DEPARTMENT OF
MINERALS AND ENERGY

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS



RECORD 1974/58



# EXPLANATORY NOTES ON THE KARIMUI GEOLOGICAL SHEET

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

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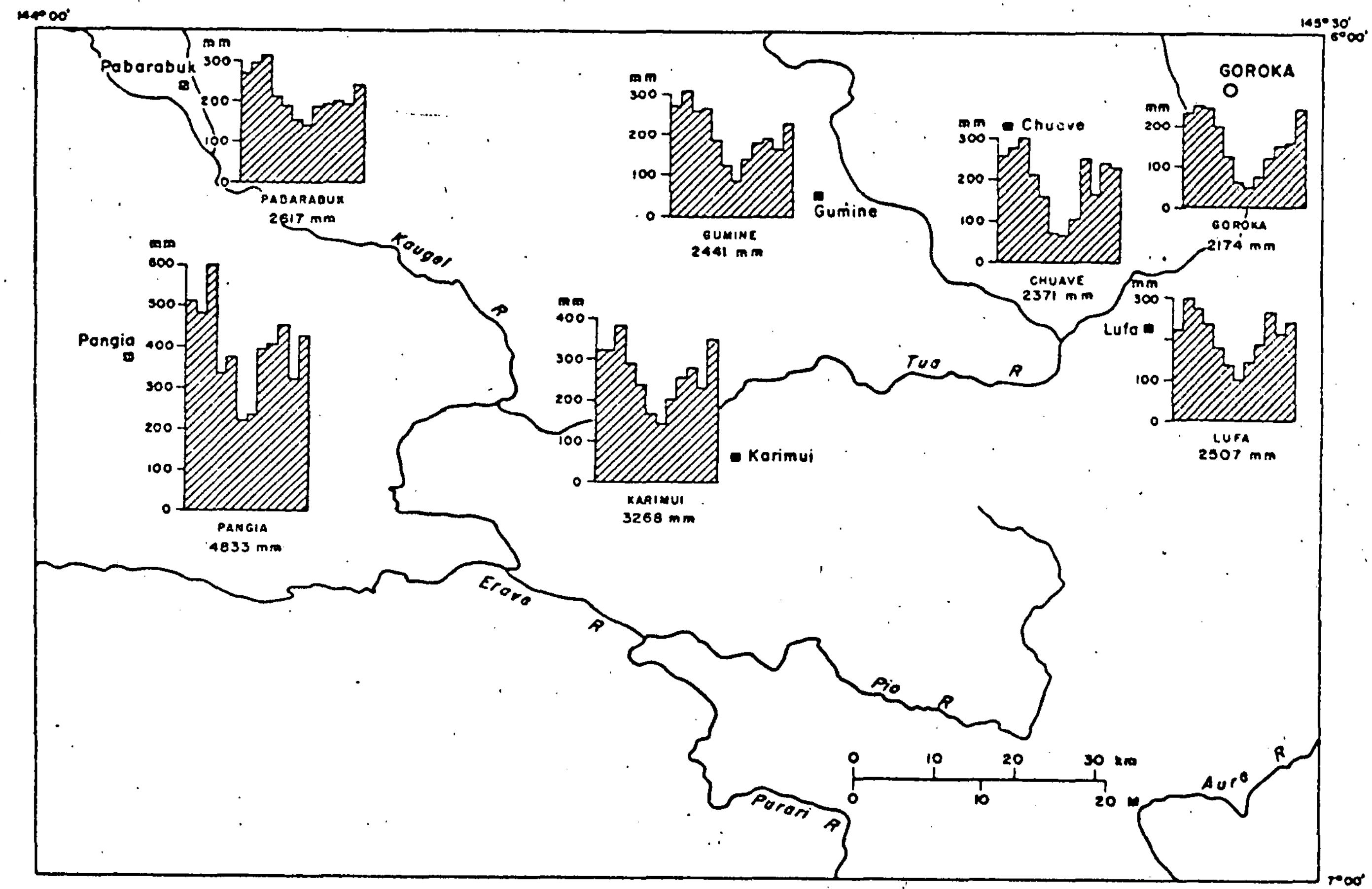
The Karimui 1:250 000 Sheet area is bounded by latitudes 6° and 7°S and longitudes 144° and 145°30'E, and covers 17 600 km$^2$ of the central range of Papua New Guinea and its southern foothills; it straddles the former territorial boundary between Papua and New Guinea.

Goroka (Eastern Highlands District) in the northeast and Kundiawa (Chimbu District), 48 km to the west, are the only towns in the area; both are Government administrative headquarters and are situated on the Highlands Highway. The subsidiary administrative centres Pangia (Southern Highlands District), Lufa (Eastern Highlands District), and Karimui, Gumine, and Chuave (Chimbu District) are situated in the northern half of the Sheet area. The essentially rural population of about 250 000 is concentrated (up to 200 persons per km$^2$) in the northeastern part of the Sheet area; most of the Kubor Range and the southern part of the Sheet area are uninhabited.

Scheduled air services to Goroka and Kundiawa, and the Highlands Highway, a gravel road connecting Lae, Goroka, Kundiawa, and Mount Hagen, provide the main access to the Sheet area. Other roads are restricted to the northeast and northwest; most are unsurfaced and suitable only for light 4-wheel-drive vehicles; they are impassable for periods during the wet season. Even the arterial Highlands Highway is often closed for short periods as a result of washouts, landslides, and road maintenance. There are a number of public and mission-owned airstrips within the Sheet area which are regularly served by scheduled light aircraft from Goroka.

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KARIMUI 1:250 000

Fig. [illegible] Expl. notes ANNUAL DISTRIBUTION OF RAINFALL (Jan. to Dec.)

J. Bela

Numerous walking tracks provide ready access to the populous areas, but the sparsely populated regions are less accessible, and some rugged uninhabited areas are best reached by helicopter.

Most field-survey supplies can be obtained in Goroka; food and some services are also available at Kundiawa. Local labour is easily obtained; without labour to carry supplies and camping equipment, field surveys away from the roads would be difficult, if not impossible.

Below 1500 m the climate closely resembles the wet tropical type (Af) of Köppen (1931). The annual mean temperature is between 21 and 24°C, the diurnal range about 10°C, and the annual range of mean monthly temperatures less than 2°C. Mean monthly relative humidity at 9 a.m. is usually between 85 and 90 percent. Mean monthly cloudiness ranges from 50 percent in the morning to as much as 80 percent in the afternoon, and totally overcast conditions are very common. Annual rainfall is in the order of 3200 - 5000 mm, increasing towards the southwest. In the southeast there is no marked seasonal trend in rainfall, although there is a slight maximum during the May to August season of southeasterly winds. Elsewhere there is a pronounced maximum from October to March as in the highland areas (Fig. 1).

Above 1500 m lower average temperatures give an equable climate. The annual mean temperature at Goroka (1560 m) is 20°C, the diurnal range is about 10°C, and the annual temperature range only 2°C. Humidity is high throughout the year. Ground frosts are common above 2550 m. Annual rainfall is between 2000 and 2600 mm and there is a pronounced wet season from October to March. In the highland valleys local air circulations are the dominant climatic control during the southeast season and an important control during the remainder of the year. These local circulations commonly result in clear basin centres and clouded slopes in the late morning; this is reversed in the early evening. Clear skies commonly prevail later in the evening and temperature inversion frequently causes early morning fogs over the basin floors (McAlpine, 1970).

Previous geological investigations

In 1939 Noakes measured and took specimens from a section Mesozoic Tertiary rocks exposed in the Chimbu River (Edwards & Glaessner, 1953; Crook, 1961). In 1947 Mott (1948) visited the Kerabi valley area during a reconnaissance of the Samberigi area. In 1949 APC geologists made a reconnaissance of the Central Highlands from Aiyura (Markham Sheet area) to Mount Hagen (Stanley, 1950). During this survey the Miocene rocks east of the Chimbu Limestone were examined and the limestone of the Kuta Formation resampled. Subsequent palaeontological examination of this limestone (Glaessner et al., 1950) established its age as Permian. The Kubor granite and the metamorphic rocks were therefore thought to be Palaeozoic and thus the oldest known rocks in eastern New Guinea. Rickwood & Paterson (1950) traversed from the Sireru River to Lake Tebera, then eastward to the Purari River and southwards to Wai Creek.

Most of the densely populated land in the mountains below 2000 m is cultivated and as a result there are large areas of grassland, secondary forest, and Casuarina groves and gardens. Elsewhere the predominating vegetation is dense rain forest, which varies broadly with altitude: below 1200 m a three-layered lowland rainforest; from 1000 to 3000 m a two-layered lower montane forest with dominant oak, beech, and coniferous communities; above 3000 m a one-layer montane rainforest with mosses and liverworts and some alpine tussock grassland on summit areas.

Aerial photographs taken by Qasco, Adastra, RAAF, and other sources afford almost complete coverage of the area (Table 1). Most have been taken from a height of about 7600 m using a 152 mm focal length lens but some were taken from a height of 4500 m (Qasco). High local relief and elevation, wandering flight lines, variations in altitude and attitude of the aircraft, large areas of cloud and shadow, and poor-quality prints make geological interpretation and base preparation difficult. Furthermore, RAAF trimetrogon and Adastra vertical photographs were flown before 1960, and shown none of the recent roads. Side-looking airborne radar imagery obtained in May 1970 by Westinghouse-Raytheon for the Commonwealth Department of the Army covers most of the southern half of the Sheet area.

None of the available maps were sufficiently accurate to be used as a topographic base. The southwestern part of the map was compiled at 1.250 000 scale, geological data being plotted directly onto the 1:250 000 scale topographic base which had been traced from the radar mosaic. Elsewhere, geological data were plotted on 1:50 000 scale bases, which were then photographically reduced to 1:250 000 scale. The 1:50 000 bases for the northeastern part of the area were obtained by enlarging 1:63 360 scale Planimetric Series (uncontoured) Preliminary Edition maps prepared by the Division of National Mapping. Elsewhere, bases were compiled by tracing major streams on uncontrolled mosaics assembled from aerial photographs.

These were reduced to 1:50 000 scale and adjusted so that at 1:250 000 scale, the drainage approximately matched the generalized stream pattern on the Royal Australian Survey Corps 1:250 000 scale topographic map. Further adjustments were made to the 1:250 000 scale base in order to accommodate the available control points and to match the drainage on Ramu 1:250 000 geological Sheet.

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Rickwood (1955) mapped the area from Chuave to Wabag, including the Kubor Range and the Wahgi valley; this was the first systematic map of the Highlands. Unfortunately, he and earlier workers had no base map or aerial photographs of the area, and consequently much of their data is not easily referable to existing maps or aerial photographs. Rickwood, however, recognized the broad structure of the area and mapped and defined the formations suggested by Edwards & Glaessner (1953). The geological knowledge of the Highlands was then regarded as adequate for the purposes of oil exploration in Papua. Rickwood and others (Rickwood & Kent, 1956) subsequently mapped the area south of Mount Michael and the Tua River, but again they had no accurate base maps.

In 1956 BMR started to map the eastern part of the Central Highlands (McMillan & Malone, 1960), using aerial photographs and semi-controlled detailed topographic bases prepared by the Division of National Mapping, Canberra.

Land research surveys by CSIRO in 1956-57, 1960-61, 1965, and 1967 (CSIRO, 1965; 1970) obtained some geological information in the Mount Ialibu and Kundiawa-Goroka areas.

In 1968 the area near Pangia was systematically mapped by BP Petroleum Development (Aust.) Pty Ltd (Buchan & Robinson, 1969).

Since 1962 engineering geologists from the Geological Survey of Papua New Guinea have made geological observations along the line of the Highlands Highway in the course of road-alignment investigations. Several large mining companies (notably Kennecott (Aust.) Pty Ltd and CRA Exploration Pty Ltd) have made brief reconnaissances throughout the northern half of the area collecting stream sediments. More recently, Dow and Harding in 1966, and Page and McDougall in 1967, collected specimens for isotopic age determination (Page, in prep; Page & McDougall, 1970 a & b).

The map and most of the information contained in these notes resulted from systematic regional geological mapping by BMR geologists in 1968 and 1970 (Bain et al. 1970).

## PHYSIOGRAPHY

### Drainage

The Purari River system drains most of the Sheet area through its tributaries of the Tua, Erave, Kaugel, Wahgi, Asaro, Aure, and Pio Rivers, emptying into the Gulf of Papua. The southwestern part also drains

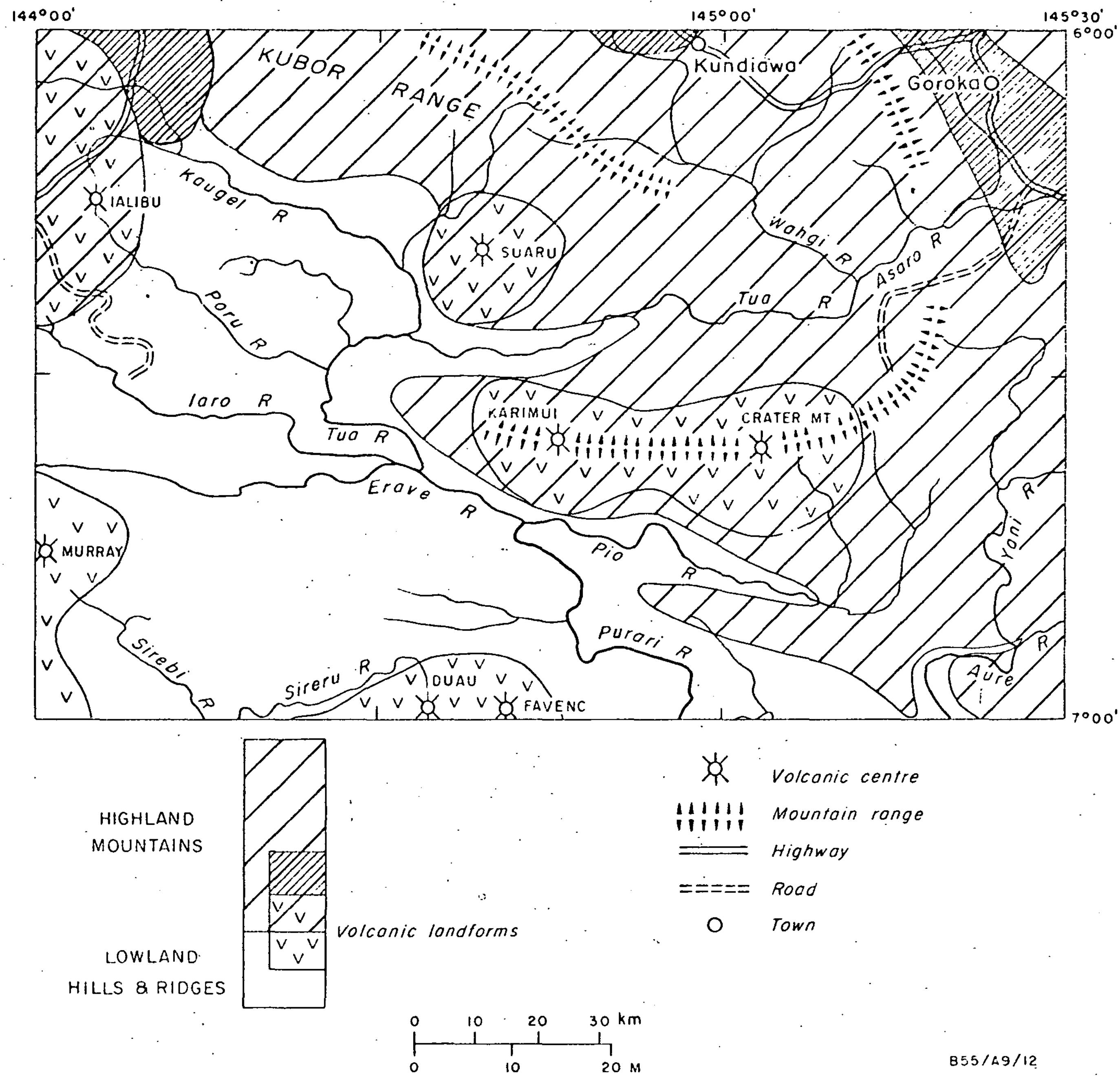



Fig. 2 Expl. No'es KARIMUI J Bain PHISIOGRAPHIC DIVISIONS

into the Gulf of Papua, via the Kikori River and its main tributaries the Sirebi and Sireru Rivers.

Structure and lithology have considerably influenced the drainage pattern. Almost all the large streams in the limestone country are constrained by regional structural trends; the Erave River is a notable example. Most minor streams drain into sinks in the limestone. Radial drainage is developed on the Quaternary volcanoes, rectilinear subsequent drainage on the Yaveufa Formation, and fine dendritic drainage on the Kubor Granodiorite.

Physiographic divisions

The Sheet area lies within the central cordillera of Papua New Guinea. The southeastern half is 150 to 1200 m above sea level and forms the southern foothills of the cordillera; the remainder of the area lies above 1200 m, with summit peaks and ridges up to 3800 m.

The main physiographic divisions are shown in Figure 2.

1. Highland Mountains
   - a) Kubor Range
   - b) Goroka intermontane valley
   - c) volcanic landforms

2. Lowland hills and ridges.

Highland Mountains

The area above 1200 m consists of rugged mountains with a diversity of landforms. Most of the area consists of low rugged mountains and hills with irregular branching ridges and a deep incised close dendritic pattern of V-shaped valleys. In some areas there are well developed strike ridges and dip-slopes and a structurally controlled rectilinear pattern of valleys. Slit gorges and waterfalls are common.

The Kubor Range, the largest and highest of the ranges in the Highland Mountains division, is made up of the resistant rocks in the core of the Kubor Anticline. It is 75 km long, and averages 2500 m in height. It is extremely rugged, the highest parts consisting of massive summit ridges with long straight slopes and rounded crests; the lower parts consist of high mountains with steep narrow ridges and a close dendritic pattern of deeply incised mountain streams.

The Goroka intermontane valley is a large flat-floored valley between 1400 and 1600 m above sea level, encircled by high rugged mountains. The valley is floored by extensively terraced and moderately dissected undulating alluvial fans and gullied lake sediments of Quaternary age.

Volcanic landforms consist of volcanic cones 1000 m to 1500 m high and 12 to 15 km across, in an advanced stage of dissection with extensive and deeply gullied gently sloping aprons. Local relief on the aprons is up to 150 m. Crater Mountain is the oldest and most deeply eroded but still preserves some of the cones, domes, and cinder cones with cliffed lava flow remnants, and deeply gorged streams.

## Lowland hills and ridges

The Lowland hills and ridges form part of a deeply dissected plateau whose maximum local relief is about 300 m, dominated by prominent limestone strike-ridges with shallow to steep concave and convex dip-slopes and precipitous fault scarps. There are also extensive areas of subhorizontal limestone. Very rugged karst topography with internal drainage is developed on the limestone (Jennings & Bik, 1962) and long subparallel through-going major streams traverse some of the valleys between the limestone ridges.

## STRATIGRAPHY

The stratigraphy is outlined in Table 2.

## UPPER PALAEOZOIC

### Omung Metamorphics

The age of the Omung Metamorphics is unknown, but they are older than the Upper Permian Kubor Granodiorite.

## MESOZOIC?

### Bena Bena and Goroka Formations

The Bena Bena and Goroka Formations consist of low to moderate grade (low-pressure type) regional metamorphics of unknown age. The Bena Bena Formation is of slightly higher metamorphic grade than the Goroka Formation and may be older than it. The formations are probably the metamorphic equivalent of some of all of the Mesozoic formations exposed on the flanks of the Kubor Anticline. For example, rocks in the Asaro Valley near Asaro village are very like the sheared Upper Triassic Kana Volcanics in the Chimbu River valley (Ramu Sheet area); moreover, they are intruded by 180-190 m.y. (Lower Jurassic) granitic stocks. Other parts of the Goroka Formation are similar to the Upper Cretaceous to Eocene Asai Shale (Ramu Sheet area). Structural and petrological properties of the metamorphics (McMillan & Malone 1960) indicate that there have been at least two metamorphic events. The main metamorphism must have been pre-Eocene because the formations are unconformably overlain by unmetamorphosed middle Eocene and younger sediments. However preliminary Rb-Sr isotopic data indicate that a metamorphic event also occurred about 20-25 m.y. ago (Page, in prep.).

## UPPER PERMIAN

### Kubor Granodiorite

A large number of isotopic age determinations by the K-Ar method indicates an age of 215 - 220 m.y. (Middle Triassic); but the Rb-Sr age of 244 m.y. (Upper Permian) is more acceptable as the granodiorite is unconformbly overlain by the fossiliferous Permian-Triassic Kuta Formation.

PERMIAN-TRIASSIC

Kuta Formation

The Kuta Formation consists of limestone reef remnants resting unconformably on granitic basement. The limestone is mainly dark grey, sligtly recrystallized, and very tough. It contains much quartz and feldspar, especially in its lower parts. Its age is believed to straddle the Permo-Triassic boundary.

UPPER TRIASSIC

Kana Volcanics

Altered volcanics called the Kana Volcanics, form conspicuous subhorizontal cappings on the summit ridges of the Kubor Range. They lie stratigraphically between the Kuta Formation and the Maril Shale and are correlated with the Upper Triassic Kana Volcanics in the Ramu Sheet area. They were deeply eroded before the deposition of the Maril Shale.

LOWER JURASSIC

Small, deeply weathered granodiorite and diorite stocks intrude the Goroka Formation near Asaro village. They have been dated isotopically at 180-190 m.y. and are much older than the nearby Bismarck Intrusive Complex. Other small intrusive bodies in the Goroka and Bena Bena Formations mapped as part of the Bismarck Intrusive Complex may also be of this age.

UPPER JURASSIC TO UPPER CRETACEOUS

Waghi Group

Up to 7250 m of shale, siltstone, sandstone, and subordinate volcanics and limestone were deposited in the northern part of the Sheet area after erosion of the Kana Volcanics. The sequence has been divided into five formations, three of which crop out in the Sheet area.

The three formations have been shown by their macrofossil assemblages to range in age from Upper Jurassic to Upper Cretaceous. All three thin towards the core of the Kubor Anticline, parts of which were emergent from Triassic time onwards.

The Upper Jurassic Maril Shale rests unconformably on older rocks and is overlain with slight unconformity by the Lower Cretaceous Kondaku Tuff, which overlaps onto the Maril Shale and in places lies directly on Kuta Formation and Kubor Granodiorite. On the northern side of the anticline the Kondaku Tuff has a strong volcanic component, with lava, agglomerate, and breccia common in the lowermost 500 to 1000 m of section; to the south and southwest this component is minor or absent. The volcanics and volcanolithic sediments, which have been buried to depths of 4500 m or more, contain lime zeolites, prehnite, pumpellyite, and zoisite. The formation grades upwards into the Upper Cretaceous Chim Formation, which is predominantly shale and siltstone with a very minor volcanic component. The Chim Formation is more calcareous in the southwest than around the Kubor Anticline. Offlap from the Kubor Anticline occurred during deposition of the Chim Formation.

LOWER CRETACEOUS?

Unnamed and undated sills and dykes of diorite and microdiorite intrude the Maril Shale. Only the larger bodies have been shown on the map.

LOWER CRETACEOUS

Unnamed lithic sandstone of Aptian, Albian, and possibly Neocomian age in the Pio and Purari River area differs from the Kondaku Tuff in that it contains much arkosic material and no volcanic detritus. It is conformably overlain by Chim Formation

UPPER PALEOCENE TO EOCENE ($Ta_1$ to Tb)

Pima Sandstone

The Pima Sandstone is a sequence of 2000 to 3000 m of feldspathic sandstone and interbedded siltstone and mudstone which rests unconformably on Chim Formation east of Mount Suaru. The formation is confined to the east-trending Pima Syncline, the western end of which is unconformably overlain by the Quaternary Suaru Volcanics. Upper Palaeocene mudstone, mapped as Chim Formation, is also present east of Mount Ialibu in a tributary of the Kaugel River (Grid ref. 18603000), and may be present in the virtually unmapped area between Mounts Suaru and Ialibu.

EOCENE ($Ta_2$ to Tb)

Unnamed detrital and micritic Eocene Limestone and ferruginous and calcareous quartz sandstone (Te) in the southern part of the Sheet area unconformably overlie the Cretaceous formations and are overlain with apparent conformity by Darai Limestone and the Aure Beds. Although thin, the sediments are probably present almost everywhere beneath the Darai Limestone.

MIDDLE EOCENE TO LOWER OLIGOCENE ($Ta_3$ to Tc)

Nebilyer Limestone

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

Chimbu Limestone

The Chimbu Limestone forms the prominent cuesta northeast of the Chuave-Kundiawa section of the Highlands Highway. It is highly fossiliferous, much thicker than the Nebilyer Limestone, and overlies the Chim Formation unconformably or paraconformably; it is overlain by the Movi Beds.

UPPER OLIGOCENE (lower Te)

Omaura Greywacke

The Omaura Greywacke is far more extensive in the Markham Sheet area, where it unconformably overlies the Goroka and Bena Bena Formations. In the Karimui Sheet area it is bounded by faults to the south and west and overlain by Yaveufa Formation to the east. In the Kami Plantation area it is mixed with sheared serpentinite.

UPPER OLIGOCENE TO MIDDLE MIOCENE (lower Te to lower Tf)

Aure Beds

The Aure Beds were deposited mainly in deep water or a basin and are of the same age as the Darai Limestone; they show graded bedding. In the west they grade into the Darai Limestone and thus include beds deposited in a transitional environment. In the north and east, sediments of the same age have been divided into three formations, Omaura Greywacke, Movi Beds, and Yaveufa Formation.

The shallow-water clastic sediments extend from the Darai Limestone near the Purari River to the vicinity of the boundary between Papua and New Guinea. They range in thickness from about 1000 m in the west to about 2500 m in the east, and consist of conglomerate, pebbly greywacke, marl, limestone, mudstone, and greywacke siltstone. The carbonate rocks are progressively less common towards the east and there are sharp lateral and vertical facies variations.

The deep-water sediments to the northeast are up to 5700 m thick and lithologically more uniform. They consist of massive greywacke siltstone and some hard shale, marl, and thin pelagic limestone beds. Abundant benthonic and planktonic foraminifera and fragmental macrofossils are found throughout. Similar deep-water sediments are also present in the Kaugel Syncline in the northwest and facies of both basinal and transitional environments are present to the south near Pangia.

Darai Limestone

The Darai Limestone is a massive cliff-forming foraminiferal shelf limestone on which karst is well developed in most places. It has been tightly folded and thrust into a series of subparallel fault-bounded anticlines and synclines.

Where the formation grades into the Aure Beds the boundary between them has been indicated by facies change to include the maximum extent of the predominantly limestone facies. Elsewhere the limestone has been variously called the Telefomin, Strickland, Kaban or New Guinea Limestone, and it extends westwards from the Sheet area into West Irian.

LOWER TO MIDDLE MIOCENE (upper Te to lower Tf)

Movi Beds

The Movi Beds consist of well bedded calcareous shale, siltstone, sandstone, polymict conglomerate, and some tuffaceous beds and coral limestone lenses. The beds reach a maximum thickness of 4000 m in the southeast, thinning northwestwards to 500 m in the Ramu Sheet area. They are the lateral equivalent of the upper Te to lower Tf part of the shallow-water clastic sediments in the Aure Beds. They were deposited in an inlet of the main Aure basin which shallowed to the northwest and which is now the Yaveufa Syncline. The inlet was filled by a large volume and variety of calcareous, lithic, and volcanolithic detritus rapidly eroded from the flanking highland. The sediments contain abundant benthonic and planktonic foraminifera, gastropods, pelecypods, echinoids, and corals, and a variety of structures characteristic of fluctuating currents and water levels, i.e. work markings and burrows; iron-stained carbonized wood, ripple marks, fine pebble lenses, thin persistant limestone beds, rounded light-coloured sandstone concretions, limestone rubble lenses, cross-bedding, small angular unconformities, irregular beds of intraformational breccia.

MIDDLE MIOCENE (lower Tf)

Yaveufa Formation

The Yaveufa Formation consists of up to 4800 m of andesitic volcanics and interfingered volcanolithic sediments that overlie the Movi Beds. Within the Sheet area it is virtually confined to the Yaveufa Syncline, which was a sinking, probably fault-controlled, depositional basin during the middle Miocene. The lavas are too low in silica and too high in potash to be typical andesites; many are shoshonitic in composition. The formation contains abundant lower Tf benthonic foraminifera in limestone lenses. Isotopically dated igneous rocks in the formation have K-Ar ages of 12.5 - 15 m.y.

Bismarck Intrusive Complex

A small stock or hornblende diorite and gabbro containing numerous xenoliths intrudes the Goroka Formation about 5 km northeast of Gorlka. It is related to the middle Miocene Bismarck Intrusive Complex (Ramu Sheet area) but may be slightly younger (Page, in prep.).

Kenangi Gabbro

Small dykes and sills of hornblende gabbro, mangerite, and granodiorite intrude the Movi Beds near the Daulo Pass and are petrographically similar to the igneous rocks in the Yaveufa Formation; they are thought to be the hypabyssal equivalent of the volcanics of the Yaveufa Formation.

UPPER MIOCENE

Michael Diorite

Almost the whole of Mount Michael (3500 m) is made up of porphyritic hornblende microdiorite which intrudes the Movi Beds; it has been isotopically dated at 6-7 m.y. (Page in prep.).

## UPPER MIOCENE TO PLIOCENE (Tg to Th)

### Orubadi Beds

The Orubadi Beds are composed of mudstone, siltstone, and sandstone, crop out in the valleys between the strike ridges of Darai Limestone. They conformably overlie the Darai Limestone and are in turn conformably overlain by the Era Beds.

## PLIOCENE TO PLEISTOCENE (Th)

### Era Beds

The Era Beds resemble the Orubadi Beds, but contain some nonmarine sediments and coal seams. They do not extend as far north as the Orubadi Beds, and are confined to the vicinity of Mount Duau and Mount Favenc. They are overlain by the Quaternary Duau Volcanics.

## PLIOCENE TO HOLOCENE

### Crater Mountain Volcanics

Crater Mountain is a moderately to deeply eroded volcanic centre with many small, much younger cones, domes, craters, and lava fields. The volcanics consist of andesitic and basaltic lava, and minor agglomerate, tuff, and derived sediments. The older volcanic complex is probably late Pliocene or early Pleistocene in age; the younger volcanics are late Pleistocene to Holocene.

## QUATERNARY

### Giluwe Volcanics

Shoshonitic lava, ash, tuff, and agglomerate form Mount Giluwe (4160 m), a large volcano most of which is west of the Sheet area, and covers parts of the Kugel valley and other low-lying areas northwest and west of Mount Ialibu.

These deposits overlie Chim Formation, Nebilyer Limestone, and Aure Beds, and are overlain by small craters, cones, and lava domes straddling a small fault. Mount Giluwe is Pleistocene to Holocene in age, with intraglacial lava 25 000 years old in the summit area (Blake & Löffler, 1971). Some of the small satellite vents may be much younger than 25 000 years.

Hagen Volcanics

Predominantly basaltic lahar deposits, agglomerate, tuff, lava, and derived sediments of the Mount Hagen volcanic complex to the north of the Sheet area floor the Nebilyer valley. These deposits are cut by deep gullies of the Nebilyer River, and other rivers and streams.

Ialibu Volcanics

Mount Ialibu is a deeply eroded composite strato-volcano with moderately well preserved outer slopes and apron. It consists of a faulted, eroded northern centre, and a more severely faulted, eroded southern centre to which the name Mount Ialibu is applied. A line of small cones, craters and domes, which appear very young, connects the northwest flank of Mount Ialibu and the southeast flank of Mount Giluwe. The rocks include basaltic (shoshonite) and andesitic lava, agglomerate, tuff, and derived sediments. Mount Ialibu is probably early or middle Pleistocene to Holocene in age.

Mount Murray Volcanics

Mount Murray, close to the western margin of the Sheet area, is a moderately well preserved stratovolcano about 19 km in diameter, which has a greatly enlarged and deeply eroded crater. Basaltic and andesitic lava, ash, agglomerate, and derived sediments extend east and west along strike valleys, north over a ridge of Darai Limestone, and south over a large part of the Eihi River area. The southern extension is separated from the volcano by an eroded but topographically much higher limestone which has apparently been uplifted after the cessation of volcanism. The volcanics overlie folded and faulted Pliocene sediments (APC, 1961).

Duau Volcanics

The Duau Volcanics are the effusive products of Mounts Duau and Favenc, both of which are small, deeply eroded strato-volcanoes. They are cut by deep gorges, and their craters are greatly enlarged by erosion, mainly by streams draining to the south. Andesitic and basaltic lava, tuff, and agglomerate spread in all directions from these two centres, their greatest extent being to the south, beyond the Sheet boundary. The volcanics rest on folded and faulted Miocene and Pliocene sediments, and are probably Pleistocene in age.

Karimui Volcanics

Mount Karimui (2570 m) is a deeply dissected strato-volcano similar in appearance to Mount Murray. The summit, which is made up of at least three adjacent craters, and the southern side are deeply gorged, but the other slopes, particularly on the northern side, are well preserved and less deeply dissected than those of Mount Murray. Products of the volcano are basaltic (shoshonitic) lava, agglomerate, breccia, and minor tuff. On the eastern side the pyroclastics bury part of an older, deeply eroded volcanic complex thought to be part of the volcanic complex of Crater Mountain. The Karimui Volcanics rest on tightly folded Chim Formation and folded Darai Limestone, and are regarded as Pleistocene, as Mount Karimui has been eroded to the same degree as Mounts Murray, Duau, and Favenc.

Suaru Volcanics

Mount Suaru (2665 m) closely resembles Mount Karimui. However, it is less deeply eroded, the main erosion being two deep gorges which originate at the summit crater and cut the cone almost in two. Larger streams have cut ravines in the outer slopes and apron. There are two small satellite cones to the east.

The volcanics are basaltic (shoshonitic) and andesitic lava, agglomerate, breccia, and minor tuff. The area of volcanics west of the Kaugel River is probably composed largely of coarse to fine fragmental material, some of which may be nuee ardente deposits. Mount Suaru is Pleistocene in age, and rests on Lower and Upper Cretaceous and Paleocene-Eocene sediments.

### Alluvial fan deposits

Dissected, gently sloping alluvial and colluvial fans cover the floor of the northern half of the Goroka valley; a small remnant fan is also present at Kundiawa. The unconsolidated fluviatile clay, sand, silt, and boulder gravel are derived from the adjacent mountains.

### Scree deposits

Talus occurs virtually everywhere beneath cliffs and very steep slopes, but only the most extensive deposits have been mapped. The debris-laden mudflows and re-cemented fragments at the base of cliffs of Chimbu Limestone are an important source of road construction and surfacing material.

### Lake sediments

Similar to, but finer-grained that alluvial fan deposits, the flat-lying sediments in the southern part of the Goroka valley were deposited in a lake that formed at the same time as the alluvial fans.

## HOLOCENE

### Alluvium

Only the most extensive river terraces, flood plains, and valley-fill deposits have been mapped. The deposits consist of clay,sand, silt, gravel, and minor peat and alluvial soils. Residual soils blanket almost the entire area and rock outcrops occur only in cliff faces and in stream beds.

## STRUCTURE

The Sheet area includes three major tectonic divisions: Papuan Fold Belt, Kubor Anticline, and New Guinea Mobile Belt (Fig. 3). The Papuan Fold Belt is a belt 50 km wide and 600 km long of subparallel folds and faults which overlies the folded and upturned margin of the crystalline Palaeozoic basement. The Kubor Anticline is a broad, gentle arch 140 km long and 65 km wide at its widest point, and is the largest and easternmost exposure of Palaeozoic basement in Papua New Guinea. It divides and deflects the Papuan Fold Belt to the south and the New Guinea Mobile Belt to the north. The 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 of the intrusive ultramafic and metamorphic rocks of Mesozoic or younger age in mainland Papua New Guinea. The Mobile Belt is regarded as the Tertiary zone of interaction between opposing crustal plates, the Australian plate to the south and the Pacific plate to the north.

### Papuan Fold Belt

The Tertiary limestone has been considerably shortened within the Papuan Fold Belt by folding and overthrusting from the north. The style and state of preservation of the folds varies across the belt, from broad, steep-sided, flat-bottomed trough synclines and tight, commonly faulted anticlines in the north to overthrust anticlines and monoclines in the south (Fig. 4). These folds are topographically well defined only in the Tertiary limestone in the southwest. To the east the fold pattern is more complex and there is no close correlation between structure and topography

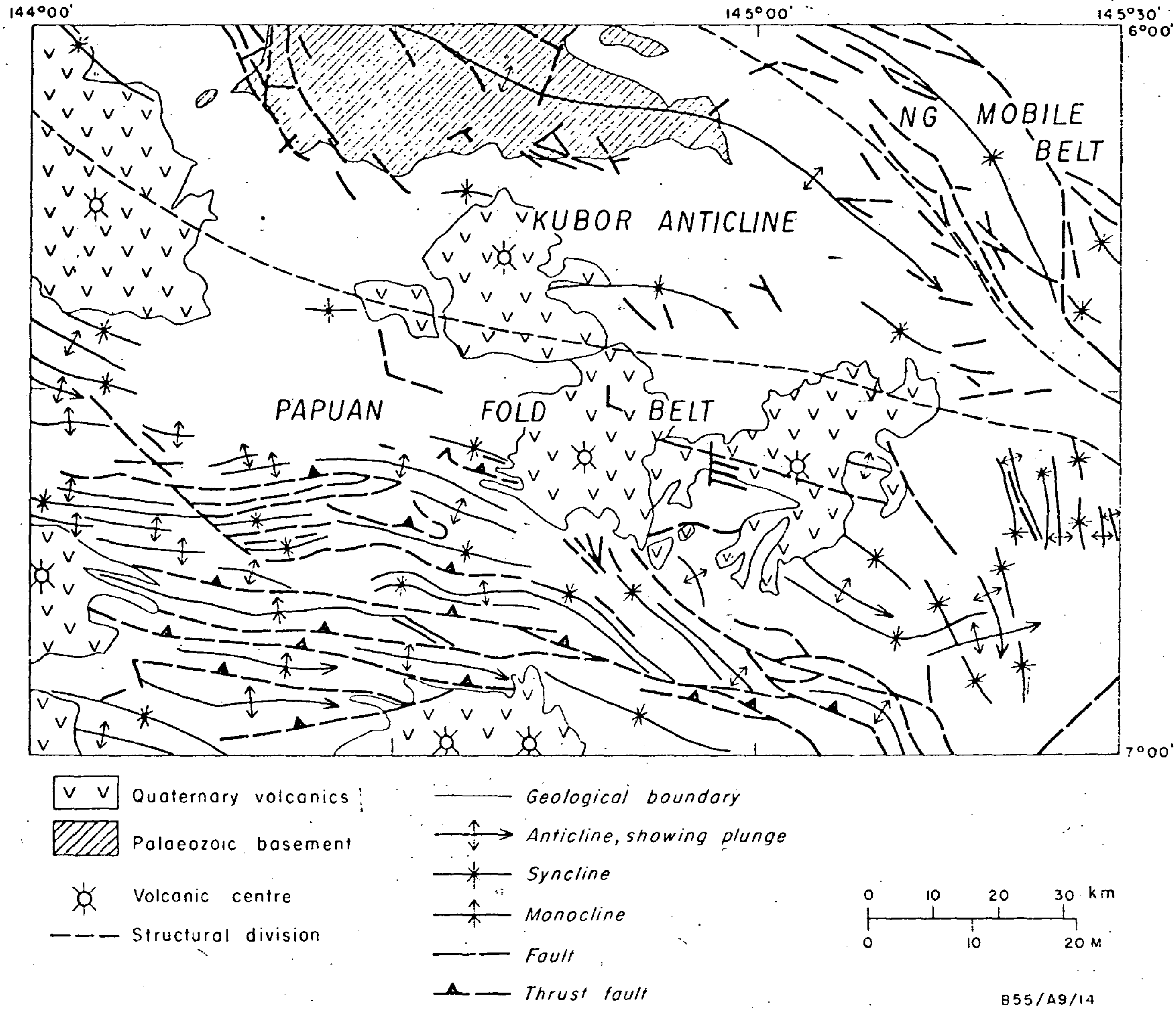


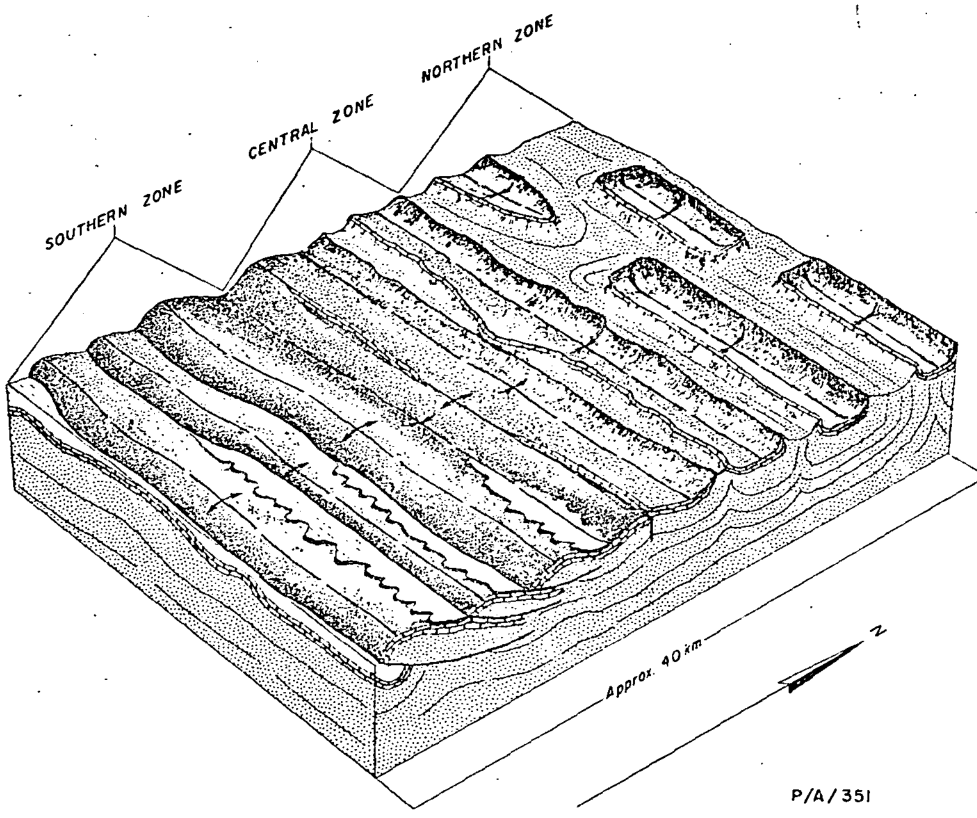

Fig 3 J Bain

Expl Notes KARIMUI

STYLE OF FOLDING IN
THE PAPUAN FOLD BELT

GENERALISED MODEL

FIGURE 2




P/A/351

Fig 4 Expl. Notes KARIMUI J. Bain

The outcrop pattern and degree of disturbance of the Mesozoic shales in the anticlinal cores in the northern part of the belt are suggestive of diapiric folding, though some faults clearly extend to considerable depth in the Mesozoic shale. The foreshortening of the sedimentary rocks in the Papuan Fold Belt, therefore, may be due either to southwards gravity sliding and associated diapirism that accompanied uplift of the Kubor Anticline or to north-south compression, or, more likely, to a combination of both.

## The Kubor Anticline

The axis of the Kubor Anticline has a sinuous east-southeast trend, and can be traced from Mount Hagen town (Ramu Sheet area) to Mount Michael, where it plunges below the Tertiary cover. Plunge is gentle to the east and steeper to the west, where it is overlain by Pleistocene volcanics. The limbs midway along the fold dip at angles of $10^{\circ}$ to $40^{\circ}$, and locally up to $70^{\circ}$. The triangular core of the anticline consists of low-grade metasediments and minor metavolcanics intruded by composite plutons of acid to basic composition.

Owing to the scarcity of bedding and the absence of distinctive marker units, the macrostructure of the Omung Metamorphics is obscure. On a regional scale, the bedding strikes east-southeast and dips at moderate to steep angles in either direction, but predominantly towards the north. Overturned bedding was noted in the Omung River in several places in the vicinity of Dek to the north of the Sheet area. The tendency for cleavage to parallel bedding suggests that the formation may be isoclinally folded.

A number of small faults occur within the basement and the surrounding sediments. They are short, straight, and mostly normal to the margin of the crystalline core. South of Mount Digini they have small vertical displacements. The majority of the faults are interpreted as tensional fractures formed during the doming of the basement.

The arched basement is overlain by Mesozoic sediments that thicken away from the axis. Numerous small subsidiary folds are developed in these sediments around the nose of the Kubor Anticline between the Wahgi River gorge and Mount Michael, and on its southern flank between the Nebilyer River and Agotu Mission. The folds developed near the axis of the main anticline are commonly small, monoclinal, and faulted, and are difficult to recognize on aerial photographs.

The several small east-trending folds and faults on the southern slopes of Mount Michael are thought to have formed during the emplacement of the Michael Diorite.

East of Mount Suaru, on the southern flank of the anticline, there are numerous small folds with east to southeast axes about 2 to 4 km apart. Many are part of an east-trending synclinorium, the Pima Syncline.

New Guinea Mobile Belt

The northern limb of the Kubor Anticline is cut by the Bismarck Fault Zone, which marks the southern limit of the New Guinea Mobile Belt. In the Sheet area the Bismarck Fault Zone is a highly disturbed zone, 20 km wide, of northwesterly subparallel anastomosing faults and shear zones. There is at least 2000 m of vertical displacement (north side up) over the width of the fault zone.

Large vertical movements on individual faults such as on the western side of the Goroka valley are uncommon. Most of the faults are marked by steeply dipping or vertical shear zones several tens of metres wide, and horizontal movements are suspected but not established.

South of Kami Plantation an area of sheared siltstone and serpentinite 3 km wide and 8 km long lies within the fault zone. Serpentinite lenses are also found in the Puburamba Fault in the Markham Sheet area.

It appears that the Bismarck Fault Zone has been active at least since Cretaceous time as the Mesozoic sediments are more strongly faulted and deformed than the overlying Tertiary rocks, and since Jurassic and Tertiary formations are in juxtaposition north of the Sheet area. The major uplift of the northern block along the Bismarck Fault Zone exposed the middle Miocene Bismarck Intrusive Complex during the upper Miocene or Pliocene.

The Yaveufa Syncline, a Tertiary structure subparallel to the eastern end of the axis of the Kubor Anticline, lies within the New Guinea Mobile Belt and has been strongly affected by the Bismarck Fault Zone. Deformation north of Kundiawa has been so intense that the original synclinal form has been almost completely obliterated. However, the greater width and thickness of sediments and volcanics to the southeast, and the greater distance from the uplifted Mount Wilhelm area have resulted in the formation and preservation of a simple southeastward-plunging synclinal form. The syncline was a sinking basin during the deposition of the Yaveufa Formation and probably during most of the Tertiary.

The metamorphic rocks near Goroka form part of a large anticlinal arch similar to the Kubor Anticline, and are topographically expressed as the Bismarck Range. The broad arching was superimposed on folded Palaeozoic sediments without greatly modifying the earlier trends. Bedding is commonly preserved and, in many places, the schistosity is parallel to bedding. The large structures which can be traced are rather broad, gently plunging folds; the minor folds are much tighter. In some areas there are two generations of folding.

## MINERAL RESOURCES

No economic mineral deposits are known, but the regional setting and abundance of oil and gas seepages in the southern half of the Sheet area makes that area prospective for petroleum.

Some parts of the Sheet area are also prospective for base-metal deposits such as porphyry copper, for example the deeply eroded, hydrothermally altered core of Mount Murray volcano. Metalliferous mineral exploration to date has been concentrated on regional and local stream-sediment sampling and analysis; no detailed geochemical or geophysical work has been attempted. Petroleum exploration is continuing; to date it has been confined to regional geological mapping. Several bores have been drilled to the south of the Sheet area.

## Gold

Known occurrences of gold are confined to the area of intrusive and metamorphic rocks north and east of Goroka. They consist of small mineralized quartz veins which assay about 4 to 8 g gold/tonne. Very small quantities of alluvial gold are being won by local miners.

## Copper

Apart from a few flecks of chalcopyrite in some specimens of Bismarck Intrusive Complex and Michael Diorite, no copper mineralization has been found. However, detailed prospecting might reveal significant zones of copper mineralization. Prospective areas are Mount Murray, Mount Karimui, Crater Mountain, Mount Michael, and the Yaveufa Formation. These have been selected on the assumption that most porphyry copper deposits are found in association with hydrothermally altered hypabyssal or subvolcanic intrusive bodies, especially where they intrude volcanics.

Mount Michael consists of hydrothermally altered hypabyssal diorite porphyry and could contain porphyry copper mineralization. Pyrite is common in the Michael Diorite, and forms as much as 2 or 3 percent of the rock in some summit areas of Mount Michael; only very small amounts of chalcopyrite are present. The extent of the mineralization is unknown as the intrusion was not mapped in detail.

A number of small intrusions, some consisting of Kenangi Gabbro, and some possibly related to the Bismarck Intrusive Complex, occur in and near the Yaveufa Formation in the headwaters of the Mai River. Most are gabbroic, but little is known of their petrography or petrogenesis, or whether or not they are mineralized. Closer examination is warranted before these bodies could be dismissed as unprospective.

The deeply eroded Quaternary volcanoes are prospective for base metals, especially porphyry copper deposits, because collectively they have a number of features very similar to the 1 m.y. old Fubilan porphyry copper deposits 220 km to the west. These features are: hypabyssal intrusive phases, hydrothermal alteration, shoshonite composition, high copper content of the lavas, age between 0.2 and 2.0 m.y., and proximity to limestone.

## Pyrite

Pyrite occurs as beds, nodules, and disseminations in the Maril Shale. Near Gumine and Genabona the abundance of pyrite in the Maril Shale serves to distinguish it from the overlying Cretaceous shales.

Local concentrations of ovoid nodules and disseminated pyrite form up to 3 or 4 percent of the rock. Some of the nodules are hard and compact, but most are friable. Thin beds of friable pyrite occur only in the most pyritic areas. Near Genabona a large body of pyrite shale breccia forms a waterfall 8 m high; the average pyrite content over a width of 12 m is about 10 percent. The breccia is cut by a vein, 25 cm wide, containing 70 percent pyrite. The vein occurs in a zone 3 m wide containing about 20 percent pyrite. Assays have shown that the breccia contains very little copper or gold.

## Petroleum prospects

The many oil and gas seepages* in the folded Mesozoic and Tertiary rocks of the southern part of the Sheet area are tantalizing. However, although this area is underlain by promising Mesozoic source rocks, the presence of suitable reservoir beds is suspected but not established. Much work remains to be done before structures can be selected for drilling, as the region is strongly folded and faulted and much of it has been mapped only by interpretation of aerial photographs and SLAR imagery. Furthermore, because of decollement tectonics, the surface structures are probably not repeated at depth; for example, the drilled Mananda (Lake Kutubu Sheet area) and Cecelia (Raggi Sheet area) Anticlines are overthrust structures.

The best prospects for large closed structures in the Mesozoic sequence are basement flexures similar to, but smaller than, the Kubor Anticline. Such structures are suspected from the combined aeromagnetic and gravity data to the west and south.

Skeletal limestone in the Darai Limestone could form reservoirs, and the Quaternary volcanics and Miocene-Pliocene formations might act as cap rocks. However, as the structures in the limestone are developed above a zone of detachment, the limestone will not be completely sealed and most structures are unlikely to be large enough to contain commercial accumulations of oil or gas.

## Coal

Coal occurs at three localities in the Sheet area: the Samia River valley; east of Mount Favenc; and in the Asaro River valley a few kilometers from Goroka. They are of no commercial significance at this time.

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* Information sources; BP - APC - IEC unpublished reports; Patrol Reports: Hughes (1971).

In the Samia valley there are at least two coal seams in the Era Beds, which are a faulted marine and non-marine sedimentary sequence. Two of the seams are 1.2 and 1.5 m thick, and consist of cannel and lignite or sub-bituminous coal.

The Era Beds east of Mount Favenc also contains coal, which is of sub-bituminous rank. The coal in the Sheet area forms a continuous, well exposed bed which thickens to the south; in the Pide Syncline south of the Sheet area there are at least four seams ranging in thickness from 2 cm to 2 m.

A seam of brown coal 50 cm by 450 m was reported near Goroka. It is not known whether it occurs in the Quaternary sediments or the middle Miocene Yaveufa Formation.

Schungite

Schungite, a vitreous carbon mineraloid with a high $TiO_2$ content, occurs in small quantities in the Maril River.

Limestone

Extensive deposits of limestone surround the Kubor Range; those on the north are easily accessible by road, but those south of the Range are very inacessible and unlikely to have any economic significance in the foreseeable future. Talus from the Chimbu Limestone, east of the lower Wahgi River, is presently quarried and used as a surfacing material on nearby roads; reserves of talus are more than 40 million $m^3$. Talus shed from the Nebilyer Limestone, Kuta Formation, and limestones near Mount Michael and within the Maril Shale would all be suitable for use as road surfacing material.

Chimbu Limestone from Mount Elimbari is a pure white foraminiferal variety, and appears suitable as a building or cladding stone.

## Blue metal

Gabbroic intrusions, for example Kenangi Gabbro, and formations which contain basaltic and andesitic lavas, for example Yaveufa Formation and Quaternary volcanics, are suitable for crushing and use as blue metal for road surfacing or concrete constructions.

## Gravel

Large deposits of stratified sand, clay, and gravel at Kundiawa and in the Goroka valley contain much material suitable for road construction.

## Quartzose sandstone

Soft to hard sandstone, ranging from white, nearly pure quartz sandstone to more feldspathic arkosic types near Gurumugl, west of Kundiawa, may be useful in cement and concrete for nearby bridges and culverts or in the township of Kundiawa.

## Diatomite

There is a reported occurrence of diatomite in the Quaternary lake deposits of the Goroka valley.

## Stone axe quarries

Before 1950, the manufacture and export of stone axes was by far the most important economic activity of the inhabitants of the Sheet area (Hughes, 1971). Almost all the stone used for tool manufacture was quarried at three sites within the Sheet area, and eleven sites in the adjacent Ramu Sheet area (Chappell, 1966). The rock types quarried occur in contact metamorphic zones and range from albite-epidote-actinolite hornfels to albitized fine-grained sediments containing quartz, prehnite, and stilpnomelane. They fracture conchoidally and have a hardness of 5 to 7 (Mohs' scale).

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APPENDIX 1.

SHEET SB/55 - 9 KARIMUI

MICROFOSSILS

| Map No. | Grid Reference | Sample No. | Age | Remarks |
|---|---|---|---|---|
| 1 | 287 326 | 1073 | Ta-b | |
| 2 | 291 325 | 0560 | Ta-b | |
| 3 | 293 316 | 0586 | Tc | |
| 4 | 299 310 | 0572 | Tb | |
| 13 | 304 319 | 2500 | Upper Te - lower Tf | |
| 14 | 305 313 | 0581 | Upper Te - Tf | |
| 15 | 305 312 | 0579 | Upper Te - Tf | |
| 17 | 307 313 | 2517 | Ta-b | |
| 16 | 305 310 | 0574 | Upper Te - lower Tf | |
| 28 | 307 302 | 0589 | Tb | |
| 29 | 310 305 | 0014 | Lower Tf | |
| 30 | 310 308 | 0600 | Tc | |
| 20 | 192 300 | 0618 | Ta | lower |
| 21 | 229 287 | 0651 | Upper Cretaceous | Prob. lower Turonian |
| 22 | 242 285 | 0648 | Upper Cretaceous | Upper Cenomanian - lower Turonian |
| 23 | 243 284 | 0647 | Upper Te; Te-Tf | Limestone float |
| 24 | 245 284 | 0646 | Upper Te | |
| 25 | 252 282 | 1444 | Upper Te - Tf | |
| 26 | 251 281 | 2861 | Upper Te | |
| 27 | 252 281 | 2860 | Upper Te | |
| 31 | 308 285 | 2636 | Upper Te | (with derived a-b) |
| 32 | 312 297 | 0601 | N 11-12 zone | |
| 33 | 314 297 | 0602 | N 11 zone | may be younger |
| 34 | 316 297 | 0603 | N 4 zone | |
| 35 | 316 298 | 2649 | Td-c | (pebble in congl.) |
| 37 | 311 285 | 2850 | Te | (with derived b) |
| 47 | 309 281 | 2830 | Upper Te - Tf | |
| 36 | 331 296 | 2678 | Upper Te - lower Tf | |
| 38 | 321 286 | 1426 | Tf | |
| 39 | 323 286 | 1428 | Tf | |
| 40 | 321 282 | 1422 | Upper Te; upper Te - Tf | |
| 50 | 321 281 | 1418 | Upper Te - Tf | |
| 42 | 324 283 | 1397 | Tb | derived |
| 41 | 324 282 | 1392 | Td-e | (with derived a-b) |

| Map No. | Grid Reference | Sample No. | Age | Remarks |
|---|---|---|---|---|
| 43 | 232 279 | 1461 | Lower Te | |
| 44 | 232 274 | 2868 | Upper Te | |
| 45 | 232 273 | 2867 | Upper Te - Tf | |
| 46 | 241 269 | 2865 | Upper Te | |
| 48 | 308 280 | 2828 | Upper Te | |
| 49 | 311 279 | 2822 | Upper Te | |
| 51 | 319 277 | 2813 | Tf | |
| 5 | 297 329 | | | Taken from McMillan & Malone (1960) |
| 6 | 297 330 | | | " |
| 7 | 298 326 | | | " |
| 8 | 298 325 | | | " |
| 9 | 299 326 | | | " |
| 10 | 303 328 | | | " |
| 11 | 305 326 | | | " |
| 12 | 306 333 | | | " |
| 18 | 328 309 | | | " |
| 19 | 333 317 | | | " |

MACROFOSSILS

| Map No. | Grid Reference | Sample No. | Age | Remarks |
|---|---|---|---|---|
| 1 | 255 334 | 2772 | Upper Jurassic (Kimmeridgian) | float |
| 2 | 257 332 | 2553 | Upper Jurassic (Kimmeridgian) | |
| 3 | 259 322 | 2563 | Upper Jurassic (Kimmeridgian) | |
| 4 | 261 331 | 2570 | Upper Jurassic (Kimmeridgian) | |
| 5 | 261 332 | 2571 | Upper Permian -Lower Triassic | |
| 6 | 266 325 | 1058 | Upper Permian -?Lower Triassic | not collected |
| 7 | 270 327 | 1140 | Upper Jurassic | |
| 8 | 270 323 | 0524 | Upper Permian-?Lower Triassic | not collected |
| 9 | 258 315 | 0003 | Upper Jurassic | |
| 10 | 258 305 | 2716 | Upper Cretaceous | |
| 11 | 280 315 | 1305 | Upper Juriassic | |
| 12 | 304 310 | 0574 | Upper Te - Tf | Echinoids & pecten-like shells |
| 13 | 217 285 | 0588 | Upper Cretaceous | |
| 14 | 247 294 | 4039 | Upper Cretaceous -Eocene | probably Eocene |

# APPENDIX 2

## ISOTOPIC AGE SPECIMENS

| Grid Reference | Sample No. | Age* (m.y.) | Remarks |
|---|---|---|---|
| 256 335 | 6026 | K-Ar | Granodiorite |
| 263 322 | 5843-50 | 205-233 (av. 215-220) | Pegmatite |
| | 5875-76 | 240-244, Rb-Sr | Hornfels |
| 297 326 | 5645 | | Trachyte |
| 303 331 | 5639 | 14.5-15.0, K-Ar | Breciated basalt |
| | 5643 | | Basalt |
| 328 332 | 5455 | | Granodiorite |
| | 5462 | 10-11, K-Ar | Granodiorite |
| 316 318 | 5872 | 14.5-15.0, K-Ar | Andesite |
| 313 296 | 5879-80 | 6-7, K-Ar | Microdiorite |
| 323 294 | 5870 | 14.5-15.0, K-Ar | Andesite |

*Age is preferred isotopic age based on the average of a number of specimens (source: Page, 1971).

TABLE 1

AERIAL PHOTOGRAPHS AVAILABLE FROM DIVISION OF NATIONAL MAPPING

**Mount Ialibu**

| | |
|---|---|
| Run A1 : | 2039 – 2025 |
| 1 | 2026 – 2037 |
| 2 | 5953 – 5962 |
| 3 | 2093 – 2078 |
| 4 | 2212 – 2195 |
| 4A | 2236 – 2225 |
| A1 | 2176 – 2189 |
| 6 | 5053 – 5039 (Mt Hagen) |
| WK | 2104 – 2095 |
| EK | 2109 – 2098 |
| 1 | 5052 – 5053 (Mt. Giluwe) |
| 2 | 5043 – 5042 ( " ) |
| 3 | 5044 – 5048 |

**PANGIA**

| | |
|---|---|
| Run A1 | 2211 – 2223 |
| 1 | 2165 – 2156 |
| 2 | 2132 – 2152 |
| 3 | 2007 – 2022 |
| 4A | 2241 – 2248 |
| 4 | 2034 – 2024 |
| 5 | 2232 – 2221 |
| 6 | 2136 – 2149 |
| WK | 2113 – 2105 |
| EK | 2125 – 2110 |

**KERABI**

| | |
|---|---|
| Run 2 | 2111 – 2100 |
| 3 | 9709 – 9718 |
| 3A | 1437 – 1444 |
| 4 | 9691 – 9682 |
| 4A | 5832 – 5826 |
| 5 | 2201 – 2192 |
| 5A | 5981 – 5992 |
| WK | 2123 – 2144 |

**BARISA**

| | |
|---|---|
| Run 1 | 2155 – 2169 |
| 2 | 2216 – 2230 |
| 3 | 2044 – 2055 |
| 4 | 2042 – 2036 |
| 4A | 2108 – 2117 |
| 3 | 9813 – 9822 (Turama) |
| 5 | 2210 – 2223 |
| 4 | 9833 – 9824 (Turama) |
| 1NS | 1906 – 1916 |
| WK | 2132 – 2124 |

**MOUNT KEGARA**

| | |
|---|---|
| Run 6 | 5038 – 5023 (Ragi) |
| 1 | 2024 – 2002 |
| A1 | 2081 – 2060 |
| 2 | 2038 – 2055 |
| 3 | 5963 – 5975 |
| 4 | 2071 – 2061 |

**TUA**

| | |
|---|---|
| Run 4 | 2249 – 2260 |
| 5 | 2220 – 2210 |

**SOARU**

| | |
|---|---|
| Run 1 | 2150 – 2163 |
| 2 | 2099 – 2087 |
| 3 | 1445 – 1454 |
| 5 | 5993– 6003 (R4. 1819 – 1814) |

**TEBERA**

| | |
|---|---|
| Run 1A | 2170 – 2181 |
| 2 | 2148 – 2139 |
| 3 | 2056 – 2066 |
| 4 | 1035 – 2027 |
| 5 | 2224 – 2235 |
| 2NS | 1893 – 1883 |
| 3 | 1820 – 1833 |

Aerial photographs (Cont.)

CHIMBU

| | | |
|---|---|---|
| Run 6 | 5023 - 5014 | Kerowagi |
| 1 | 5129 - 5108 | |
| 1A | 5005 - 5118 | |
| 2 | 5049 - 5029 | |
| 3 | 5053 - 5069 | |
| 4 | 5112 - 5093 | |

OIMA R.

| | | |
|---|---|---|
| Run 5 | 5114 - 5139 | |
| 2 | 2100 - 2112 | |
| 3 | 2180 - 2171 | |
| 4 | 2185 - 2196 | |
| 5 | 2261 - 2272 | |
| 6 | 2209 - 2198 | |

MOUNT KARIMUI

| | | |
|---|---|---|
| Run 1 | 2164 - 2177 | |
| 2 | 2086 - 2075 | |
| 4 | 1455 - 1462 | |
| A4 | 1372 - 1383 | |
| 5A | 6004 - 6007 | |

MOUNT TRUBE

| | | |
|---|---|---|
| Run 2 | 1429 - 1418 | |
| 3 | 2138 - 2129 | |
| 4 | 5022 - 5001 | |
| 5 | 5046 - 5032 | |
| 2 | 1813 - 1804 | |
| 1A | 3401 - 3385 | (Kereru R.) |

CHUAVE

| | | |
|---|---|---|
| Run 6 | 5013 - 5001 | |
| 1 | 5029 - 5038 | |
| 2 | 5093 - 5113 | |
| 2A | 5131 - 5114 | |
| 3 | 5093 - 5074 | |
| 4 | 5054 - 5073 | |
| WK | 5147 - 5133 | |

LUFA

| | | |
|---|---|---|
| Run 1 | 2094 - 2082 | |
| 2 | 2113 - 2124 | |
| 3 | 2170 - 2157 | (WK 2038-2049) |
| 4 | 2197 - 2212 | |
| 5 | 2251 - 2244 | (EK 2007-2019) |
| 5A | 2273 - 2281 | |
| 6 | 2253 - 2264 | |
| 6A | 2197 - 2189 | |

CRATER MOUNTAIN

| | | |
|---|---|---|
| Run 1 | 2162 - 2156 | |
| 2 | 2178 - 2187 | |
| 2A | 2166 - 2176 | |
| 3 | 2074 - 2064 | |
| 4 | 1467 - 1487 | |
| 5 | 1384 - 1399 | |
| WK | 2028 - 2037 | |
| EK | 2066 - 2054 | (EK 2024-2020) |

SONGHE

| | | |
|---|---|---|
| Run 2 | 2240 - 2227 | |
| 3 | 1417 - 1402 | |
| 3 | 2128 - 2117 | |
| 4 | 2077 - 2087 | |
| 5 | 5031 - 5014 | |
| WK | 2019 - 2027 | |
| EK | 2078 - 2067 | |

BENA BENA

| | | |
|---|---|---|
| Run 1 | 5039 - 5045 | |
| 2 | 5074 - 5065 | |
| 3 | 5075 - 5085 | |
| 4 | 5003 - 5012 | |
| 4A | 5170 - 5105 | |
| 5 | 5037 - 5031 | |
| WK | 5159 - 5149 | |

GONOMI

| | | |
|---|---|---|
| Run | 1 | 2081 - 2075 |
| | 2 | 2125 - 2131 |
| | 3 | 2156 - 2148 |
| | 4 | 2213 - 2221 |
| | 5 | 2243 - 2235 |
| | 6 | 2265 - 2273 |
| | 6A | 2155 - 2149 |

TAMILOA RA.

| | | |
|---|---|---|
| Run | 1A | 7644 - 7648 |
| | 2 | 2177 - 2181 |
| | 3 | 2108 - 2102 |
| | 4 | 2110 - 2117 |
| | 5 | 2151 - 2147 |

KUWARABI RA.

| | | |
|---|---|---|
| Run | 1 | 2036 - 2042 |
| | 2 | 2074 - 2072 |
| | 3 | 2226 - 2221 |
| | 4 | 2116 - 2111 |
| | 5 | 2088 - 2094 |

APPENDIX 3

| ADAMS 1970 * | | CAINOZOIC TIME SCALE<br>CLARKE & BLOW 1969, BLOW 1969 | | RADIOMETRIC TIME SCALE | | |
|---|---|---|---|---|---|---|
| Epoch | Tertiary Letter Stage | Planktonic Foram Zone | Tertiary Letter Stage | Epoch | Papuan Stage | m.y. |
| | | N23 | | | | |
| Pleistocene | | | | Pleistocene | | |
| | : | N22 | | | | Pleist. 1.85 |
| | Th | N21 | ? ? | | | Plio. |
| | | N20 | Th | Pliocene | late | |
| | | N19 | | | Muruan | Plio. 5.5 |
| | | N18 | | | | Mio. |
| | | N17 | | late | early | |
| | Tg | N16 | Tg | Miocene | | Tg Tf 9 |
| upper | upper Tf ( $f_3$) | N15 | upper Tf ( $f_3$) | | Ivorian | |
| Miocene | | N14 | | | Kikorian | |
| | | N13 | | middle | Tourian | upper Tf lower Tf 12.5 |
| middle | lower | N12 | lower | Miocene | | |
| Miocene | Tf | N11 | Tf | | ? | |
| | ( $f_{1-2}$) | N10 | ( $f_{1-2}$) | | | |
| | | N9 | | | | |
| | | N8 | | | ? | |
| | upper Te ( $e_5$) | N7<br>N6<br>N5 | upper Te ( $e_5$) | early Miocene | | |
| | | N4 | | | Kereruan | Mio. 22.5 |
| upper Oligocdne | lower Te ( $e_{1-4}$ | N3<br>N2 | lower Te ( $e_{1-4}$) | | | Olig. |
| | | N1 | | | | u Olig. m Olig. 30 |
| middle Oligocene | Td | P19 | Td | Oligocene | | |
| | | | | | | m Olig. 1 Olig. 32 |
| lower Oligocene | Tc | P18 | Tc | | | |
| | | P17 | | late | | Olig. Eo. 36 |
| upper Eocene | Tb | P16<br>P15 | Tb | Eocene | | |
| | | P14 | ? ? | ? ? ? | | u Eo. m Eo. 45 |
| middle Eocene | $To_3$ | | | | | |
| lower Eocene ? ? ? | $To_2$ | | | | | |
| | | | | | | Eo. Paleo. 53.7 |
| upper Paleocene | $To_1$ | | | | | u Paleo 1 Paleo 60 |
| | | | | | | Paleo. Cret. 65 |

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

Blow, W.H., 1969 - Late middle Eocene to Recent planktonic foraminiferal stratigraphy. Proc. 1st Int. Conf. Planktonic Microfossils, Geneva, 1967, 1, 199-421

Clarke, W.J., & Blow, W.H., 1969 - The inter-relationships of some late Eocene, Oligocene and Miocene Foraminifera and planktonic biostratigraphic indices: Proc. 1st Int. Conf. Planktonic Microfossils, Geneva, 1967,1,82-97

TABLE 2

STRATIGRAPHY KARIMUI SHEET AREA

| ERA | AGE | ROCK UNIT AND SYMBOL | ESTIMATED THICKNESS (m) | LITHOLOGY | TOPOGRAPHY | DISTRIBUTION | REMARKS |
|---|---|---|---|---|---|---|---|
| CAINOZOIC | HOLOCENE | Alluvium Qa | | Clay, sand, silt, gravel, minor peat, alluvial soils | River terraces, flood plains, and valley fill | Throughout Sheet area | Only the most extensive areas shown |
| | QUATERNARY | Ql | about 100 | Unconsolidated bedded clay, silt, sand, quartz-rich gravel | Flat to undulating, gullied with rounded and benched ridges | half of Goroka valley | Lake sediments correspond to Abiera Land System (CSIOR) 1970. Mainly grassland. A small deposit of brown coal 'a few km' SW of Goroka (Grainger, 1969) may occur within these lake beds |
| | | Qs | 10-100 | Rock-fall debris mixed with soil beneath limestone cliffs. Landslip and outwash rubble and soil at the foot of Mt Michael | Low dissected and slumped foothills and hummocky valley fill | SW of and below the Chimbu Limestone and on N footslopes of Mt Michael | Scree: much of the limestone talus is re-cemented; large areas have moved as debris laden mudflows. Extensively used as road construction material |
| | | Qf | about 80 | Unconsolidated fluviatile clay, sand, silt, and boulder gravel derived mainly from granitic and metamorphic rocks | Terraced and moderately dissected gently undulating to hummocky fans. | N half of Goroka valley and a small remnant in the Chimbu Rim valley at Kundiawa | Alluvial fan sediments may contain some fluvioglacial debris |
| | | Suaru Volcanics Qvs<br>Karimui Volcanics Qvk<br>Duau Volcanics Qvd<br>Mt Murray Volcanics Qvm<br>Ialibu Volcanics Qvi | | Basaltic (shoshonite) to andesitic lava, agglomerate, tuff; minor derived sediments | Poorly to well preserved volcanic cone forms with extensive and deeply gullied gently sloping aprons. Cone height about 1000-1500 m, diameter 12-15 km. Some minor satellite cones | W, S and central Sheet area | All extinct; distinctive shoshonitic composition |
| | | Hagen Volcanics Qvh | 120 max | Basaltic (shoshonitic) lahar deposits, agglomerate, conglomeeate; minor tuff, lava | Gently sloping smooth to undulating valley fill; deeply incised (max 120 m) major streams with precipitous slopes | Nebilyer valley, NE corner of Sheet area | Mainly basaltic and shoshonitic composition. More in Ramu Sheet area |
| | | Gilume Volcanics Qvg | | Basaltic (shoshonitic) lava, ash, tuff, agglomerate | Deeply gullied footslopes of large shield-like strato-volcano. Relief up to 150 m | NW corner of Sheet area | More extensive in Lake Kutubu Sheet area. Some small satellite vents may be as young as 1000 yrs |
| | PLIOCENE TO HOLOCENE | Crater Mountain Volcanics TQvc | | Andesitic and basaltic lava; minor agglomerate, tuff, derived sediments | Extremely rugged mountains; cliffed lava flow remnants; deeply gorged streams; some minor volcanic forms | Near Crater Mt in E central Sheet area | Deeply eroded volcano or volcanic complex with superimposed younger minor volcanic centres |
| | PLIOCENE TO PLEISTOCENE Th | Era Beds TQe | Variable but generally 300 + | Blue-grey fine to coarse well compacted sandstone, siltstone and mudstone; thin shelly quartz sandstone beds and coal seams | Moderate relief, dendritic drainage, strike ridges NE of Mt Favenc and valleys between limestone strike ridges | S part of Sheet area near Mts Duau and Favenc | Conformable on Orubadi Beds. Coal measures mainly in the upper part; marine and nonmarine |
| | UPPER MIOCENE to PLIOCENE Tg to Th | Orubadi Beds Tmup | 100-750 m; av. 350 m; thickens eastwards | Well bedded blue-grey mudstone with carbonaceous laminae; subordinate siltstone and sandstone. Minor, hard calcareous sandstone, shelly beds | Valleys between limestone strike ridges; dendritic drainage, low relief | S part of Sheet area; mainly between Mts Duau and Murray | Greatest thickness in Wailk Cr area; conformably overlies Darai Limestone. Mott (1948) believed mudstones bentonitic in places. Micro and macro fossils abundant |

| ERA | AGE | | ROCK UNIT AND SYMBOL | ESTIMATED THICKNESS (m) | LITHOLOGY | TOPOGRAPHY | DISTRIBUTION | REMARKS |
|---|---|---|---|---|---|---|---|---|
| MESOZOIC | UPPER CRETACEOUS | WAHGI GROUP | Chim Formation Kuc | Av about 2000; max about 3300 near Kundiawa | 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, volcano-lithic greywacke, calcarenite, and conglomerate | Moderate relief, dip-slopes not commonly preserved; broad V-shaped valleys, few gorges | Throughout Sheet area SW of the Chimbu Limestone | Coarser-grained rock and soft sediment slump structures mostly confined to upper part of formation. Mostly Cenomanian-Turonian, some Cenomanian-lower Campanian near Pangra. Shallow-water deposition indicated by small-scale cross-bedding, ripple marks, and well sorted sandy beds. Volcanic and volcanolithic rocks confined to Kundiawa area |
| | LOWER CRETACEOUS | | Kondaku Tuff Klk | Av 2000; max 2450 near Kundiawa | Greenish grey coarse lithic sandstone, greywacke, tuffaceous sandstone, dark grey or green shale and siltstone. Conglomerate, agglomerate, volcanic breccia, and amygdaloidal lava are sbuordinate | Rugged low mountains and hills; irregular branching ridges with close dendritic pattern of V-shaped valleys; long ridges, structurally controlled rectilinear pattern of valleys. Relief up to 300 m, elevation 1000-2400 m. Mostly grass-covered except SW of Kubor Ra. Outcrop largely restricted to stream channels and cliffs | Peripheral to Kubor Ra in N central Sheet area | Abundant charred wood fragments, some leaf impressions. Ammonites pelecypods, gastropods belemnites, mainly Aptian-Albian. Volcanics mostly confined to lower 500-1000 m of formation. Shale and siltstone most common but least prominent part of sequence. Soft sediment slump deformation common in fine-grained beds |
| | UPPER JURASSIC | | Maril Shale Jum | Variable; max about 1200-1500 thins to about 400 nearest the anticlinal axis | Dark grey to black moderately indurated shale and stilstone with variable carbonate and mica content. Commonly pyritic especially the darker more carbonaceous beds. Subordinate fine to medium sandstone, grey calcilutite, and maroon and green shale. Basal unit of arkose, silicified and calcareous shale/slate breccia and conglomerate | Generally well developed strike ridges and dip-stones. Prominent V-shaped 'flat irons' on N flank of anticline. Max relief about 300 m; elevation 1500-2400 m on N side of anticline, much lower on S side | Peripheral to Kubor Ra in N central Sheet area | Massive or well bedded; commonly two well developed sets of joints at a high angle to bedding and to each other. The weathered surfaces of the calcareous shale and siltstone tend to disintegrate into small blocky fragments. Distinctive Kimmeridgian fauna of Malayomaorica m. and Inoceramus cf haasti. Largely unaffected by burial metamorphism probably because of high $CaCO_3$ content |
| | LOWER JURASSIC | | Jlu | | Deeply weathered granodiorite and diorite with aplite and dolerite dykes | Hilly, low relief | Near Asaro village in the Goroka valley, NE corner of Sheet area | Unconformably overlain by Chimbu Limestone. Previously thought part of Bismarck Intrusive Complex. Rb-Sr age 180-190 m.y. |
| | UPPER TRIASSIC | | Kana Volcanics | 200-700 on Kubor Ra. Max 3500 in Chimbu R. N of Kundiawa in Ramu Sheet area | Fine-grained greenish grey lava and tuff; chloritized, epidotized flow-banded lavas, multicoloured fine to coarse agglomerate (lapilli tuff?); volcanolithic and feldspathic sandstone | Very rugged; relief 200-700 m; conspicuous subhorizontal cappings on summit ridges. Cirques, scarps and bare rock pinnacles. Mostly above 3000 m; alpine grassland | Outliers on core of Kubor Anticline, N central Sheet area | Extensively recrystallized to low greenschist facies. Lavas mostly andesite, but some basalt and dacite. Mostly marine but some subaerial lava and pyroclastics. No fossils (Upper Triassic bivalves present in Jimi valley in Ramu Sheet area |
| CAINOZOIC | UPPER OLIGOCENE TO MIDDLE MIOCENE | | Aure Beds Tm | 1000-5700 Thickness increases to E | Predominantly massive siltstone with subsidiary hard shale, marl, and thin pelagic limestone beds. Also conglomerate, pebble greywacke, detrital and conglomeratic limestone, mudstone, and greywacke siltstone | Rugged to very rugged. N and E - trending strike ridges. Relief 300-1000 m | S half of Sheet area S and E of Crater Mt. | Abundant benthonic and planktonic Foraminifera and fragmental macro-fossils. Rapid lateral and vertical facies variations. Includes facies transitional to Darai Limestone. Apart from the transitional basin facies, formation consists larg of turbidites. Well bedded |

| ERA | AGE | ROCK UNIT AND SYMBOL | ESTIMATED THICKNESS (m) | LITHOLOGY | TOPOGRAPHY | DISTRIBUTION | REMARKS |
|---|---|---|---|---|---|---|---|
| CAINOZOIC | UPPER OLIGOCENE | Omaura Greywacke Tou | Unknown | Light grey to green and purple shale and siltstone; greenish grey cross-bedded feldspathic sandstone. Schistose serpentinite (mainly mixed with sediments) | Hilly, low to moderate relief | S of Goroka valley in NE corner of Sheet area; bounded by the Kami-Puburamba Fault to W and S | Lithologically very similar to the younger Movi Beds which are faulted against it, Serpentinite along Kami Fault |
| | MIDDLE EOCENE TO LOWER OLIGOCENE | Chimbu Limestone Teoc | 300 max about 1000 | Very fine-grained grey and buff algal Heterostegina limestone, white Nummulite limestone, dark grey coarse calcarenite and finer grained brownish grey to buff Alveolina limestone; minor buff to brown Lacazinella limestone | Fault-bounded strike ridges 1600 to 2900 m with prominent scarps and gentler dip-slopes with rocky barren surfaces; no local surface drainage; some sink holes. Relief up to 360 m | Between Kundiawa and NE corner of Sheet area | Richly fossiligerous, some beds composed almost entirely of cemented foraminiferal tests. Gastropods, belemnites, pelecypods, and echinoids also abundant |
| | | Nebilyer Limestone Teon | Less than 100; thins to S | Grey and brownish grey calcarenite, with thin silty argillaceous interbeds; dark brownish grey fine-grained limestone | Cliffs above steep, dissected, irregular footslopes. Relief up to 100 m | Between Kaugel and Nebilyer Rs in NE corner of Sheet area | Contains planktonic Foraminifera and algae. |
| | EOCENE | Te | 0-200 av about 50-100 | Fine to coarse green, grey and blue to cream detrital and micritic limestone: ferruginous, glauconitic and calcareous quartz sandstone and sandy limestone; minor sandstone, siltstone, and mudstone | Base of Darai Limestone scarps | Throughout S half of Sheet area | Max. development (up to 100 m) in Valkaru Ra 30 km W of Pangia (Lake Kutubu Sheet area). Some lower Oligocene beds may be present cf. Chimbu Limestone |
| | UPPER PALEOCENE TO EOCENE | Pima Sandstone Tap | 2000 possible max 3000 | Thick-bedded fine to coarse pale grey, greyish green to dark grey feldspatholithic sandstone with small lenticular coquina beds, tuff, and rare conglomerate; dark grey to black mudstone and siltstone, with laminations and thin interbeds of sandstone | Rugged, deeply incised streams, 300-1000 m relief. Prominent strike ridges, dip-slopes and bluffs | Centre of Sheet area E of Mt Suaru and N of Mt Karimui | Detritus from weathering of Kondaku Tuff and Chim Formation. The mudstone/siltstone is rich in carbonaceous material, rock fragments, and clay minerals. Sandstone clasts rare. Fine laminations, ripple marks; small-scale cross-bedding in sandstone beds indicate shallow-water deposition |
| MESOZOIC | LOWER CRETACEOUS | Kl | Max about 1200-1500 | Massive to thick-bedded dense bluish grey lithic sandstone inter-bedded with thin bedded mudstone/siltstone. Minor shelly greywacke and gastropod limestone | Rugged, close drainage pattern, steep slopes, gorged streams. Most tributary streams short, torrential, interrupted by waterfalls. Relief about 300 m | Between Pio and Purari Rs. S central Sheet area | Some ripple marks. Diagnostic mineral constituents of greywacke are glauconite, quartz, feldspar, common hornblende, metamorphic rock fragments, apatite, and tourmaline (and lack of pyroxene and andesitic igneous rock fragments). Probably Aptian-Albian (gastropods, ammonites). Equivalent to Klk; overlain by Kuc |
| | | Kle | about 15 | Pyroxene-hornblende diorite and micro-diorite, mostly altered (especially chloritized), and veined with coarsely crystalline calcite | As for Maril Shale | Strip 200 m wide and 8 km long 10 km S of Kundiawa in N central Sheet area | Sills in Maril Shale. Age unknown. Composition similar to that of volcanic rocks in the overlying Kondaku Tuff and apparent absence of these intrusives in rocks younger than Upper Jurassic suggests Lower Cretaceous age cf. Kenangi Gabbro/Yaveufa Formation relations |
| CAINOZOIC | UPPER MIOCENE | Michael Diorite Tmum | Only topmost 2000 exposed | Porphyritic hornblende microdiorite | Extremely rugged; forms a single deeply dissected mountain with a glaciated NW-trending summit ridge. | Slopes of Mt Michael above 2000 m (about 20 km S of Goroka) and several very small bodies up to 18 km to W | Large hypabyssal stock with parts of roof preserved. Strongly pyritic; moderate late-stage hydrothermal alteration. Isotopic age 7.3 ± 0.2 m.y. |

| ERA | AGE | ROCK UNIT AND SYMBOL | ESTIMATED THICKNESS (m) | LITHOLOGY | TOPOGRAPHY | DISTRIBUTION | REMARKS |
|---|---|---|---|---|---|---|---|
| CAINOZOIC | MIDDLE MIOCENE | Kenangi Gabbro Tmke | | Hornblende gabbro; mangerite, granodiorite; commonly porphyritic and altered | Same as for Yaveufa Formation and Movi Beds | NE corner of Sheet area in areas of Miocene formations | Sills, dykes, and small stocks in Movi Beds and Yaveufa Formation; thermal aureoles up to 12 m wide. Strong petrographic similarity to, and close spatial relation with lavas of Yaveufa Formation suggests a genetic relation |
| | | Bismarck Intrusive Complex Tmb Tmb | | Hornblende diorite; minor gabbro | Same as Goroka Formation | 5 km ENE of Goroka in NE corner of Sheet area | Mainly finer-grained, darker and more porphyritic than rocks of main batholith in Ramu Sheet area |
| | | Yaveufa Formation Tma | Max about 4800 8 km north of Asaro R gorge; mainly 2000-3500. Thins to NW | Volcanics; coarse red, purple and multicoloured polymict agglomerate, and interbedded porphyritic andesitic and basic lava. Welded ash flow tuff. Volcanolithic sediments: Waterlaid tuff, polymict volcanic pebble, cobble and boulder conglomerate, greywacke, and calcarenite | Moderate to high relief, steep slopes; fine dendritic drainage pattern partly bedding controlled | NE corner of Sheet area in 10-15 km wide belt along the W and S sides of Goroka valley | Volcanics and volcanolithic sediments interfinger, the former being dominant N from 15 km N of Lufa, and in the area 5 km E of Kami. Elsewhere the sedimentary rocks predominate. Isotopic age 12.5 - 15 m.y. |
| | LOWER TO MIDDLE MIOCENE | Movi Beds Tmo | 500-4000. Thins to NW | Well bedded volcanolithic and calcareous siltstone, sandstone, and shale, polymict conglomerate: some tuffaceous beds, coral limestone lenses, minor chert | Irregular branching steep mountain ridges; large valley embayments with low ridges and spurs; dendritic pattern of closely spaced, narrowly incised streams, locally with strike alignment. Relief up to 450 m; altitude 1000-2700 m | NE corner of Sheet area (lateral equivalent (Tm) extends to S boundary of Sheet area) | Well bedded shallow-water clastics sediments with abundant Foraminifera (interbedded benthonic and planktonic forms), gastropods, pelecypods, echinoids, and corals |
| | UPPER OLIGOCENE TO MIDDLE MIOCENE | Darai Limestone Tmd | 100-1200 thickens to S | Thick-bedded to massive, light-coloured biosparite, biomicrite, and calcareous arenite with minor biosparudite and breccia (terminology Folk, 1965) | Structurally controlled prominent strike ridges with shallow to steep concave and convex dip slopes and precipitous fault scarps; some extensive subhorizontal areas. Max relief about 300 m. Hilly to very rugged karst-land with internal drainage . Traversed by series of long, sub-parallel, through-going major streams draining areas of volcanics and non calcareous rocks | S half of Sheet area between Mts Ialibu, Suaru, Karimui, Favenc, and Murray | Calcareous quartz-feldspar arenites most common at base of sequence and especially in the Northernmost outliers. Abundant benthonic and planktonic Foraminifera |
| MESOZOIC | | Goroka Formation Mg | Unknown | Soft black schistose carbonaceous siltstone, Minor interbedded laminated recrystallized limestone and buff massive quartzite. Grey mica schist and minor interbedded limestone. Pyritic quartz-veined black siltstone. Hornfels common (especially andalusite-bearing schist) | Rugged high mountains with steep narrow ridges and close dendritic pattern of deeply incised mountain torrents. Relief up to 1000 m. Mostly forested; some gardens and grassland | NE side of Goroka valley | Bedding well preserved. May contain lower Teetiary meta-sediments. Preliminary isotopic age (Page, in prep.) indicates most recent metamorphic event 20-25 m.y. B.P. |
| | | Bena Bena Formation Mb | Uncertain; min 450 | Greenish quartz-sericite (or muscovite) schist, partly garnetiferous; actinolite-chlorite schist; minor knotted hornblende feldspar gneiss, granite gneiss, garnet quartzite, and hornfels. Also slightly metamorphosal siltstone, greywacke, and arkose | Same as Goroka Formation | E side of Goroka valley near Bena Bena | Moderately to tightly folded. Slightly higher grade of regional metamorphism than Goroka Formation; up to albite-epidote-amphibolite facies. Relation to Goroka Formation unknown. Two episodes of metamorphism. Preliminary isotopic age (Page, in prep.) indicates most recent metamorphic event 20-25 m.y. B.P. |

| ERA | AGE | ROCK UNIT AND SYMBOL | ESTIMATED THICKNESS (m) | LITHOLOGY | TOPOGRAPHY | DISTRIBUTION | REMARKS |
|---|---|---|---|---|---|---|---|
| PALAEOZOIC - MESOZOIC | UPPER PERMIAN TO LOWER TRIASSIC | *Kuta Formation PRk | Variable, up to 100 in Gurumgul area and 250 at W end of the Kubor Anticline | Dark grey to buff limestone, sandy limestone; minor arkose | Forested dip-slopes with some poorly developed karst; bare cliffs up to 100 m high | W and E margins of Kubor Anticline in N part of Sheet area | Contains varied fauna of brachiopods, gastropods, ammonites, corals, and forams which indicate an age straddling Permian-Triassic boundary |
| PALAEOZOIC | UPPER PERMIAN | Kubor Granodiorite Puk | | Coarse biotite-hornblende granodiorite and tonalite; small stocks and dykes of diorite and gabbro, dykes and veins of aplite and muscovite pegmatite | Extremely rugged mountains; relief about 1200 m; altitude 1500-4000 m. Massive summit ridges, long straight slopes (25-45$^{0}$) rounded crests, and high mountains with steep (25-60$^{0}$) narrow ridges and close dendritic pattern of deeply incised streams | Core of Kubor Anticline in N central Sheet area. Main intrusion in W limb of anticline | Probably contains unmapped roof pendants of Omung Metamorphics. Sulphide minerals (mainly pyrite) very sparse. Coarse-grained rocks commonly altered and deeply weathered. Rb-Sr age 244 m.y. |
| | UPPER PALAEOZOIC | Omung Metamorphics Pzo | Unknown | Slate, phyllite, sericite, schist, partly recrystallized indurated silt-stone and shale; less common meta-greywacke, basic metavolcanics (mostly green), spotted slate, and hornfels. Quartz veins and pods common | Same as for Kubor Granodiorite and Goroka Formation | Core of Kubor Anticline in N central Sheet area. | Low-grade low-pressure regional metamorphics, hornfels. Slaty cleavage only in fine-grained rocks. Contains numerous small unmapped Kubor Granodiorite bodies. Age unknown, but older than upper Kubor Granodiorite. |

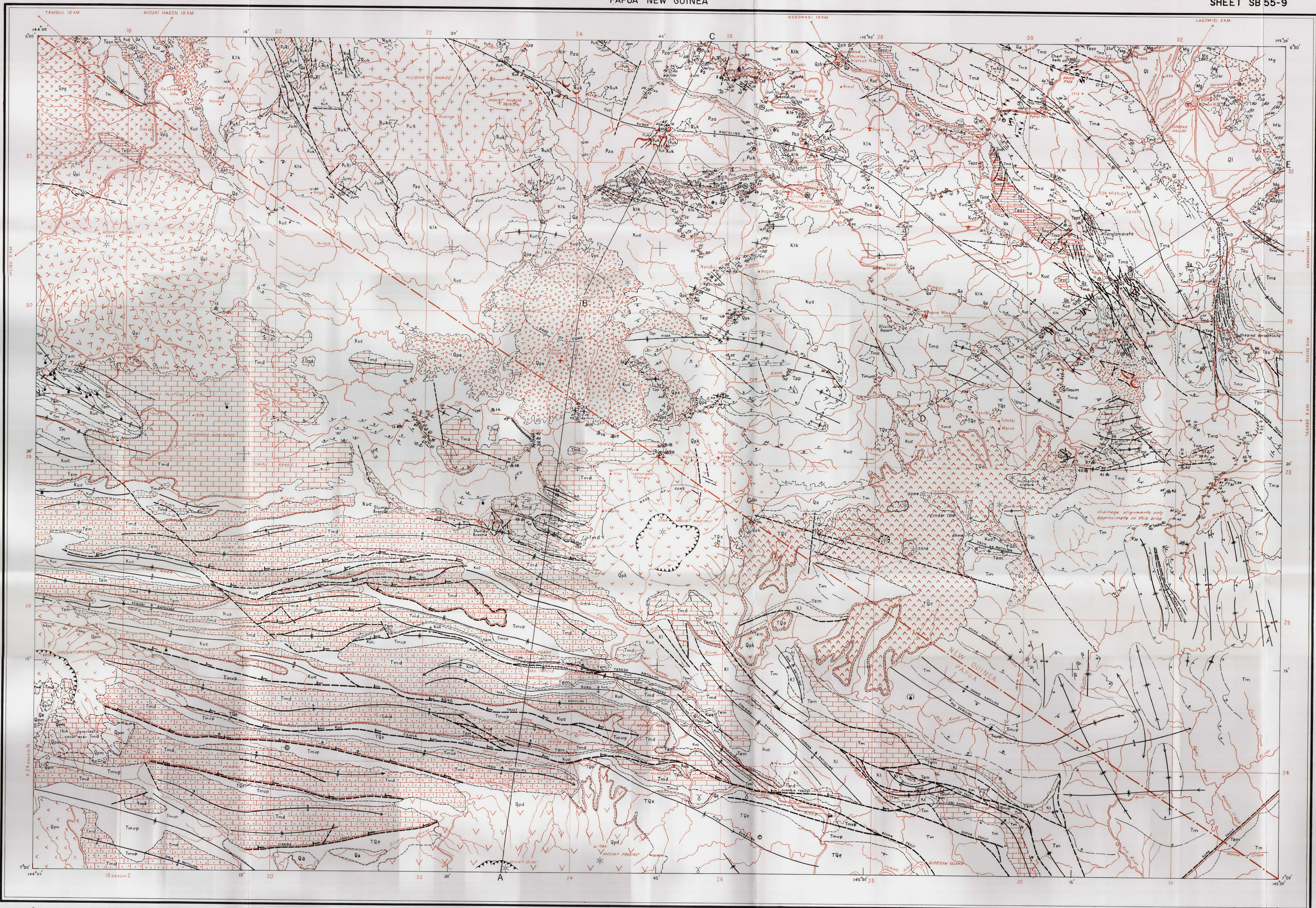
* Recent palaeontological work indicates an Upper Traissic age for the Kuta Formation

PAPUA NEW GUINEA 1:250,000 GEOLOGICAL SERIES

# KARIMUI

PAPUA NEW GUINEA

SHEET SB 55-9



## Reference

- Geological boundary
- Facies change
- Anticline showing direction of plunge
- Syncline
- Monocline
- Overturned anticline
- Overturned syncline
- Fault (DU indicates relative movement down up)
- Fault, low-angle thrust (T indicates upper plate)

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

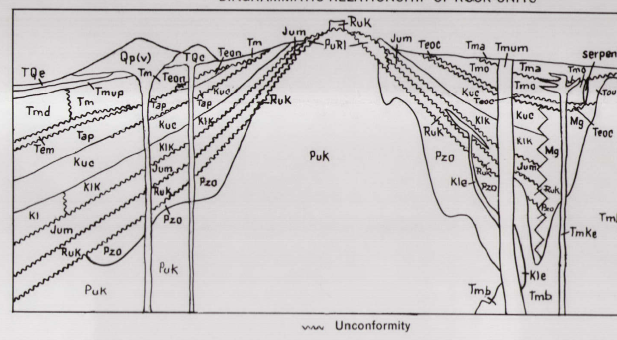
- Shear zone
- Strike and dip of strata
- Vertical strata
- Dip } air-photo interpretation
- Dip, overturned } air-photo interpretation
- Trend line } air-photo interpretation
- Strike and dip of foliation
- Foliation with plunge of lineation
- Major eruptive centre with no recorded eruption
- Minor eruptive centre with no recorded eruption
- Crater wall, caldera wall or other escarpment associated with volcano
- Lava flow; true outline shown
- Gas seep
- Oil seep
- Oil seep, weak
- Oil and gas seep or show
- 1-14 Macrofossil locality and specimen number
- 1-42 Microfossil locality and specimen number
- 1-8 Sample locality for age determination and sample number
- Dyke
- Unworked deposit, C coal, Sc shungite, Py pyrite
- Spring, salinity greater than 10,000 ppm
- Escarpment
- Cirque
- Highway
- Road
- Track
- Airport
- Landing ground
- Town
- Settlement
- Trigonometrical station
- • 1912 Elevation in metres, approximate

## Reference

| | | | | | |
|---|---|---|---|---|---|
| CAINOZOIC | QUATERNARY | HOLOCENE | | Qa | Alluvium |
| | | | | Ql | Lake sediments |
| | | | | Qs | Talus, scree |
| | | PLEISTOCENE TO HOLOCENE | Banz Fanglomerate | Qpb | Fanglomerate composed of gravel, sand, silt, tuff and clay |
| | | | Suaru Volcanics | Qps | Shoshonitic to andesitic lava, agglomerate and tuff, minor derived sediments |
| | | | Karimui Volcanics | Qpk | |
| | | | Duau Volcanics | Qpd | |
| | | | Mount Murray Volcanics | Qpm | |
| | | | Ialibu Volcanics | Qpi | |
| | | | Hagen Volcanics | Qph | Basaltic to dacitic lava, agglomerate, tuff and lahar deposits |
| | | | Giluwe Volcanics | Qpg | Basaltic and andesitic lava, tuff and agglomerate |
| | | | (Qps–Qpg) | | Qp(v) in diagrammatic relationship of rock units |
| | | PLIOCENE TO PLEISTOCENE | Crater Mountain Volcanics | TQc | High potash calc-alkaline lava, minor tuff and agglomerate; derived sediments |
| | | | Era Formation | TQe | Marine and non-marine fine sandstone and mudstone; coal seams |
| | TERTIARY | UPPER MIOCENE TO PLIOCENE | Orubadi Formation | Tmup | Mudstone, clay, siltstone, sandstone |
| | | UPPER MIOCENE | Michael Diorite | Tmum | Porphyritic hornblende microdiorite |
| | | | Kenangi Gabbro | TmKe | Gabbro, mangerite, granodiorite |
| | | | Bismark Intrusive Complex | Tmb | Gabbro, diorite, subordinate mangerite, granodiorite, tonalite, granite; minor aplite |
| | | MIDDLE MIOCENE | ** Daulo Formation | Tma | Andesitic to shoshonitic agglomerate; subordinate lava, ash-flow tuff; Volcanolithic conglomerate and sandstone, greywacke, tuff; Calcarenite |
| | | LOWER TO MIDDLE MIOCENE * Upper Te to Lower Tf | Movi Beds | Tmo | Volcanolithic and tuffaceous calcareous sandstone and siltstone, shale and conglomerate; Limestone |
| | | UPPER OLIGOCENE TO MIDDLE MIOCENE * Td to Tf | Darai Limestone | Tmd | Limestone calcarenite, calcirudite, marl; Karst development |
| | | | ** Aure Beds | Tm | Calcareous mudstone, greywacke and minor siltstone; Limestone |
| | | * UPPER OLIGOCENE Lower Te | Omaura Greywacke | Tou | Greywacke, calcareous greywacke, siltstone; minor limestone, arkose and conglomerate |
| | | MIDDLE EOCENE TO LOWER OLIGOCENE * $Ta_3$ to Tc | Chimbu Limestone | Teoc | Foraminiferal dark grey, buff and white limestone; calcarenite |
| | | | Nebilyer Limestone | Teon | Grey limestone, calcarenite; minor argillite, siltstone |
| | | * EOCENE $Ta_2$ to Tb | Mendi Group | Tem | Limestone, calcareous mudstone, calcarenite, sandstone, siltstone |
| | | UPPER PALAEOCENE TO EOCENE * $Ta_1$ to Tb | Pima Sandstone | Tap | Sandstone, tuffaceous sandstone, siltstone, mudstone |
| MESOZOIC | | 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 |
| | | | | Kl | Dense blue-grey and coarse shelly greywacke, siltstone and shale, gastropod limestone |
| | | | ** 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 |
| | | LOWER JURASSIC | ** Urabagga Intrusives | Jlu | Granodiorite, diorite |
| | | UPPER TRIASSIC | Kana Volcanics | Ruk | Red, purple and green acid to basic agglomerate; volcanolithic sediments, lava, tuff |
| | | | Goroka Formation | Mg | Schist, schistose carbonaceous siltstone, subordinate phyllite, quartz greywacke, marble |
| | | | Bena Bena Formation | Mb | Schist, phyllite, quartzite, gneissic granite meta greywacke, arkose |
| 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 |

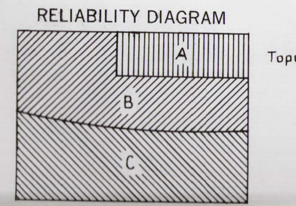
* Tertiary letter stage
** Informal name

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



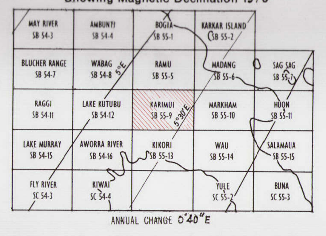

Compiled by Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development.
Base map adapted from topographic maps prepared by Division of National Mapping and Royal Australian 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



Topo
A Adjusted National Mapping Bases; detailed, poorly controlled
B Photo mosaics partly adjusted to U.S. Army Map Service and Division of National Mapping Bases; detailed, poorly controlled
C Traced from adjusted SLAR mosaic at approximately 1:250,000 scale; not detailed, uncontrolled

INDEX TO ADJOINING SHEETS
Showing Magnetic Declination 1970




Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

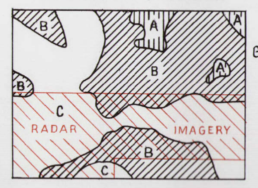
5 0 5 10 MILES

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

Sections

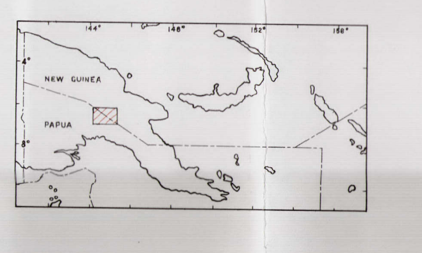
Scale: $\frac{V}{H} = 1$

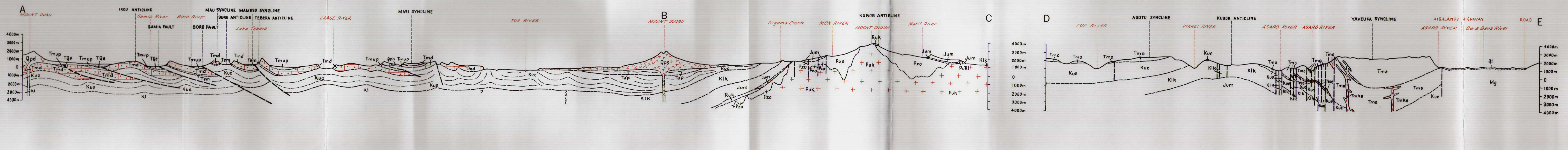
RELIABILITY DIAGRAM




Geology
A Detailed mapping
B Detailed reconnaissance: numerous traverses, interpretation of air-photos and radar imagery
C General reconnaissance: some traverses, interpretation of air-photos and radar imagery

Geology 1947, 1950, 1955 APC Pty Ltd and IEC Pty Ltd
1956 N.J. McMillan, J.E. Johnson
1957 E.J. Malone, K.K. Hughes
1968 J.H.C. Bain, D.E. Mackenzie, R.J. Ryburn, R.J. Tingey, D.B. Dow, R.W. Page, I.E. Smith; G. Cifali, BP Pet. Dev. (Aust) Pty Ltd
1970 J.H.C. Bain, D.E. Mackenzie, D.J. Belford
Compiled 1971 J.H.C. Bain, D. Green
Drawn by D. Green




PRELIMINARY EDITION, 1972
SUBJECT TO AMENDMENT

KARIMUI
SHEET SB 55-9

# RAMU

PAPUA NEW GUINEA 1:250,000 GEOLOGICAL SERIES

SHEET SB 55-5

## Reference

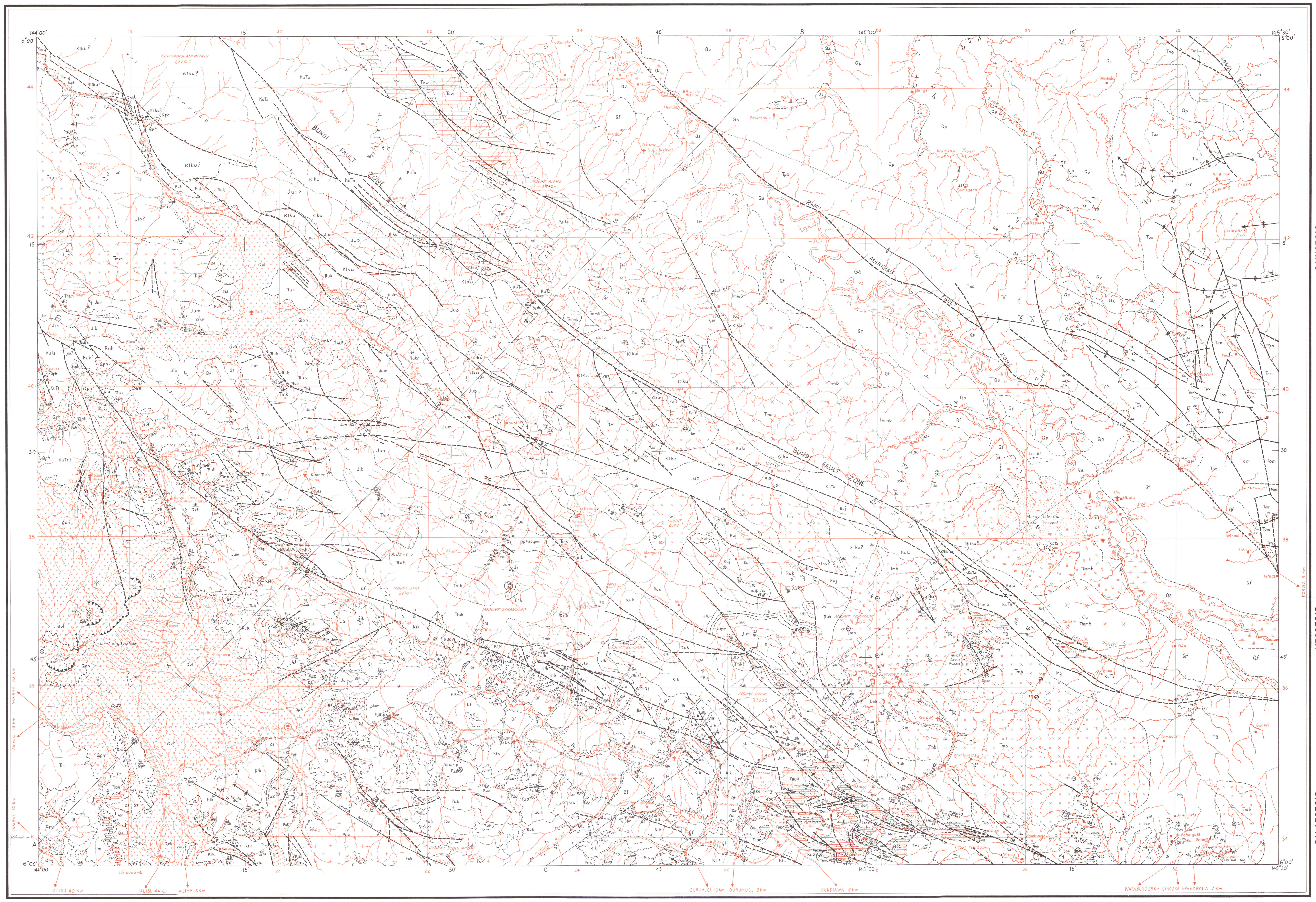
- Geological boundary
- Anticline showing direction of plunge
- Syncline, showing direction of plunge
- Overturned anticline, showing direction of plunge
- Overturned syncline, showing direction of plunge
- Fault (D, U indicate relative movement down, up)

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

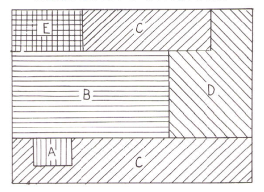
Cu - Copper, Au - Gold, Cp - Clay - pottery, Mo - Molybdenite, Zn - Zinc, Ba - Barite, Dt - Diatomite

- 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



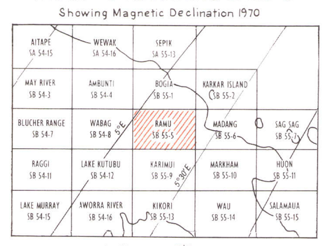
Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Issued under the authority of the Hon. R.W. Swartz, M.B.E., E.D., Minister for National Development.
Base map adapted from topographic maps prepared by Division of National Mapping and Royal Australian 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



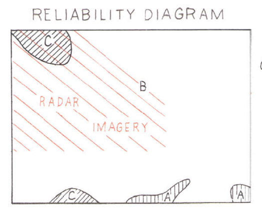

Scale 1:250,000

5 0 5 10 15 20 25 KILOMETRES

5 0 5 10 MILES

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

RELIABILITY DIAGRAM



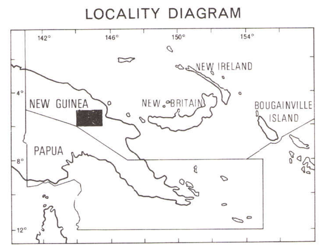

Geology: A Detailed mapping

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

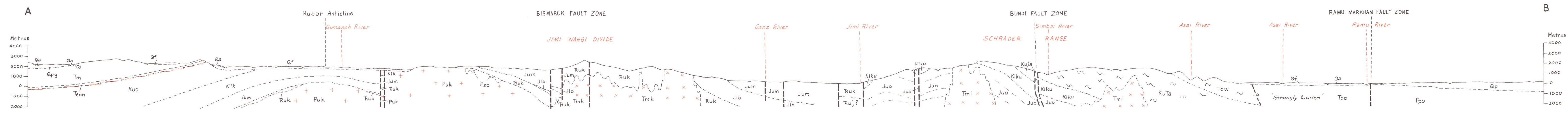
Geology, 1960, by E.J. Malone, N.J. McMillan
1964, by F.E. Dekker, D.B. Dow
1967, by J.H.C. Bain, D.B. Dow, R.J. Ryburn
1968, by J.H.C. Bain, D.B. Dow, D.E. Mackenzie, R.W. Page, R.J. Ryburn, I.E. Smith
1970, by J.H.C. Bain, D.E. Mackenzie, Continental Oil Company (Australia)
Compiled 1971, by J.H.C.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

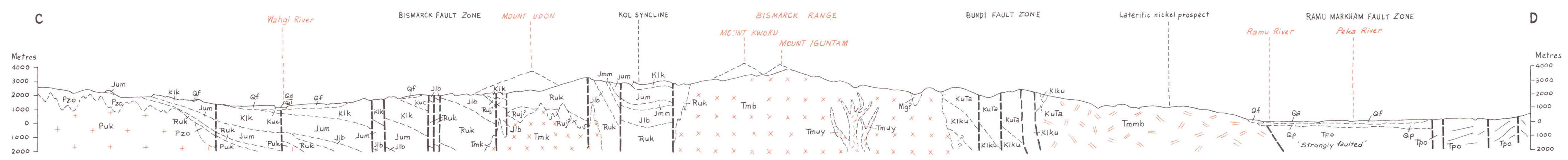
LOCALITY DIAGRAM




Sections

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



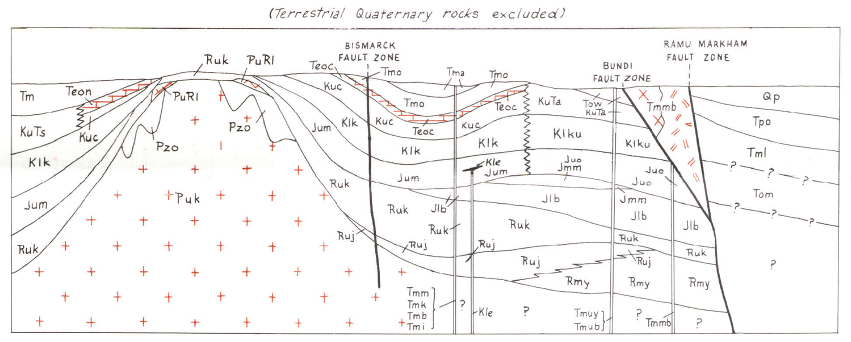

## Reference

| | | | | | |
|---|---|---|---|---|---|
| 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 | 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 |
| | | * lower Tf | ** 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 |

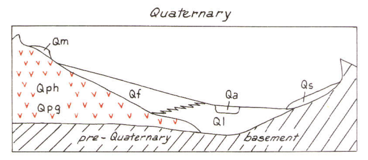
* Tertiary letter stage ** Name not yet approved

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

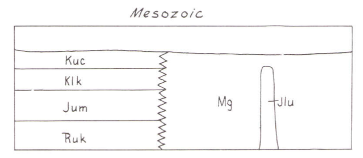
(Terrestrial Quaternary rocks excluded)




Quaternary




Mesozoic




PRELIMINARY EDITION, 1972

SUBJECT TO AMENDMENT



RAMU
SHEET SB55-5