 40 m and grades are 0.3 to 2.0 percent nickel. Prospect evaluation is continuing.

Barite

A 12 m wide dyke of leucocratic pyritic microdiorite in the bed of the Pint River 12 km north-northeast of Tabibuga Subdistrict Headquarters contains disseminated barite crystals. Large coarsely crystalline segregations of barite are common near the centre of the dyke.

Nonmetals

Diatomite: Beds of diatomite each up to 1 m thick comprising a total thickness of 1 to 2 m and interbedded with volcanic sand and ash occur in the Trauna Valley, about 3 km east of Baiyer River Patrol Post. The deposit is at least 400 x 100 m in area and overlain by thick dark brown soil along a stream about 2 km west of Trauna Valley Farm (R.J. Tingey, pers. comm. 1969). When wet, the diatomite is light grey and plastic; when dry, it is almost white and extremely light and friable.

Construction materials

Basaltic and andesitic lavas, such as occur in the Quaternary Hagen Volcanics, when crushed are suitable aggregate for road surfacing, concrete constructions, and rock fill for dam construction. Extensive deposits of unconsolidated gravel (Qf) in the Wahgi valley, and limestone talus beneath escarpments in Kuta Formation and Nebilyer Limestone are also suitable road-surfacing material. Deeply weathered granite and sand derived from the weathered granite near Mount Hagen town are also potential sources of construction materials. Many streams, especially the Jimi River and southwestern tributaries of the Ramu River contain huge quantities of washed gravel.

Peat

Large quantities of peat at present in the swampy areas east of Mount Hagen town and in the Ramu River flood plain. Quality and grade are unknown.

Petroleum prospects

Gas seepages (mostly methane) commonly occur along faults in the Ramu Basin sediments, and at least one highly saline spring is present in the area of the seepages. However, structures are so small and strongly faulted that petroleum prospects appear to be poor.

Pottery clay

Unglazed clay pots have long been manufactured locally from material quarried in the headwaters of Sogeram River, 8 km northeast of Usino Patrol Post.

Stone axe quarries

Before 1950, the manufacture and export of stone axes was by far the most economic activity of the inhabitants of the Sheet area (Hughes, 1971). Almost all the stone used for tool manufacture was quarried at eleven sites within the Sheet area, and three sites in the adjacent Karimui Sheet area (Chappell, 1966). The rock types quarried occur in contact metamorphic zones and range from albite-epidoie-actinolite hornfels to albitized fine-grained sediments containing quartz, prehnite, and stilpnomelane. They fracture conchoidally and have a hardness of 3 to 5 (Mohs' scale).

BIBLIOGRAPHY

AUSTRALIAN PETROLEUM CO., 1961 - Geological results of petroleum exploration in western Papua 1937-1961. J. geol. Soc. Aust., 8, 1-133.

BAIN, J.H.C., 1967 - Schrader Range, New Guinea - reconnaissance geology. Bur. Miner. Resour. Aust. Rec. 1967/94 (unpubl.).

BAIN, J.H.C., 1973 - A summary of the main structural elements of Papua New Guinea. In THE WESTERN PACIFIC : ISLAND ARCS, MARGINAL SEAS, GEOCHEMISTRY. Perth, Univ. W.A. Press.

BAIN, J.H.C., & BINNEKAMP, J.G., 1972 - Foraminifera and stratigraphy of the Chimbu Limestone, New Guinea. Bur. Miner. Resour. Aust. Bull. 139.

BAIN, J.H.C., MACKENZIE, D.E., & RYBURN, R.J., 1970 - Geology of the Kubor Anticline, Central Highlands of New Guinea. Bur. Miner. Resour. Aust. Bull. 155

BIK, M.J.J., 1967 - Structural geomorphology and morphoclimatic zonation in the Central Highlands, Australian New Guinea. In JENNINGS, J.N., & MABBUTT, J.A. (eds) - LANDFORM STUDIES FROM AUSTRALIA AND NEW GUINEA. Canberra, ANU Press, 26-47.

BINNEKAMP, J.G., & BELFORD, D.J., 1970 - Foraminifera and age of outcrop samples collected during the Kubor Range survey, 1968, Central Highlands, New Guinea. Bur. Miner. Resour. Aust. Rec. 1970/12 (unpubl.).

BLAKE, D.H., & LÖFFLER, E., 1971 - Development of volcanic and glacial landforms on Mount Giluwe, Territory of Papua and New Guinea. Bull. geol. Soc. Amer. 82, 1605-14.

BROOKFIELD, H.C., & HART, D., 1966 - Rainfall in the tropical southwest Pacific. Canberra, ANU Press (Aust. Nat. Univ. Dept. Geol. Publ. G/3).

CAREY, S.W., 1938 - The morphology of New Guinea. Aust. Geogr., 3, 3-30.

CHAPPELL, J., 1966 - Stone axe factories in the Highlands of East New Guinea. Proc. Pre. histor. Soc., 32, 96-121.

CHINNERY, E.W.P., 1934 - The Central ranges of the Mandated Territory of New Guinea from Mount Chapman to Mount Hagen. Geogr. J., 84, 5.

CSIRO, 1970 - Lands of the Goroka-Mount Hagen Area, Territory of Papua and New Guinea. Sci. ind. Res. Org. Canb., Land Res. Ser. 27.

CSIRO, 1965 - Lands of the Wabag-Tari Area, Papua and New Guinea. Ibid., 15, 70-84.

CRESPIN, I., & BELFORD, D.J., 1956a - Fossiliferous rocks from the Central Highlands, New Guinea. Bur. Miner. Resour. Aust. Rec. 1965/100 (unpubl.).

CRESPIN, I., & BELFORD, D.J., 1956b - Further collection of fossiliferous rocks from the Central Highlands, New Guinea. Ibid., 1956/117 (unpubl.).

CROOK, K.A.W., 1960 - Diagenesis in the Wahgi valley sequence, New Guinea. Proc. Roy. Soc. Vic., 74, 77-81.

DAVIES, H.L., & DOW, D.B., 1968 - The use of helicopters in geological mapping in Papua-New Guinea. Bur. Miner. Resour. Aust. Rec. 1968/63 (unpubl.).

DOW, D.B., 1961 - Geology of the Sau River and environs, New Guinea. Bur. Miner. Resour. Aust. Rec., 1961/73 (unpubl.).

DOW, D.B., 1962 - A geological reconnaissance of the Jimi and Sau Rivers, Territory of Papua and New Guinea. Bur. Miner. Resour. Aust. Rec., 1962/110 (unpubl.).

DOW, D.B., & BAIN, J.H.C., 1970 - A Miocene volcanic arc in New Guinea (abs.). Aust. N.Z. Ass. Adv. Sci., 42nd Cong., Abs. Sec. 3.

DOW, D.B., & DEKKER, F.E., 1964 - Geology of the Bismarck Mountains, New Guinea. Bur. Miner. Resour. Aust. Rep. 76

DOW, D.B., SMIT, J.A.J., BAIN, J.H.C., & RYBURN, R.J., (in press) - The geology of the south Sepik region, New Guinea. Bur. Miner. Resour. Aust. Bull. 133.

EDWARDS, A.B., 1950 - The petrology of the Cretaceous greywackes of the Purari valley, Papua. Proc. Roy. Soc. Vic., 60, 163-71.

EDWARDS, A.B., & GLAESSNER, M.F., 1953 - Mesozoic and Tertiary sediments from the Wahgi valley, New Guinea. Proc. Roy. Soc. Vic., 64, 93-112.

GLAESSNER, M.F., 1943 - Problems of stratigraphic correlation in the Indo-Pacific Region. Proc. Roy. Soc. Vic., 55, 41-80

GLAESSNER, M.F., 1945 - Mesozoic fossils from the Central Highlands of New Guinea. Ibid., 56, 151-68.

GLAESSNER, M.F., LLEWELLYN, K.M., & STANLEY, G.A.V., 1950 - Fossiliferous rocks of Permian age from the Territory of New Guinea. Aust. J. Sci., 13, 24.

HASTIE, L.M., & WALKER, D.G., 1962 - Two methods of Gravity Traversing with helicopters. Bur. Miner. Resour. Aust. Rec. 1962/134 (unpubl.).

HUGHES, I., 1971 - Recent Neolithic trade in New Guinea. Ph.D. thesis. Aust. Nat. Univ., Canberra (unpubl.).

JAKES, P., & WHITE, A.J.R., 1969 - Structure of the Melanesian arcs and correlation with distribution of magma types. Tectonophysics, 8, 223-36.

JENKINS, D.A.L., FINDLAY, A.L., & ROBINSON, G.P., 1969 - Mendi geological survey, permits 46, 27, Papua. B.P. Petrol. Devel. Aust. Rep. 84, (unpubl.)

JENKINS, D.A.L., & MARTIN, A.J., 1969 - Recent investigations into the geology of the Southern Highlands, Papua. In Symposium on the development of petroleum resources of Asia and the Far East. Econ. Comm. Asia Far East, Comm. Indust. Nat. Resour.

JOHNSON, R.W., MACKENZIE, D.E., & SMITH, I.E., 1970 - Short papers on Quaternary volcanic areas in Papua New Guinea. Bur. Miner. Resour. Aust. Rec. 1970/72 (unpubl.).

KOPPEN, W., 1931 - GRUNDRISS DER KLIMAKUNDE. Berlin, Walter de Gryyter Co.

LEAHY, M., 1936 - The central highlands of New Guinea. Geogr. J., 87, 3.

LÖFFLER, E., 1970 - Pleistocene glaciation in Papua New Guinea (abs.). Aust. N.Z. Ass. Adv. Sci., 42nd Cong., Abs. Sec. 21.

MACGREGOR, J.P., & READ, J.R.L., 1967 - Geological investigation of the Goroka-Daulo Pass-Chauve Road, Eastern Highlands District, New Guinea. Bur. Miner. Resour. Aust. Rec. 1967/25 (unpubl.).

MACKENZIE, D.E., & BAIN, J.H.C., 1972 - Baiyer River-Jimi valley reconnaissance geology. Bur. Miner. Resour. Aust. Rec. 1972/35 (unpubl.)

MACKENZIE, D.E., & CHAPPELL, B.W., 1971 - Shoshonitic and calcalkaline lavas from the highlands of Papua New Guinea. Contr. Miner. Petrol. 35, 50-62.

MCALPINE, J.R., 1970 - Climate of the Goroka-Mount Hagen area. In : Lands of the Goroka-Mount Hagen area, Papua New Guinea. CSIRO Land Res. Ser. 27, 66-79.

McMILLAN, N.J., & MALONE, E.J., 1960 - The geology of the eastern Central Highlands of New Guinea. Bur. Miner. Resour. Aust. Rep. 48.

NOAKES, L.C., 1939 - Geological report on the Chimbu-Hagen area, Territory of New Guinea. Geol. Surv. T.N.G. (unpubl. ms.).

PAGE, R.W., (in prep.) - The geochronology of igneous and metamorphic rocks in the New Guinea region. Bur. Miner. Resour. Aust. Bull.

PAGE, R.W., & McDOUGALL, I., 1970a - Potassium-argon dating of the Tertiary f_{1-2} stage in New Guinea and its bearing on the geological time-scale. Amer. J. Sci., 269, 321-42.

PAGE, R.W., & McDOUGALL, I., 1970b - Isotopic dating of the igneous and metamorphic rocks in the New Guinea Highlands (abs.) Aust. N.Z. Ass. Adv. Sci., 42nd Cong., Abs. Sec. 3

PARKER, F., 1967 - The caves of the Porol Ranges between the Chimbu River and Chuave in the Chimbu District of the Eastern Central Highlands of New Guinea. Sydney Speleol. Soc. Occas. Pap. 2, 20-7.

READ, J.R.L., 1967a - Geological investigation of proposal Lufa-Chuave road. Bur. Miner. Resour. Aust. Rec. 1967/55 (unpubl.).

READ, J.R.L., 1967b - Geological investigation of the proposed Minj-Wahgi River roadway, New Guinea. Ibid., 1967/143 (unpubl.).

READ, J.R.L., & MACGREGOR, J.P., 1967 - Caves in the Chimbu and Eastern Highlands Districts. PNG geol. Surv. Note Invest. 67404.

RICKWOOD, F.K., 1955 - The geology of the Western Highlands of New Guinea. J. geol. Soc. Aust., 2, 63-82.

REINER, E., 1960 - The glaciation of Mount Wilhelm, Australian New Guinea. Geogr. Rev., 50, 491-503.

SKWARKO, S.K., 1967 - Mesozoic Mollusca from Australia and New Guinea. Bur. Miner. Resour. Aust. Bull. 75.

SKWARKO, S.K., in press - First report of Domerian (Lower Jurassic) marine Mollusca from New Guinea. Bur. Miner. Resour. Aust. Bull. 140

SPINKS, K.L., 1935 - The Wahgi River valley of central New Guinea. Geogr. J., 83 (3).

STANLEY, E.R., 1922 - Salient geological features and natural resources of the New Guinea Territory. Report on the Territory of New Guinea, 1921-1922. Aust. parl. Pap. 18, 1923.

STANLEY, G.A.V., 1950 - A geological reconnaissance in the Central Highlands of New Guinea. Unpubl. rep. to Island Exploration Co.

ST JOHN, V.P., 1967 - The gravity field in New Guinea. Ph.D. thesis, Univ. Tasmania, Hobart (unpubl.).

THOMPSON, J.E., & FISHER, N.H., 1965 - Mineral deposits of New Guinea and Papua, and their tectonic setting. Proc. 8th Comm. Min. metall. Cong., 115-48.

VALE, K.R., 1962 - Reconnaissance gravity surveys using helicopters, for oil search in Australia. Bur. Miner. Resour. Aust. Rec. 1962/130 (unpubl.).

WARD, J.H., 1949 - A geological reconnaissance of the country between Mount Hagen and Mongureba, Central Highlands Districts, Mandated Territory of New Guinea. Bur. Miner. Resour. Aust. Rec. 1949/79 (unpubl.).

WARD, R.G., & LEA, D.A.M., (eds) 1970 - AN ATLAS OF PAPUA AND NEW GUINEA. Dep. Geogr. Univ. PNG and Collins & Longman.

WATTS, D., 1969 - Helicopter gravity survey Sepik River 1968. Bur. Miner. Resour. Aust. Rec. 1969/24 (unpubl.).

ZADOROSNJ, I., & COUTTS, D., 1973 - Central Highlands helicopter gravity survey, New Guinea, 1970. Bur. Miner. Resour. Aust. Rec. 1973/14 (unpubl.)

APPENDIX 1

MACROFOSSILS

MAP NO.	GRID REFERENCES	SAMPLE NO.	AGE	FORMATION (MAP SYMBOL)
1	172 411	-	Kimmeridgian	Jum
2	171 412	-	Kimmeridgian	Jum
3	187 410	-	Kimmeridgian	Jum
4	236 393	-	Kimmeridgian	Jum
5	246 383	M26	Carnian-Norian	Ruj
6	246 384	H200	Carnian-Norian	Ruj
7	248 383	H199 M29	Carnian-Norian	Ruj
8	260 382	H185	Carnian-Norian	Ruj
9	266 388	H782	Carnian-Norian	Ruj
10	271 376	H157	Carnian-Norian	Ruj
11	268 372	?	? ?	Ruk?
12	261 374	H607	Carnian-Norian	Ruj
13	263 373	H575	Carnian-Norian	Ruj
14	264 372	H176	Carnian-Norian	Ruj
15	265 372	H574	Carnian-Norian	Ruj
16	269 370	H558	Carnian-Norian	Ruk
17	269 369	H565	Sinemurian-Pleinsbachian	Jlb
18	270 368	H29	Sinemurian-Pleinsbachian	Jlb
19	271 368	-	Kimmeridgian	Jum?
20	272 368	-	Kimmeridgian	Jum?
21	264 367	-	Kimmeridgian	Jum?
22	261 367	H507	Kimmeridgian	Jum
23	262 366	H25	Kimmeridgian	Jum
24	270 363	20/1377	uppermost Permian or lowermost Triassic	PuRl
25	215 355	20/1376	" " "	PuRl
26	224 352	20/0584	Kimmeridgian	Jum
27	239 346	20/0578	Kimmeridgian	Jum float
28	247 352	20/2676	Lower Cretaceous	Klk
29	248 352	20/2675	" "	Klk
30	247 343	20/1163	" "	Klk
31	271 363		Kimmeridgian	Jum
32	274 356	20/1283	Kimmeridgian	Jum

MAP NO.	GRID REFERENCES	SAMPLE NO.	AGE	FORMATION (MAP SYMBOL)
33	268 353	20/1265	Carnian-Norian	Ruk
34	270 351	H550	Sinemurian-Pleinsbachian	Jlb
35	282 345	20/0563	Kimmeridgian	Jum
36	293 345	20/0564	Kimmeridgian	Jum
37	283 347	20/0561	Kimmeridgian	Jum
38	290 343	20/2680	Carnian-Norian	Ruk
39	291 343	20/2685	Carnian-Norian	Ruk

APPENDIX 2

ISOTOPIC AGE SPECIMENS

MAP NO.	GRID REFERENCES	SAMPLE NO.	AGE	FORMATION (MAP SYMBOL)
1	176 420	5827	11-12 m.y. K/Ar min age*	Tmm
2	235 405	5828 5679		Tmi
3	255 375	5815		Tmi
		5859		Tmi
		5877	15-17 m.t. K/Ar min ages	Tmi
		5971		Tmi
		5972		Tmi
4	172 364	5678	? ?	Qvh
5	203 378	12NG1504	15 m.y. K/Ar min age	Tmk
6	251 380	20NG1358	15-17 m.y. K/Ar min age	Tmi
7	277 367	5498		Tmb
8	280 372	5676-77		Tmb
9	280 364	5499-5500		Tmb
10	284 371	5682		Tmb
		5882		Tmb
		5898		Tmb
11	285 375	5680		Tmb
		5681	11-13 m.y. K/Ar age	Tmb
12	287 364	5670	12.5 m.y. Rb/Sr isochron (granodiorites)	Tmb
		5671	8-9 m.y. K/Ar, Rb/Sr (pegmatites)	Tmb
		5688		Tmb
13	291 367	5684		Tmb
		5485		Tmb
		5486		Tmb
		5497		Tmb
		5674		Tmb
14	292 371	5487		Tmb
		5675		Tmb
		5886		Tmb
15	293 366	5490		Tmb + Tmuy
		5492		Tmb + Tmuy
		5884		Tmb + Tmuy
		5672		Tmb + Tmuy
		5488		Tmb + Tmuy

* N.B. Most other specimens of the Maramuni Diorite (Ambunti Sheet area) gave 13-14 m.y. K/Ar min ages.

MAP NO.	GRID REFERENCES	SAMPLE NO.	AGE	FORMATION (MAP SYMBOL)
		5489		Tmb + Tmuy
		5883		Tmb + Tmuy
16	295 368	5491	7-10 m.y. K/Ar, Rb/Sr min. porphyries (Tmuy)	Tmb + Tmuy
		5673		Tmb + Tmuy
		5826		Tmb + Tmuy
		5493		Tmb + Tmuy
		5981		Tmb + Tmuy
		5818		Tmb + Tmuy
17	296 362	5483		Tmb + Tmuy
		5495		Tmb + Tmuy
18	296 364	5496		Tmb + Tmuy
		5482		Tmb + Tmuy
		5885		Tmb + Tmuy
19	320 361	5819		Tmb
		5820		Tmb
		5821		Tmb
20	178 358	20NG1607	? ? ?	Qvh
21	198 340	5865		Puk
22	200 345	2168		Puk
23	204 341	5684		Puk
		5804		Puk
		5807		Puk
		5813	244 m.y. Rb/Sr (preferred age)	Puk
		2130		Puk
		2135	215-220 m.y. K/Ar	Puk
24	208 348	5811	Total rock, Bi, Hbl, Musc, & felsp min ages from specimens of granodiorite, aplite, pegmatite & hornfels	
25	213 343	2191		Puk
		5801		Puk
		5802		Puk
		5683		Puk
26	221 347	5808		Puk
27	228 347	5458		Puk
		5466		Puk
28	230 347	5687		Puk
		5817		Puk
29	236 346	5686		Puk
		5809		Puk

ISOTOPIC AGE SPECIMENS Cont/..

MAP NO.	GRID REFERENCES	SAMPLE NO.	AGE	FORMATION (MAP SYMBOL)
30	286 359	5457		Tmb
31	289 357	5465		Tmb
32	291 356	5456		Tmb
		5463		Tmb
		5464	as for Tmb above	Tmb
33	301 358	5822		Tmb
		5823		Tmb
		5824		Tmb
34	307 348	5900		Tmb
35	307 338	5973		Jlu
		5974		Jlu
		5975		Jlu
		5976		Jlu
		5977	180-190 m.y.	Jlu
		5887	K/Ar	Jlu
		5888	Rb/Sr	Jlu
		5897		Jlu
		5898		Jlu
		5899		Jlu
36	328 342	5957	as for Tmb above	Tmb

TABLE. STRATIGRAPHY RAMU EXPLANATORY NOTES

ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
CAINOZOIC	Holocene	Alluvium (Qha)	-	Clay, sand, silt, and gravel; minor peat and alluvial soils	River terraces, flood plains and valley fill; alluvial plains over lacustrine deposits	Throughout the Sheet area: most extensive in Ramu and Wahgl valleys	Only the most extensive deposits shown
	Quaternary	Scree (Qs)	Variable, but about 10-100	Rock fall debris mixed with soil beneath limestone cliffs. Landslip and outwash rubble at base of steep slopes	Low dissected and slumped foothills and hummocky valley fill	Below the Chimbu and Nebilyer Limestone cliffs, on slopes of Mt Wilhelm and at western end of Wahgi valley	Only the most extensive deposits shown
	Quaternary	Alluvial fans (Qf)	80	Unconsolidated fluviatile clay, sand, and boulder gravel commonly containing granitic boulders	Terraced and moderately dissected gently undulating to hummocky fans	Wahgi, Baiyer, Tambul (Kaugel), Jimi, Goroka and Ramu valleys. Most extensive in the Ramu and Wahgi valleys	May contain some fluvioglacial debris. Area SE of Obulu veneered with Holocene alluvium
	Quaternary	Lake sediments (Ql)	100	Unconsolidated clay, silt, sand, gravel and peat	Flat to undulating coalesced fans, gullied with rounded ridges	Wahgi, Baiyer, and Tambul valleys	Partly veneered with Holocene flood plain alluvium; mainly grassland. Contains diatomite at Baiyer River and Tambul.
	Quaternary	Glacial deposits (Qm)	10-20	Unconsolidated moraine and fluvioglacial gravels	Hummocky valley fill and straight or curving ridges with steep slopes and sharp crests	Confined to the glaciated areas of Mts Wilhelm and Hagen	Mount Hagen deposits too small to be shown on map
	Quaternary	Hagen Volcanics (Qvh)	Cone greater than 2000; aprons less than 150	Basaltic (shoshonite) to dacitic lava, agglomerate, tuff, lahars and fluviatile conglomerate; hyperbyssal intrusives	Deeply eroded coalesced volcanic cones with extensive and deeply gullied gently sloping hummocky aprons. Cone height about 1500-2000m. Some minor satellite cones	Mount Hagen Ra, Nebilyer, upper Wahgi, Baiyer, and Lai-Jimi valleys in the W Sheet area. Some small areas along the Yuat valley as far N as Sepik valley. (Ambunti Sheet area)	Derived from three major and at least six minor eruptive centres. Extensive aprons and valley-fill material mostly lahars. Summit area of the southern-most major centre has been glaciated. All major cones deeply eroded on NW side
	Quaternary	Giluwe Volcanics (Qvg)	Less than 100	Shoshonite agglomerate	Hummocky, low relief	SW corner of Sheet area in Kaugel (Tambul) valley	Far more extensive on Karimui and Lake Kutubu Sheets. Overlain by lake sediments and alluvium
	Quaternary (Pleistocene)	Unnamed marine sediments (Qp)	800	Mudstone, soft grey carbonaceous and shelly, interbedded with grey friable carbonaceous sandstone and siltstone, partly conglomeratic grading laterally into grey chalky limestone which contains corals, molluscs, and bryozoa	Hilly, low relief and elevation, dendritic drainage	Ramu River basin, NW corner of Sheet area	Mostly low dips. Overlain by fanglomerate and alluvium
	Pliocene	Ouba Beds (Tpo)	1000-3000	Mudstone, blue-grey, massive to thinly bedded; minor sandstone and siltstone interbeds. Interbedded soft grey mudstone, siltstone and sandstone and minor conglomerate and limestone; pebble, boulder conglomerate, partly calcareous	Hilly, low relief, dense dendritic drainage	Ramu-Gogol valleys, NE corner of Sheet area	In places unconformable on unnamed Oligocene? to Lower Miocene? beds (Tlm). Lowermost conglomerate beds grade laterally into limestone which contains abundant corals, bryozoa, and molluscs. Foraminifera common throughout

ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
CAINOZOIC	Upper Miocene	Unnamed Intrusives Yanderra area (Tmuy)	-	Monzonite, porphyritic microdiorite, quartz feldspar andesite porphyry, leococratic quartz-biotite andesite porphyry and hornblende andesite porphyry	Same as for Bismarck Intrusive Complex	Mainly in Yanderra area within the main batholith of the Bismarck Intrusive Complex, SE corner of Sheet area	Occurs as irregularly shaped dykes and veins cutting the Bismarck Intrusive Complex. Believed to be the source of copper and gold at Yanderra. K-Ar isotopic age about 7.0 m.y.
	Upper Miocene?	Benembi Diorite (Tmub)	-	Porphyritic hornblende-quartz microdiorite	Area too small to have characteristic topography	One small pluton 8km SW of Mt Hagen town in SW part of Sheet area	May be source of gold at Kuta. Age deduced from similarity to Michael Diorite and Yanderra Intrusives
	Middle Miocene	Oipo Intrusives (Tmi)	-	Gabbro, granodiorite, tonalite, dolerite, diorite, pyroxenite, and lamprophyre	Very rugged (similar to Bismarck Intrusive Complex)	Schrader and Bismarck ras in central part of Sheet area	Textures range from fine-grained to pegmatite. Felsic stockworks and complex veining common. Pyrite, and pyrrhotite common. Hornblende more common than biotite. Occurs as stocks and dykes. Intrude Asai Shale. K-Ar isotopic age 15-17 m.y.
	Middle Miocene	Bismarck Intrusive Complex (Tmb)	-	Hornblende gabbro; hornblende-biotite-quartz diorite; subordinate hornblende-pyroxene-biotite tonalite and granodiorite; minor mangerite, granite, aplite, muscovite pegmatite, hornblendite, dunite, peridotite, and anorthosite	Same as for Goroka Formation (See Karimui Sheet)	Bismarck Ra, SE part of Sheet area	Gabbro and diorite are predominant rock types. Smaller bodies SW of main batholith have less varied lithology. K-Ar and Rb-Sr isotopic age (more than 50 determinations) on mineral and whole rock samples of 12-13 m.y. for the bulk of the rocks, 9-10 m.y. for the pegmatite. (Page, in prep.)
	Middle Miocene	Kimil Diorite (Tmk)	-	Diorite, gabbro, tonalite, granodiorite; andesite porphyry, dolerite, and basalt dykes and veins; minor trachyandesite. Fine to coarse grained and porphyritic varieties of all rock types	Very rugged (similar to Kana Volcanics in Jimi Wahgi divide)	A discontinuous chain of small plutons between the Maramuni and Bismarck batholiths, in the central part of Sheet area N of the Wahgi valley	Diorite commonly intruded by complex network of basalt, dolerite and gabbro dykes, and veins. Commonly altered, with development of chlorite, actinolite, muscovite and marked foliation; some pyrite. Includes some andesite porphyry dykes which may be correlativeof the Yanderra intrusives. K-Ar isotopic age (15 m.y.), size, and distribution pattern similar to Oipo Intrusives. Both may be earliest-cooled uppermost portions of batholithic bodies comagmatic with the more deeply eroded Maramuni Diorite and Bismarck Intrusive Complex
	Middle Miocene	Maramuni Diorite (Tmm)	-	Porphyritic and nonporphyritic hornblende diorite and microdiorite, leucocratic biotite-hornblende granodiorite, and less common augite-hornblende gabbro, hornblende-biotite rhyodacite, porphyry and medium grained biotite-augite monzonite, hornblende andesite and dolerite dykes	Very rugged, dense dendritic drainage (similar to Bismarck Intrusive Complex)	S of Yuat R and N of Lai R in the NW corner of the Sheet area	Part of large batholitic body also as small satellitic bodies. More extensive on Ambunti and Wabag 1:250,000 Sheet areas. K-Ar isotopic age 11-12.5 m.y. Correlated with Kimil Diorite, Bismarck Intrusive Complex and Oipo Intrusives
	Middle Miocene (lower Tf)	Yaveufa Formation (Tma)	2000	Coarse red, purple, and multicoloured polymict andesitic to shoshonitic agglomerate and subordinate interbedded andesitic and basic lavas. Tuff and polymict volcanolithic pebble, cobble and boulder conglomerate	See Karimui Sheet	Vicinity Mount Kerigonna SE part of Sheet area; thicker and more extensive to the SE on Karimui 1:250,000 Sheet area	Volcanics and volcanolithic sediments interfinger, the former predominating

ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
CAINOZOIC	Lower to Middle Miocene Upper Te to Lower Tf	Movi Beds (Tmo)	500	Well bedded calcareous grey-green siltstone, shale and sandstone, and minor polymict pebble conglomerate. Limestone beds and lenses. Some micaceous siltstone	Steep slopes, moderate relief, mainly occupies valleys between limestone strike ridges	Chimbu valley to Asaro valley on S edge of Sheet area. More extensive on Karimui Sheet area	Unconformable on Chimbu Limestone, strongly folded and faulted in Bismarck Fault Zone. Massive limestone lenses contain abundant upper Te to lower Tf foraminifera. Ripple marks, thin persistent limestone beds, fine pebble lenses and worm marks indicate shallow water deposition
	Upper Oligocene to Middle Miocene Lower Te to Lower Tf	Aure Beds (Tm)	-	Thin bedded to laminated dark green-grey calcareous mudstone and siltstone, volcanolithic greywacke; minor siltstone and algal and laminated limestone	Moderate to strong relief	Kaugel-Gogimp valley area in SW corner of Sheet area	Basinal facies of Aure Beds, which are much more extensive on Karimui Sheet area. Formed in a deep-water environment close to a rapidly eroding land mass. Provenance volcanic. Correlated with Pundugum Formation (Wabag Sheet) by Dow et al (in Press). Extensively covered by Holocene? volcanic ash
	Miocene?	Marum Basic Belt (Tmmb)	-	Gabbro, minor norite; anorthosite and gabbro pegmatite veins. Dunite, commonly serpentinized, minor pyroxenite	Mountainous, but lower and more subdued than rest of Bismarck Range	S side of Ramu R, central and E parts of Sheet area	Banding common in main NW gabbro body. Ultramafics intrude the gabbro
	Oligocene?	Wulamer Beds (Tow)	1500 - 3700	Phyllitic grey shale and slate, sheared grey calcareous sandstone, stretched pebble conglomerate, massive purplish green volcanic agglomerate and interbedded red and green siltstone and some cherty mudstone. Laminated light buff finely crystalline limestone	Extremely rugged mountain ridges; deeply incised torrential streams and waterfalls	N flank of the Schrader Ra S of the Ramu R; central N part of Sheet area	Probably unconformable on Asai Shale but contact is mostly faulted. The top appears to be faulted against Ramu-Markham Fault Zone. Intruded by small gabbroic and ultramafic bodies of the Oipo Intrusives. Age unknown, unfossiliferous. Type section along Wulamer R
	Oligocene? to Lower Miocene?	Unnamed Beds (Tlm)	Probably greater than 1000	Well indurated sandstone, siltstone, mudstone, conglomerate, and massive volcanic agglomerate; quartz and calcite veins	Slightly more relief than Tpo	Ramu Basin, NE edge of Sheet area	Structurally complex, generally unfossiliferous. Mainly fault-bounded blocks. Regarded as basement to the petroleum prospective sediments of the Ramu basin
	Middle Eocene to Lower Oligocene Ta_3 - Tc	Chimbu Limestone (Teoc)	300	Very fine grained grey and buff algal <u>Heterostegina</u> limestone, white <u>Nummulite</u> limestone, dark grey coarse calcarenite, and finer grained brownish grey to buff <u>Alveolina</u> limestone; minor buff to brown <u>Lacazinella</u> limestone	Fault-bounded strike ridges between 1600 and 2900m with prominent scarps and gentler dip-slopes with rocky barren surfaces; no local surface drainage, some sink holes. Relief up to 360m	Between Kerowagi and Mt Kerigomna, central S edge of Sheet area	Richly fossiliferous, some beds being composed almost entirely of cemented foraminiferal tests. Gastropods, belemnites, pelecypods, and echinoids. Type section in Chimbu gorge 3.5 km northeast of Kundiawa
	Middle Eocene to Lower Oligocene Ta_3 - Tc	Nebilyer Limestone (Teon)	100	Grey and brownish grey calcarenite, with thin silty and argillaceous interbeds; dark brownish-grey fine-grained limestone	Cliffs above steep, dissected, irregular footslopes. Relief up to 100m	Between Kaugel and Nebilyer Rs in SW corner of Sheet area, and between Lai and Sau R, central W edge of Sheet area	Contains planktonic foraminifera and algae. Type section west of Togoba
MESOZOIC CAINOZOIC	Upper Cretaceous to Eocene	Asai Shale (KuTa)	Minimum 100 probably much thicker	Soft phyllitic and schistose, and hard carbonaceous shale, siltstone, and mudstone, minor limestone, calcarenite, greywacke, and conglomerate	Rugged mountains, deeply incised torrential streams	Schrader Ra and along Bundi Fault Zone in a NW-trending strip across centre of Sheet area	Most rocks have undergone some low grade (low greenschist facies) regional metamorphism. Conformably overlies Kumbruf Volcanics. Numerous ramifying quartz and calcite veins. Minor leucocratic acid dykes. Some limestones lenses are foraminiferal. Correlated with Chim Formation and Chimbu Limestone

ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
	Lower Cretaceous?	Kumbruf Volcanics (Klku)	1800	Green epidotised basaltic agglomerate and pillow lava, volcanolithic conglomerate, dark grey, amygdaloidal lava; dark grey indurated calcareous siltstone and lithic and feldspathic sandstone	Rugged strike ridges with short, deeply incised torrential streams and steep slopes	Along S flank of Schrader R and in Bundi Fault Zone; central part of Sheet area	Conformably overlain by Asai Shale; underlying relation unclear - probably conformable on Kompiai Fm. Commonly altered. Correlated with Kondaku Tuff. Type sectio along Tunonk Cr near Kumbruf
	Lower Cretaceous?	Unnamed intrusives (Kle)	-	Altered quartz-hornblende microdiorite, augite dolerite, gabbro	See Karimu Sheet	In the hills between Kotna and Baiyer R, central W part of Sheet area	May be correlative of Kera sill as intrudes Maril Shale but age unknown
	Upper Jurassic?	Kompiai Formation (Juk)	-	Dark grey siltstone, light grey laminated greywacke siltstone and sandstone, dark grey phyllitic shale, schistose shale, maroon phyllite, and dark grey highly indurated cleared shale. Minor indurated fossiliferous calcareous sandstone	As for Goroka Fm	Between Bundi Fault Zone and Jimi R; central part of Sheet area	Apparently conformably underlies the Kumbruf Volcanics. Correlated with the Maril Shale. Type area around Kompiai village
	Upper Cretaceous	Wahgi Group Chim Formation (Kuc)	Average about 2000; max. ab. 3300 near Kundiawa (Karimui Sheet)	Massive finely laminated calcareous grey shale, some with fine grained calcareous nodules and cone-in-cone structures; laminated sandstone, siltstone and shale with minor calcarenite and tuff beds; minor laminated tuff, altered volcanics, volcanolithic greywacke, calcarenite and conglomerate	Moderate relief, dipslopes not commonly preserved; broad V-shaped valleys, few gorges	Wahgi and Nebilyer valleys in S part of Sheet area; near Linganas on central W edge of the Sheet area	Coarse grained rock types and soft sediment slump structures mostly confined to upper part of the formation. Mostly Cenomanian-Turonian; Campanian to Maestrichtian near Linganas. Shallow water deposition indicated by small scale cross-bedding, ripple marks and well sorted sandy beds. Volcanic and volcanolithic rocks confined t the Kundiawa area
MESOZOIC	Lower Cretaceous	Wahgi Group Kondaku Tuff (Klk)	Average about 2000; min. ab. 300 (in Kol syncline)	Greenish-grey coarse, lithic sandstone or greywacke, tuffaceous sandstone, dark grey or green shale and siltstone. Conglomerate, agglomerate, volcanic breccia and amygdaloidal lava are subordinate	Same as on Karimui	Peripheral to Kubor R and along the N side of the Wahgi valley. Also in Kol Syncline	Shale and siltstone most common but least prominent part of the sequence. Abundant charred wood fragments, some leaf impressio Ammonites, pelecypods, gastropods, belemnit mainly Aptian Albian. Volcanics mostly confined to lower part of formation. Type section along Wahgi River south of Kundiawa (Karimui Sheet)
	Upper Jurassic	Wahgi Group Maril Shale (Jum)	Variable; max. about 1200-1500 thins to about 400 nearest the Kubor anticlinal axis	Dark grey to black moderately indurated shale and siltstone with variable carbonate and mica content. Commonly pyritic, especially the darker more carbonaceous beds. Subordinate fine to medium-grained sandstone, grey calcilutite, and maroon and green shales. Basal unit of arkose, silicified and calcareous shale/slate breccias and conglomerate	Generally well developed strike ridges and dipslopes. Prominent V-shaped "flat irons" on northern flank of anticline. Maximum relief about 300 m; elevation 1500-2400 m on north side of anticline, much lower on S side	Peripheral to the Kubor Range, north of the Lai River, south of the Jimi River and in the Chimbu valley; central, southern and northwestern parts of the Sheet area	Massive or well bedded. Basal unit prese only on Kubor Anticline. Elsewhere confor ably overlies Ballimbu Greywacke or Morgua Volcanics. Distinctive Kimmeridgian fauna of Malayomaorica m and Inoceramus cf haastie (in upper part)
	Middle Jurassic?	Wahgi Group Mongum Volcanics (Jmm)	250	Basaltic agglomerate and pillow lava, interbedded with pebble and cobble conglomerate and feldspathic greywacke	As for Kana Volcanics	Restricted to the Mongum-Kol area, central southern part of Sheet area	Basalt is amygdaloidal. Age inferred fro conformable stratigraphic position between early Lower Jurassic Balimbu Greywacke and late Upper Jurassic Maril Shale. Type section along small unnamed creek that crosses the Mongum-Mami track 3 km S of M

ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
MESOZOIC	Middle Jurassic?	Wahgi Group Balimbu Greywacke (Jlb)	280 in type section; max of 2000 in Ganz R area	Dark grey calcareous and volcanolithic greywacke and interbedded dark siltstone; dark blue-grey to light grey fine sandstone and siltstone; minor shale	As for Kana Volcanics	In the Kol-Mongum-Gembogl, and Jimi-Wahgi divide areas and tentatively S of the Yuat R in the NW corner of the Sheet area	Conformably underlies Maril Shale and Mongum Volcanics; unconformably overlies Kana Volcanics. Probably partly derived by reworking of Kana Volcanics. Well indurate resistant sandstone beds rhythmically inter bedded with recessive siltstone and shale. Ammonites, belemnites, and bivalves are poorly preserved. Sinemarian Plionsbachian age
	Lower Jurassic?	Unnamed intrusives (Jlu)	-	Deeply weathered granodiorite and diorite, with aplite and dolerite dykes	Hilly, low relief	Immediately west of Asaro R, SE edge of Sheet area	Unconformably overlain by Oligocene limeste (Chimbu Limestone?). Previously thought to be part of Bismarck Intrusive Complex but has 180-190 m.y. old Sr-Rb isotopic age. Type area near Asaro village (Karimui Sheet
	Upper Triassic	Kana Volcanics (Ruk)	600-2500	Massive dark green and multi-coloured basic to intermediate agglomerate, basalt flows and dykes, maroon and grey-green tuff and conglomerate, light green acid? lava, fine volcanic breccia (lapilli tuff?) with purple clasts, pillow lava, black greywacke, recrystallized coral limestone, red calcarenite, volcanolithic and feldspathic sandstone, rhyolite	Extremely rugged terrain, with steep narrow ridges and a close dendritic pattern of deeply incised mountain torrents	Central part of sheet area	Extensively epidotized and recrystallized to low greenschist facies. Lavas mostly andesite, but some basalt, dacite, and rhyolite. Mostly marine but some subaerial lavas and pyroclastics. Fossils restrict to area in headwaters of Jimi R where bivalves indicate Upper Triassic age. Extensively intruded by Miocene plutonic a hypabyssal rocks and unconformably overlai by Balimbu Greywacke or younger formations
	Upper Triassic	Jimi Greywacke (TR uj)	800 (base not seen)	Highly indurated fine-to-medium grained dark grey, blue and brown greywacke and siltstone; minor shale, red and purple siltstone and pink feldspathic sandstone	Extremely rugged terrain with steep narrow ridges and a close dendritic pattern of deeply incised mountain torrents. Relief	Jimi valley and along Bundi Fault Zone between the Yemi R and the Simbai R	Commonly micaceous and calcareous; coarse beds generally carbonaceous. Grades upwar through transition zone into Kana Volcanic Contains pelecypods, gastropods, brachiopo and cephalopods of Carnian-Norian age. Type locality: S side of Jimi Valley between Bubaltunga and Gebal.
	Middle to Upper Triassic	Yuat Formation (TR my)	only about 100 exposed	Black shale, massive, indurated, and well-jointed; very minor feldspathic sandstone	Very rugged. (Simil to Kana Volcanics)	Yuat River, NW corner of Sheet area	Richly fossiliferous (ammonites, nautiloid lamellibranches, crinoid stems) where seen further downstream on the Ambunti and Waba Sheets. Anisian to Carnian-Norian. Type section: Yuat Gorge, Ambunti Sheet; not measured
	Mesozoic	Goroka Formation (Mg)	unknown	Quartz veined grey biotite and andalusite-biotite schist and shistose siltstone, grey-green phyllite and minor buff gneiss (commonly with lit-par-lit injections of Bismarck Intrusive Complex Rocks) amphibolite and marble. Hornfels common	Rugged high mountains with steep narrow ridges and close dendritic pattern of deeply incised mountain torrents. Relief up to 1000 m. Mostly forrested, some gardens and grassland	SE corner of Sheet area	Bedding well preserved, schistocity parall to it. Absolute age unknown. May contai some lower Tertiary metasediments. Preliminary isotopic age indicates most recent metamorphic even occurred 20-25 m.y B.P.

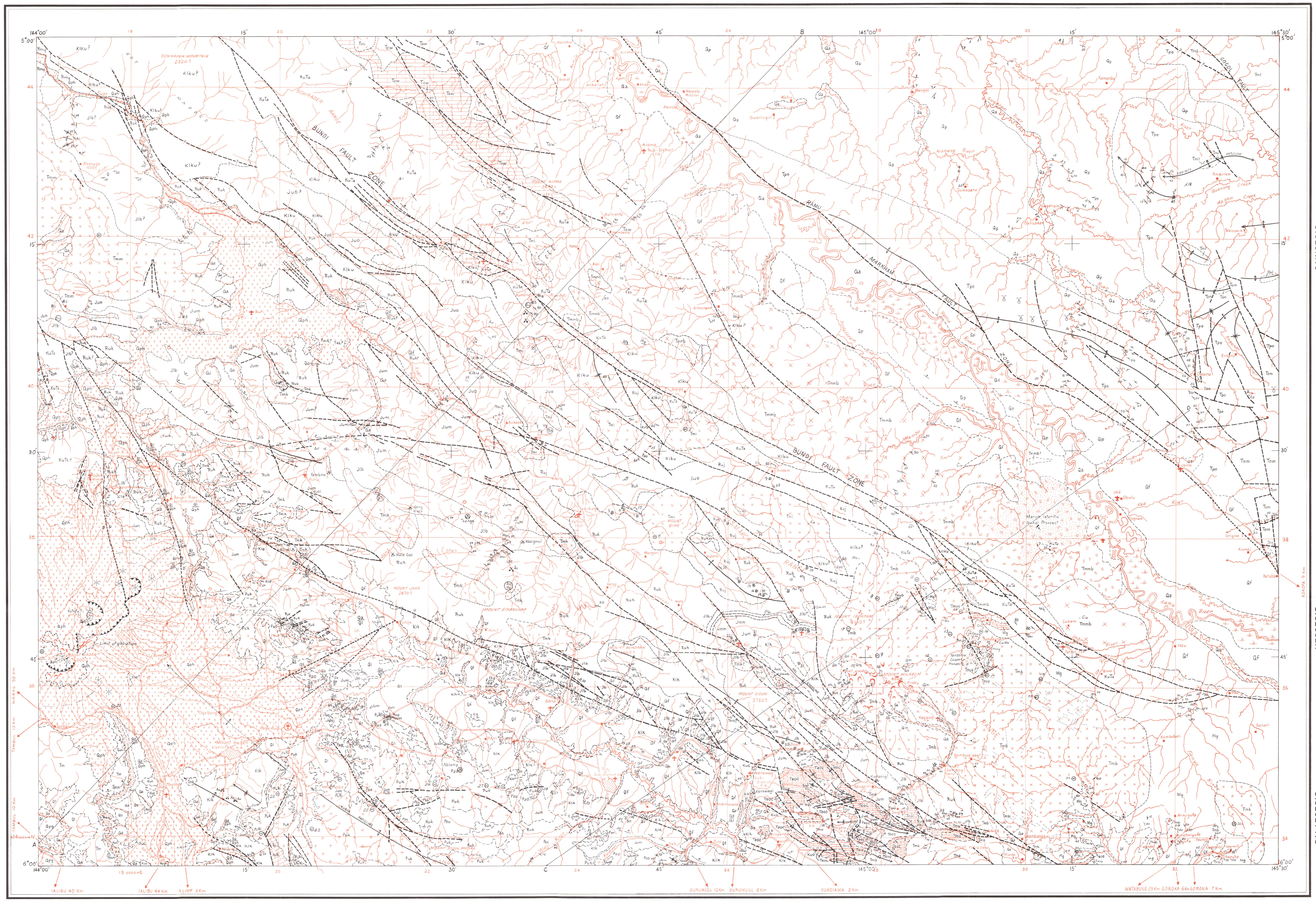
ERA	AGE	ROCK UNIT AND SYMBOL	ESTIMATED THICKNESS (m)	LITHOLOGY	TOPOGRAPHY	DISTRIBUTION	REMARKS
PALAEOZOIC	Upper Permian to Lower Triassic	* Kuta Formation (PTR k)	Variable; up to 100 in Gurumugl area and 250 at the western end of the Kubor Anticline	Dark grey to buff limestone, sandy limestone and minor arkose	Forrested dipslopes with some poorly developed karst; bare cliffs up to 100 m high	Western end of Kubor Anticline, S part of Sheet area	Contains varied fauna of brachiopods, gastropods, ammonites, corals and forams which indicate an age straddling the Permian-Triassic boundary
	Upper Permian	Kubor Granodiorite (Puk)	-	Coarse grained biotite-hornblende granodiorite and tonalite; small stocks and dykes of diorite and gabbro, dykes and veins of aplite and muscovite pegmatite	Extremely rugged mountains; maximum relief about 1200m; altitude 1500-4000m. Massive summit ridges, long straight slopes (25°-45°), rounded crests, and high mountains with steep (25°-60°) narrow ridges and close dendritic pattern of deeply incised streams	Kubor Anticline, S part of Sheet area	Western batholith probably contains unmapped roof pendants of Omung Metamorphics. Sulphide minerals (mainly pyrite) very sparse. Coarse grained rocks commonly altered and deeply weathered
	Upper Palaeozoic	Omung Metamorphics (Pzo)	-	Slate, phyllite, sericite schist, partially recrystallized indurated shale and siltstone; less common metagreywacke, basic metavolcanics (mostly green), spotted slate and hornfels. Quartz veins and pods are common	Same as for Kubor granodiorite and Goroka Formation	Kubor Anticline S part of Sheet area	Contains numerous small unmapped Kubor Granodiorite bodies. The metagreywacke and slightly metamorphosed shale and siltstone have blocky jointing, poorly developed cleavage, some graded and fine current bedding and intraformational breccia. Slaty cleavage present only in finer grained rocks and commonly parallels bedding. Secondary strain-slip cleavage and resultant small folds and crenulation lineations on main cleavage surfaces are locally present. In places tightly folded beds have axial plane cleavage. Post metamorphic chevron folds and kink bands in phyllite

* Recent palaeontological work indicates an Upper Triassic age for the Kuta Formation.

RAMU

PAPUA NEW GUINEA 1:250,000 GEOLOGICAL SERIES

SHEET SB 55-5



Reference

- Geological boundary
- Anticline showing direction of plunge
- Syncline, showing direction of plunge
- Overturned anticline, showing direction of plunge
- Overturned syncline, showing direction of plunge
- Fault (D, U indicate relative movement down, up)

Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, folds are dotted, faults are shown by short dashes

- Shear zone
- Strike and dip of strata
- Unmeasured strike and dip of strata
- Vertical strata
- Horizontal stata
- Overturned strata
- Dip } Air-photo interpretation
- Trend line } Air-photo interpretation
- Strike and dip of joint
- Joint pattern (Air-photo interpretation)
- Strike and dip of foliation
- Unmeasured strike and dip of foliation
- Strike and dip of cleavage
- Unmeasured strike and dip of cleavage
- Vertical cleavage
- Platy flow - inclined
- Unmeasured platy flow
- Major eruptive centre with no recorded eruption
- Minor eruptive centre with no recorded eruption
- Crater wall
- Gas seep
- Macrofossil locality and specimen number
- Microfossil locality and specimen number
- Plant fossil locality
- Sample locality for age determination and sample number
- ·Cu Minor mineral occurrence
- Unworked deposit
- Prospect
- Alluvial workings

Cu - Copper, Au - Gold, Cp - Clay - pottery
Mo - Molybdenite, Zn - Zinc, Ba - Barite,
Dt - Diatomite

- Abandoned stone axe quarry – minor
- Abandoned stone axe quarry – major
- Spring - salinity 2500 - 10000 ppm
- Spring - salinity > 10000 ppm
- Swamp
- Escarpment
- Cirque
- Highway
- Road
- Track (graded in part)
- Airport
- Landing ground
- Settlement
- Town
- Minor control point used by BMR for topographic base preparation
- 2320± Approximate elevation in metres (exact position not determined)
- abd Abandoned

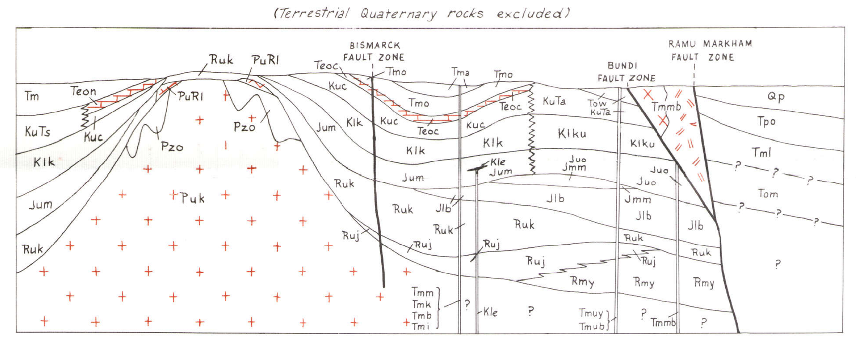
Reference

CAINOZOIC	QUATERNARY	HOLOCENE		Qa	Alluvium
		PLEISTOCENE TO HOLOCENE		Qs	Talus, scree
				Qf	Fanglomerate
				Ql	Lake sediments
				Qm	Moraine, fluvioglacial deposits
			Hagen Volcanics	Qph	Basaltic (shoshonitic) to dacitic lava, agglomerate, tuff, lahars and conglomerate; Hypabyssal intrusives
			Giluwe Volcanics	Qpg	Shoshonitic lava, agglomerate, minor ash and tuff
		PLEISTOCENE		Qp	Marine sandstone, siltstone, conglomerate, alluvial fans
	TERTIARY	PLIOCENE * Th	** Ouba Beds	Tpo	Marine and terrestrial clastic sedimentary rocks
		UPPER MIOCENE	Yanderra intrusives	Tmuy	Hornblende diorite and granodiorite porphyries
			Benembi Diorite	Tmub	Porphyritic hornblende microdiorite
		MIDDLE MIOCENE * lower Tf	Marum Basic Belt	Tmmb	Gabbro, norite, anorthosite; Dunite, serpentinite, pyroxenite
			Oipo intrusives	Tmi	Gabbro, granodiorite, tonalite, diorite, pyroxenite, lamprophyre
			Bismarck intrusive Complex	Tmb	Gabbro, diorite, subordinate mangerite, granodiorite, tonalite, granite; minor aplite, ultrabasics
			Kimil Diorite	Tmk	Diorite, gabbro, tonalite, granodiorite, mangerite, dolerite
			Maramuni Diorite	Tmm	Diorite, granodiorite, gabbro, andesite porphyry
			** Daulo Formation	Tma	Andesitic to shoshonitic agglomerate; subordinate lava, ash-flow tuff; volcanolithic conglomerate and sandstone, greywacke, tuff
		LOWER TO MIDDLE MIOCENE * upper Te to lower Tf	Movi Beds	Tmo	Calcareous sandstone and siltstone, shale and minor conglomerate; Limestone
		LOWER MIOCENE * upper Te	** Mena Beds	Tml	Marine clastic sediments, intermediate to basic agglomerate and lava
		UPPER OLIGOCENE TO MIDDLE MIOCENE * Td to Tf	** Aure Beds	Tm	Calcareous mudstone, greywacke and minor siltstone
		UPPER OLIGOCENE ? * lower Te	Wulamer Beds	Tow	Agglomerate, calcareous sandstone, slate, shale; Limestone
			Mebu Beds	Tom	Intermediate to basic agglomerate and lava, marine clastic sediments
		MIDDLE EOCENE TO LOWER OLIGOCENE * Ta_3 – Tc	Chimbu Limestone	Teoc	Foraminiferal dark grey, buff and white limestone; calcarenite
			Nebilyer Limestone	Teon	Grey limestone, calcarenite; minor argillite, siltstone
MESOZOIC		UPPER CRETACEOUS TO EOCENE	Asai Shale	KuTa	Phyllitic carbonaceous shale, siltstone, mudstone; minor limestone, calcarenite, greywacke, conglomerate
			Salumei Formation	KuTs	Shale, sandstone, conglomerate; minor foraminiferal limestone
		UPPER CRETACEOUS	Chim Formation	Kuc	Shale, siltstone and laminated sandstone and siltstone; minor calcarenite, agglomerate, greywacke, conglomerate and tuff
		LOWER CRETACEOUS	Kondaku Tuff	Klk	Siltstone, shale, volcanolithic sandstone, tuffaceous sandstone and tuff, andesitic agglomerate and lava
		LOWER CRETACEOUS ?	Kumbruf Volcanics	Klku	Basaltic agglomerate and pillow lava; subordinate tuff, greywacke, siltstone
			** Kera intrusives	Kle	Augite dolerite and gabbro
		UPPER JURASSIC	Maril Shale	Jum	Dark grey calcareous pyritic shale and siltstone; minor grey sandstone, limestone; Basal rudite, arkose
		UPPER JURASSIC ?	Kompiai Formation	Juo	Phyllitic shale, siltstone, greywacke, feldspathic sandstone, conglomerate
		MIDDLE JURASSIC ?	Mongum Volcanics	Jmm	Basic submarine agglomerate and pillow lava; conglomerate, tuffaceous greywacke
		LOWER JURASSIC	Balimbu Greywacke	Jlb	Calcareous and volcanolithic greywacke, siltstone, shale
		LOWER JURASSIC ?	** Urabagga intrusives	Jlu	Granodiorite, diorite
		UPPER TRIASSIC	Kana volcanics	Ruk	Red, purple and green acid to basic agglomerate; volcanolithic sediments, lava, tuff; Calcarenite
			Jimi Greywacke	Ruj	Greywacke, siltstone; minor shale, sandstone
		MIDDLE TO UPPER TRIASSIC	Yuat Formation	Rmy	Black shale
			Goroka Formation	Mg	Quartz veined schist, phyllite, schistose, carbonaceous and calcareous siltstone, hornfels; minor gneiss, amphibolite; Marble
PALAEOZOIC		UPPER PERMIAN TO LOWER TRIASSIC	Kuta Formation	PuRl	Limestone, sandy limestone and arkose; very minor basalt
		UPPER PERMIAN	Kubor Granodiorite	Puk	Granodiorite, tonalite, minor diorite, gabbro, adamellite, aplite, pegmatite
		LATE PALAEOZOIC	Omung Metamorphics	Pzo	Slate, phyllite, metagreywacke, basic metavolcanics, hornfels

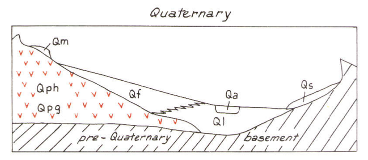
* Tertiary letter stage ** Name not yet approved

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

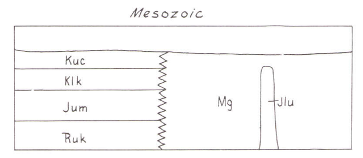
(Terrestrial Quaternary rocks excluded)



Quaternary

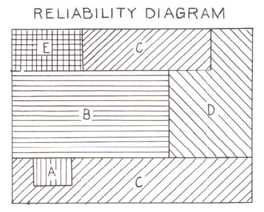


Mesozoic



Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development.
Base map adapted from topographic maps prepared by Division of National Mapping and Royal Australian Survey Corps, with additional compilation by Bureau of Mineral Resources, 1971 from Commonwealth Aerial Photography and uncontrolled SLAR mosaics with horizontal control station data supplied by Division of National Mapping

RELIABILITY DIAGRAM



A. Army base, detailed, well controlled.
B. Slotted Template Assembly, detailed, semi-controlled.
C. Adjusted National Mapping bases, detailed, poorly controlled.
D. Army base, not detailed, poorly controlled.
E. Drawn from adjusted SLAR mosaic at approximately 1:250,000 scale, not detailed, uncontrolled.

INDEX TO ADJOINING SHEETS

Showing Magnetic Declination 1970

AITAPE SA 54-15	WEWAK SA 54-16	SEPIK SA 55-13		
MAY RIVER SB 54-3	AMBUNTI SB 54-4	BOGIA SB 55-1	KARKAR ISLAND SB 55-2	
BLUCHER RANGE SB 54-7	WABAG SB 54-8	RAMU SB 55-5	MADANG SB 55-6	SAG SAG SB 55-7
RAGGI SB 54-11	LAKE KUTUBU SB 54-12	KARIMUI SB 55-9	MARKHAM SB 55-10	HUON SB 55-11
LAKE MURRAY SB 54-15	AWORRA RIVER SB 54-16	KIKORI SB 55-13	WAU SB 55-14	SALAMAUA SB 55-15

ANNUAL CHANGE 37'E

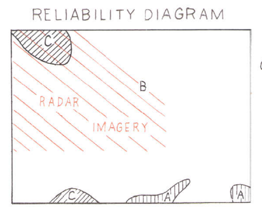
Scale 1:250,000

BROWN NUMBERED LINES ARE 20,000 METRE INTERVALS OF THE AUSTRALIAN MAP GRID, ZONE 55 TRANSVERSE MERCATOR PROJECTION

Sections

Scale: $\frac{V}{H} = 1$

RELIABILITY DIAGRAM



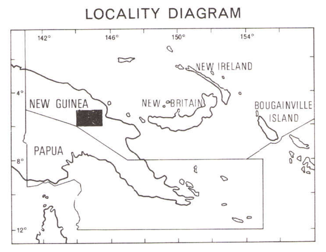
Geology: A Detailed mapping

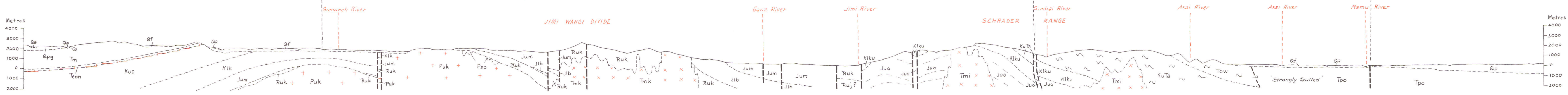
B Detailed reconnaissance: numerous traverses, interpretation of air-photos and radar imagery

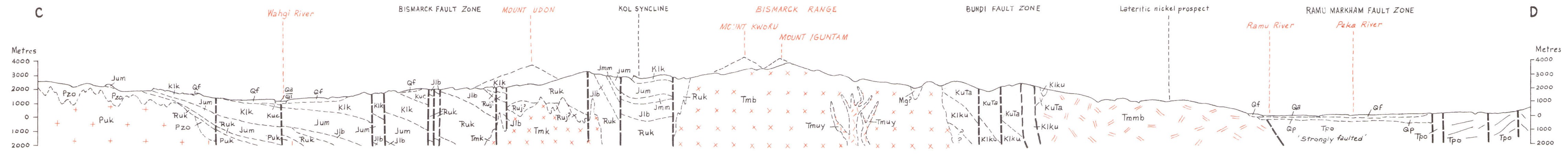
C General reconnaissance: few traverses, mainly interpretation of air-photos and some radar imagery

Geology, 1960, by E.J. Malone, N.J. McMillan
1964, by F.E. Dekker, D.B. Dow
1967, by J.H.C. Bain, D.B. Dow, R.J. Ryburn
1968, by J.H.C. Bain, D.B. Dow, D.E. Mackenzie, R.W. Page, R.J. Ryburn, I.E. Smith
1970, by J.H.C. Bain, D.E. Mackenzie, Continental Oil Company (Australia)
Compiled 1971, by J.H.C. Bain, D.E. Mackenzie
Drawn 1971, by P.G. White

LOCALITY DIAGRAM







PRELIMINARY EDITION, 1972
SUBJECT TO AMENDMENT

RAMU
SHEET SB55-5

MERCURY-WALCH