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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1967/26

THE GEOLOGY OF THE SOUTH SEPIK REGION, PROGRESS REPORT FOR 1966.

by

D.B.Dow, J.A.J.Smit & J.H.C. Bain.

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SUMMARY

In 1966, the mapping of the geology of the region between the Sepik River and the Central Range was started. This, the largest unexplored area in New Guinea, separates the swampy Sepik Plain on the north, from the high, dissected, plateau, forming the backbone of New Guinea, to the south. The whole region is rugged, bush-covered, and almost uninhabited: the long meandering southern tributaries of the Sepik River provided the only practicable access, and as there are very few tracks, travel within the area is extremely slow and laborious.

The only available information from the whole of the South Sepik Region was gained by German explorers before World War I. They made collections of diorite and schist, and since then the area has been shown on geological maps as Palaeozoic basement rocks. Probably the most important result of the mapping to date, is to show that the rocks are almost all little-altered sediments of Mesozoic to Tertiary age, intruded by dioritic, gabbroic, and ultramafic rocks.

Apart from isolated hills of schist in the Sepik Plain, which may be of Palaeozoic age, the oldest rocks are Triassic sediments derived mostly from acid volcanics. These are the Yuat Beds and the overlying Kana Formation. The Upper Jurassic Maril Shale, and the Lower Cretaceous Kondaku Tuff overlie the Triassic beds.

During Upper Cretaceous and Lower Tertiary time, fine-grained sediments, called the Lagaip Beds, were laid down in a shelf environment over most of the map area, while eugeosynclinal sediments, the Keram Beds, were being laid down to the north-east. Plutons of composition ranging from ultramafic to acidic, called the Maramuni Diorite, and the April Ultramafites, were intruded in the Lower Miocene, after which shallow-water marine sediments and minor volcanics were laid down. These younger rocks are called, in the north the Karawari Conglomerate, and in the south the Burgers Formation.

The large shield volcano of Mount Hagen erupted south-east of the map area in Pliocene or Lower Pleistocene time, setting off huge lahars (volcanic mud flows), which filled the valley of the Yuat River to a depth of about 100 feet over 70 miles downstream near the Sepik Plain.

THE GEOLOGY OF THE SOUTH SEPIK REGION NEW GUINEA

PROGRESS REPORT 1966

INTRODUCTION

The northern fall of the Central Range, the largest unexplored area in New Guinea (Fig. 1), separates the Swampy Sepik Plain on the north, from the high dissected plateau forming the backbone of New Guinea to the south. The whole region is rugged, bush-covered, and almost uninhabited: the long meandering southern tributaries of the Sepik River provide the only practicable access (Fig. 1), and as there are very few tracks, travel within the area is extremely slow and laborious.

Mapping of the region is part of a program to map the mainland of New Guinea at a scale of 1:250,000, so despite the difficulties of access, the mapping was started in June 1966 by a field party consisting of D.B. Dow, J.A.J. Smit, R.P. Macnab, and J.H.C. Bain. Initial planning had shown that if conventional canoes powered by outboard motors were used, the amount of time spent by the party travelling in the unproductive lower reaches of the tributaries would have been inordinately long; helicopters would have speeded up the work immensely, but to mount a party using helicopters exclusively would have been prohibitively expensive. Thus, it was decided to use boats driven by the Hamilton jet units for transport in the lower reaches of the main tributaries. The use of these boats in New Guinea has been reported on by Dow (1967).

The area mapped during the 1966 field season covers about 1000 square miles, and is bounded by the Yuat and Korosameri Rivers on the east and west, by the Burgers Mountains on the south, and by the Sepik Plain on the north (Fig. 1).

Access

The party used the Sub-district Offices at Angoram and Ambunti as supply centres. These are on the Sepik River, and are supplied by coastal trading ships and light aircraft. The Patrol Post at Amboin was used for an advanced base camp, but as this is supplied only by powered canoes, equipment for this and other advanced base camps was carried by a chartered 20-foot jet-boat. These three Government centres are part of the Sepik District, and are administered from Wewak.

Kompiam in the south-eastern part of the map area is a Patrol Post of the Western Highlands District, administered from Wabag; it has an airstrip capable of taking Piaggio aircraft. The only other airstrip in the area mapped is at Pasalagus in the head of the Maramuni River, but safety standards of this airstrip are so marginal that commercial airlines refuse to land, and it is used almost exclusively by Mission aircraft.

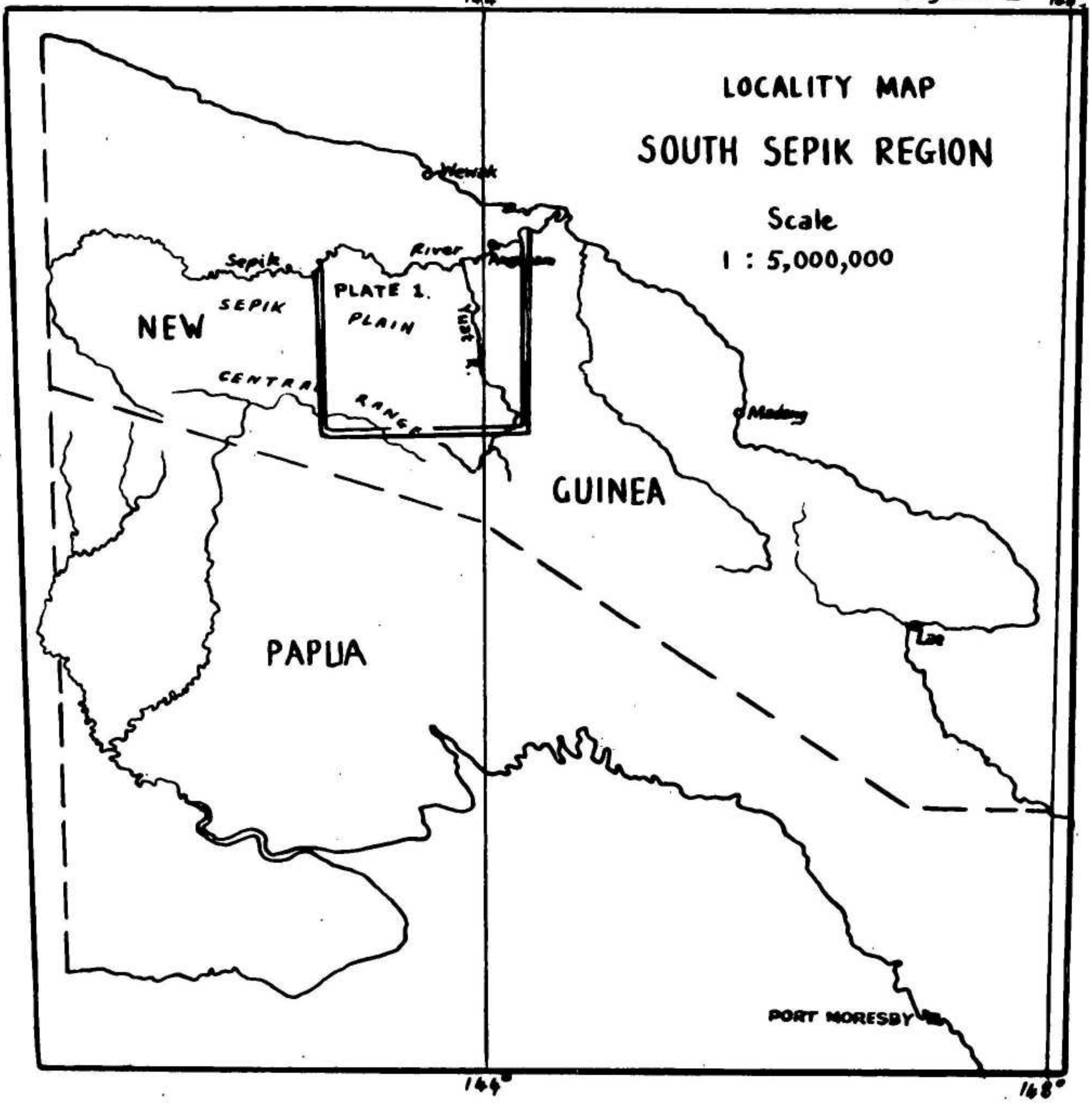
To gain access to the mountains from the Sepik River centres, 50 miles of swampy Sepik Plain must be crossed, and the southern tributaries of the Sepik River provide the only routes. In their lower reaches these are deep and slowly-flowing, and they provide excellent travel for boats; however, as most follow extremely meandering courses, the river distances are up to three times the straight-line distances.

Stranded logs and shoals are the only obstructions, but even in times of low water they are generally not troublesome. The level of the rivers fluctuates greatly, and during the wet season they are at or above plain level, but at times in the dry season they flow between steep muddy banks up to 20 feet high.

Within a few miles of the mountains the gradients of the streams are steeper, and gravel banks make their appearance. Log jams are common in these reaches and may provide serious obstacles, especially in times of low water. These gravel reaches generally persist for several miles into the mountains, and while they are impassable to canoes, they are generally navigable by jet-boats. Within the mountains the stream gradients steepen further, the streams are obstructed by gorges and rapids, and the limit of jet-boat navigability is soon reached.

The Yuat River is an exception, for though it flows through a long, steep-sided gorge, it proved navigable for about 35 miles into the mountains. The gorge contains many rapids, but only three were cause for great anxiety when they were being negotiated (Fig. 2). Another was impassable, but one boat was hauled around by means of a wooden track built over the river boulders (Fig. 3), and this enabled a further ten miles of river to be traversed.

Figure 1



LOCALITY MAP
SOUTH SEPIK REGION
Scale
1 : 5,000,000
144°
148°
Wewak
Sepik
River
PLATE 1.
SEPIK
PLAIN
CENTRAL
RANGE
NEW
GUINEA
PAPUA
Madang
Lae
PORT MORESBY

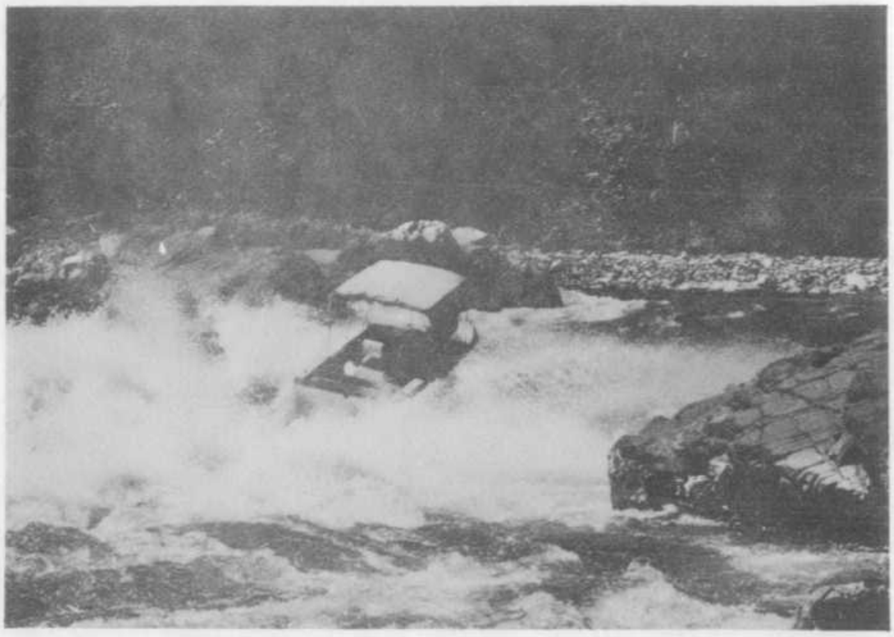


Figure 2: One of the 16-foot jet boats negotiating a difficult rapid in the Yuat River.

(G9347)

Figure 3: Bypassing a cascade in the Yuat River. The primitive mountain people living several thousand feet above the river were persuaded to help build the railway and drag the boat around.

(G9295)

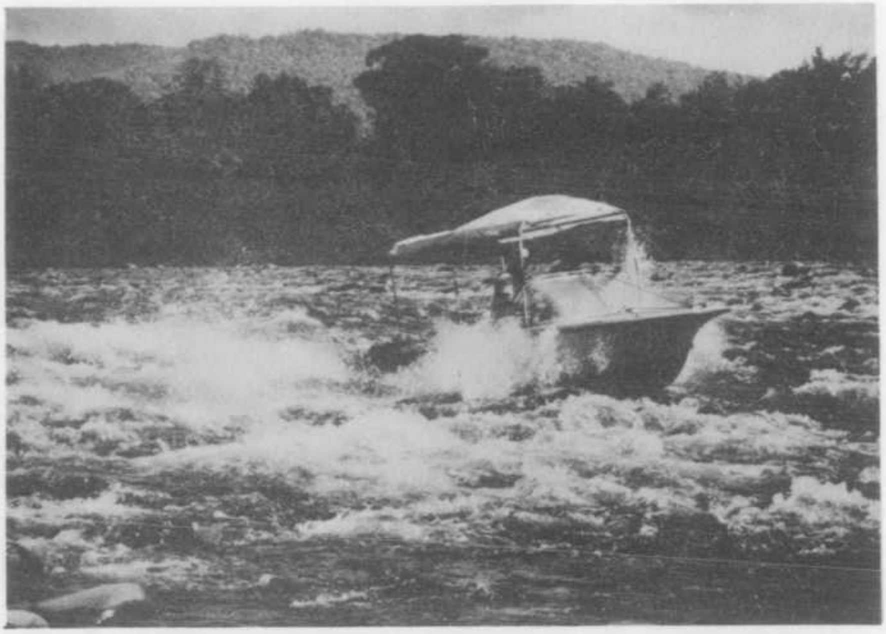


Figure 4: Negotiating a shallow rapid in the Karawari River. The boats sustained some damage under these conditions, particularly going downstream when protruding boulders are not so readily seen.

(G9348)

Access within the mountains proved much more difficult than anticipated. In New Guinea most travel is done on foot using local people as carriers: in populated areas carriers are generally readily available and there is a network of foot-tracks, the worst of which provide much quicker access than breaking virgin bush.

In the South Sepik Region however, there are only very small groups of semi-nomadic people, many of whom have had little or no contact with the New Guinea Administration. Thus there are large areas with no tracks at all, and while tracks are known to link the scattered groups of population, it is generally impossible to get the local populace to co-operate to the extent of acting as guides. As a further difficulty each group of people speaks a different language, and as many have never before seen white people, communication was often possible only by sign language.

Because of the difficulties of access, equipment for each geologist was cut to the minimum: the normal 14 to 16 carriers for each geologist was cut down to 5 carriers per geologist at the end of the season. Even so, in the worst areas where tracks had to be cut progress was often less than two miles per day. Known tracks, and the routes followed where there were not tracks, are shown on the geological map (Pl. 1).

A helicopter would be of considerable use in these areas, but even so, possible landing sites are generally rare, and are not always conveniently placed. A helicopter will be used during the 1967 field season to gain access to critical areas not visited in 1966.

Population

The Sepik Plain supports a large number of people who live in villages on the main waterways: as they travel almost exclusively by canoe they never penetrate the mountains and are of no use as guides in the mountains. They are generally poor carriers, but most speak the lingua franca, Pidgin English; a few of those near the mountains can act as interpreters for the mountain people.

In contrast to the plains people the mountain people do not live in villages. They are generally stronger and healthier and are excellent carriers. They congregate in small groups of about a dozen families each living in a hut sited near the family gardens, but the soil is poor; new gardens have to be established every year. Thus it is quite common for a group to move up to ten miles between seasons. The gardens of these semi-nomadic people are shown on the geological map with the name of the group where known. The largest population is concentrated in the headwaters of the Maramuni River, and here the people are more settled and tend to move within a much more restricted areas. The gardens shown between the Tarua and Yuat Rivers also belong to more settled people locally known as the Wapi. The Sau and Lagaip Rivers support large concentrations of people, and here it was impossible to show the gardens without obscuring geological detail. Most of the people in the area mapped have been contacted by the Administration, either by patrols from the Highlands, or from the Sepik River.

Method of Working

The region was mapped by ground traverses from advanced bases at the foot of the mountains. Positioning and maintaining the party posed formidable problems as the only access from the supply centres of Angoram and Ambunti involved over 100 miles of river transport. Canoes powered by outboard motors are the normal means of transport but these are slow and the outboard motors are susceptible to damage from logs and other underwater obstructions. Also, as the mapping was confined to the mountains, access was needed up the larger tributaries of the Sepik River well into the mountains, and these upper reaches are inaccessible to conventional craft. Helicopters were considered, but the cost of working out of Angoram would have been prohibitive, and working from an advanced base camp would have posed the same logistics problems. It was decided that jet boats would provide the fastest and most economical means of transport to the mountains.

During the field season the party worked from two advanced base camps, one in the Yuat River near the Maramuni Junction, the other at Ambcin Patrol Post in the Karawari River. Three jet boats were used, two smaller 16 foot boats with a payload of 1200 pounds each, and a 20 foot boat, with a payload of 3500 pounds. The larger boat was mainly used for transport of personnel and supplies from Angoram to the base camps. The smaller boats were used mainly to position each traverse party (generally one geologist and at least 5 carriers) at the upper limit of navigability of the rivers. These traverses lasted from 4 to 10 days, and the party was picked up at the end of each traverse, either at the same point, or if the party had crossed the divide, somewhere along the next river.

Also, several traverses were made over the ranges to airstrips in the Highlands: Laiagam, Pasalagus, and Kompiam, from where the parties were flown back to Angoram, and thence by jet boat back to base camp.

The thin section descriptions used in this report were done by J. Bain.

Airphotographs and base maps

The area mapped is covered by vertical airphotographs taken in 1961, and by a useful trimetrogon run (M1087) taken in 1948 which runs diagonally across the map area from the north-north-east. These photographs gave the first reliable topographic information on the area, so an uncontrolled compilation was made and used as a base map for the survey.

U.S.A.F. Aeronautical Approach Charts at a scale of 1:250,000 were used as the base for the Geological Map Plate 1: however, much of the detail of the mountain region shown on these maps was wrong, and here the field sheets were reduced photographically to give the best fit with the Approach Charts.

Acknowledgements

The survey would have been impossible without the wholehearted co-operation of Officers of the Department of District Administration who helped with transport and storage arrangements, and many other administrative problems. The hospitality extended at the various outstations was very much appreciated, especially at the end of some of the arduous traverses across the main range.

HISTORY OF EXPLORATION

Until 1966 no geological work and only a little exploration had been done in the map area. The first white people to visit the area were members of the expedition led by W. Behrmann (1923) who penetrated to the mountains from the Sepik River in 1912. The expedition followed the Keram River to its Clay River tributary which it then followed to its source, finally crossing the eastern end of the Schrader Range to the middle reaches of the Yuat River. The expedition also followed the Karawari River, penetrating a short distance above the site of Ambo:in Patrol Post.

The region was not visited again until just before World War II when gold was discovered by prospectors in the lower Yuat, Maramuni, and Arafundi Rivers. Several of the prospectors crossed the Central Range in the eastern part of the map area, and at about this time Patrol Officer Taylor also crossed the range from the Karawari River to Wabag.

The western part of the area was not visited by white men until the early 1960's when patrols from the Sepik District made contact with the Gadio, Towi, and Pundugum peoples on the northern fringe of the mountains. The small group of people at Kasagari on the north-western flank of the Burgers was the latest group visited and they were first contacted by a patrol from Laigam in the Western Highlands in 1964.

Up to 1966 however, the more inaccessible western part of the area mapped had not been visited, and a member of the Sepik Party made the first crossing of the Central Range west of the Burgers Mountains. The Meakambut people who live in the middle reaches of the Karawari River were first contacted by the party in July 1966 (Fig. 6).

PHYSIOGRAPHY

The region mapped is one of extreme relief. The Sepik Plain is flat, swampy, and only about 100 feet above sea level at the foot of the mountains over 300 river miles from the sea. South of the Plain the mountains rise steeply and culminate in the bare-topped Burgers Mountains 13,000 feet above sea level. Most of the intervening area is deeply dissected and has a fine dendritic drainage. The ridges are sharp, valleys steep-sided, and the local

Figure 5.

AVERAGE MONTHLY RAINFALL
SEPIK DISTRICT

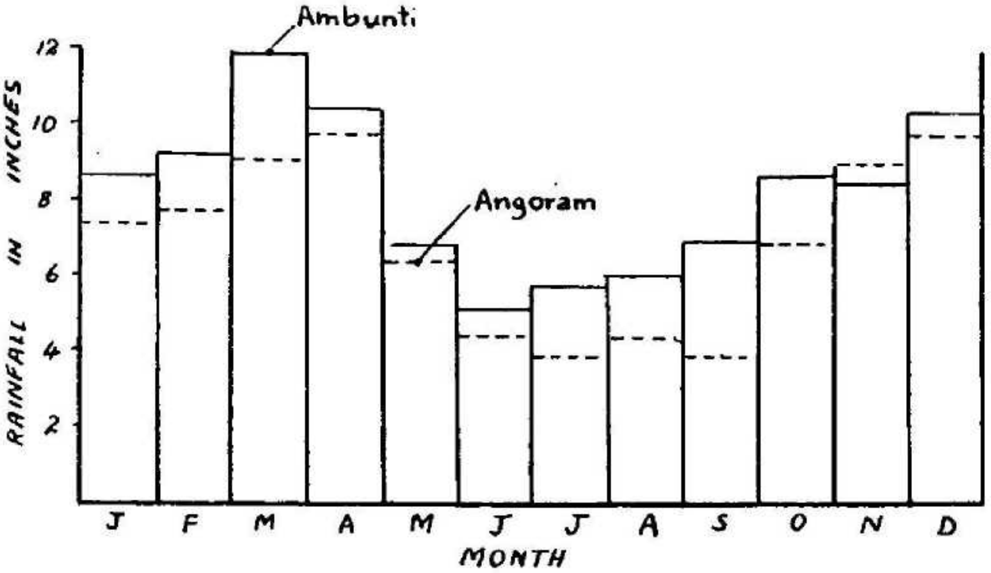


Figure 5: Average monthly rainfall for Ambunti and Angoram. Records have been kept for 12 years at Ambunti, and 11 years at Angoram.

Annual averages - Angoram : 82 inches
- Ambunti : 98 inches

relief between 3000 feet and 5000 feet.

In the lower reaches of the Karawari River, massive conglomerate forms broad mesas between the major valleys. Bold cliffs of conglomerate up to 3000 feet high flank these rivers and give some of the most striking scenery in the Highlands of New Guinea.

Except in areas of large population such as the Maramuni and Sau Rivers, the whole region has a dense forest cover relieved only by very small, sporadic garden clearings, and areas of grass on the crest of the Burgers Mountains.

Most of the rivers such as the Maramuni, Karawari, Korosameri, and Salumei, have their sources near the crest of the Central Range, and follow steep, direct courses to the Sepik Plain to the north. The Yuat River has its source on the south side of the Central Range and it breaks through the mountains by way of a very long deep gorge. The south-western corner of the map area is drained by the Lagaip River which makes its way westwards to the Strickland River, finally reaching the south coast.

Climate

Most of the region is hot and humid, and has a high rainfall. Rainfall records have been kept only at Angoram, Ambunti, and Kompiam, and they show that while the rainfall is spread throughout the year it is considerably lower between May and September (Fig. 5).

The annual average rainfall is 98 inches at Ambunti (records kept for twelve years), and 82 inches at Angoram (over eleven years) and these are probably representative of most of the Sepik Plain. Rain falls much more frequently in the mountains, and it is probable that here the rainfall is higher. The rainfall recorded at Kompiam supports this contention, for though it is probably not typical of the northern fall of the Central Range, has an annual average rainfall of 126 inches (over six years).

The high mountainous regions are cold, wet, and almost perpetually cloud-covered. In these regions sodden moss covers ground and trees alike, and camping above 10,000 feet is not a pleasant experience.

The Sepik Plain is renowned for the myriads of mosquitoes found at most localities, but their incidence drops off markedly in the mountains. A large biting fly (March Fly) makes daytime stops a trial in some areas, and sandflies are unpleasant above 10,000 feet, but in general one is not greatly troubled by insect pests. However, bush mites, tiny insects which burrow under the skin and cause intense irritation to some people are common in the lower altitudes, and were probably the worst insect pest.

Game is plentiful in the lower altitudes, and a party can extend a traverse several days by living off the land. Animals commonly shot by the party included tree-climbing kangaroos, cuscus', wallabies, wild pigs, cassowaries, and various pigeons.

GEOLOGY

GENERAL

Samples collected by Behrmann's expedition were mostly plutonic rocks and mica schist, and since that time the area has been shown on geological maps as probable Palaeozoic crystalline basement. However, most of the area is composed of little-altered Mesozoic and Lower Tertiary marine sediments and volcanics, intruded by plutonic rocks ranging in composition from ultramafic rocks to granodiorite.

Quartz mica schist is found along the northern margin of the mountains but its age is not known: it could be related to the pre-Mesozoic basement rocks found in Papua over 100 miles to the south-west, (A.P.C. 1961), or to the probable Lower Tertiary schists mapped by Dow and Dekker (1964) in the Bismarck Mountains 40 miles to the east.

The oldest known rocks are shallow-water marine sediments of Middle to Upper Triassic age which are probably equivalent in part to the Jimi Greywacke found in the Jimi Valley 60 miles to the east (Dow and Dekker, 1964). Overlying this unit are sediments, derived from acid vulcanism, called the Kana Formation. These are almost identical with the formation in the type area, the Jimi Valley, and were formed during vulcanism which accompanied intrusion of the Bismarck Granodiorite in uppermost Triassic times (Dow and Dekker).

Figure 6: Meakambut warriors first contacted by the Sepik Party. Some owned steel axes which had been traded with neighbouring tribes, but they had never before seen white men.

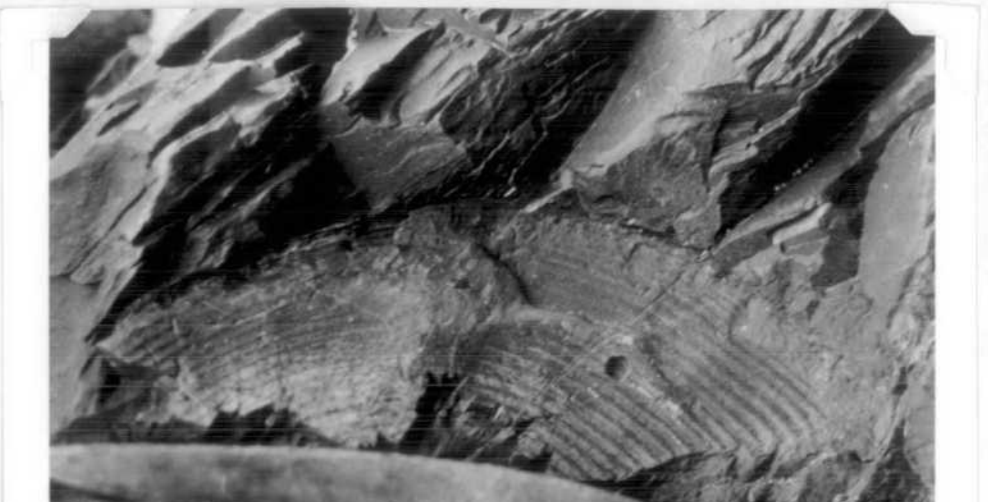


Figure 7: Fossil cast in the Yuat Beds, in the gorge of the Yuat River. It appears to be a large plate-like ammonite, over one foot across and less than an inch thick. (G9510)

TABLE 1.

SUMMARY OF STRATIGRAPHY - SOUTH SEPIK REGION

AGE	FORMATION	ROCK TYPE	THICKNESS (feet)	RELATIONSHIP WITH OTHER UNITS
Recent		Clay, peat, sand, tuffaceous sand, and some gravel.	Not known	
		Raised alluvial deposits	Not known	
?Pleistocene	Hagen Volcanics	Volcanic breccia and conglomerate, gravel, basalt lava.	100' to 500'+	Valley fill deposits
Tertiary f_{1-2} - stage	Burgers Formation	Greywacke, tuaffaceous sandstone, conglomerate	8000' in Burgers Mountains.	Probably unconformable on Lagaip Beds.
	Tarua Volcanic Member.	Tuff, agglomerate, pillow lava	5000 feet	
	Karawari Conglomerate.	Conglomerate, carbonaceous sandstone, basic to volcanic rocks.	2000 feet +	Apparently conformable on Lagaip Beds.
(Not known)		Quartz mica schist of unknown age.	Not known	Unconformably overlain by Karawari Conglomerate.
	EMPLACEMENT OF MARAMUNI DIORITE AND APRIL ULTRAMAFICS			
Upper Cretaceous to Tertiary e-stage.	Lagaip Beds	Calcareous siltstone, shale, and sandstone; calcarenite.	8000 feet +	Faulted.
	Sau Greywacke Member	Tuffaceous greywacke, conglomerate, siltstone, minor conglomerate.	8000 feet to 12000 feet.	Conformable within Lagaip Beds.
	Yeim Limestone Member	Calcarenite, marl.	500' to 1000'	
?Upper Cretaceous	Kerai Beds	Basic and intermediate marine volcanic rocks, tuffaceous sediments.	Possibly 5000'	Faulted.
Lower Cretaceous	Kondaku Tuff	Basic agglomerate and tuff, tuffaceous sandstone.	1000'+ to east.	Apparently conformable on Maril Shale.
Triassic to Jurassic.	Undifferentiated	Shale, siltstone.	Not known	Faulted
Upper Jurassic	Maril Shale	Shale, siltstone; some greywacke and quartz sandstone.	3000' to S.E.	Not known
	Kana Formation	Tuffaceous sandstone, dacite pebble conglomerate, tuffaceous siltstone.	2000 feet +	Probably conformable on Yuat Beds.
Triassic	Yuat Beds	Shale, massive greywacke, sheared acid volcanics.	2000 feet +	Base not seen.

To the east of the map area there is a conformable sequence ranging in age from Lower Jurassic to Upper Cretaceous, but in the map area only a fragmentary record of this period is preserved. Thus the Upper Jurassic Maril Shale, Lower Cretaceous Kondaku Tuff, and the Upper Cretaceous Keram Beds are found as isolated fault blocks.

During Upper Cretaceous and Lower Tertiary time, fine-grained sediments called the Lagaip Beds were laid down in a shelf environment. As in the Bismarck Mountains to the east, there is a change in facies across the Jimi Fault, because to the west sediments laid down at the same time (the Keram Beds) are eugeosynclinal sediments and basic volcanics.

The Maramuni Diorite and the April Ultramafites intruded the Lagaip Beds, probably in Lower Miocene time.

The youngest marine sediments are the Middle and Upper Miocene shallow-water sedimentary rocks which appear to post-date the plutonic rocks.

The large shield volcano of Mount Hagen erupted south-east of the map area in Pliocene or Lower Pleistocene time, setting off huge lahars (volcanic mud flows), which filled the valley of the Yuat River to a depth of about 100 feet over 70 miles downstream near the Sepik Plain.

TRIASSIC

Yuat Beds (New Name)

Apart from the schists which may be older, the Yuat Beds are the oldest known in the map area.

Rock Type:	Shale, greywacke, and feldspathic sandstone.
Distribution:	Confined to the Yuat Gorge.
Derivation of Name:	From the Yuat River.
Type Area:	The Yuat Gorge. No type section was measured.
Stratigraphic Relationships:	The base of the Beds is not exposed: the Beds are overlain, probably conformably, by the Kana Formation.
Thickness:	Not measured, but at least 2000 feet.

Fossils and Age: Ammonites, Nautiloids, Lamellibranchs, and crinoid stems: Middle to Upper Triassic.

Detailed Description:

The formation is well exposed only along the Yuat River where the dominant rock-type is a massive black shale; overlying this shale is very poorly exposed tuffaceous greywacke which forms the steep western wall of the Yuat Valley. The Beds are about 2000 feet thick but the bottom of the sequence was not seen.

The black shale is about 300 feet thick, generally massive, indurated, and well-jointed: outcrop is excellent in the Yuat River, and generally fine silty bands can be distinguished on close examination. The shale is richly fossiliferous and contains well-preserved Ammonites, Nautiloids, and Lamellibranchs, abundant crinoid stems, and some rare bone fragments. Rare beds of feldspathic sandstone up to 3 feet thick are interbedded with the shale, and these are brown to grey, fine to medium-grained, consisting of well-sorted grains of sub-rounded quartz and kaolinised feldspar in about equal proportions. Fragments of ferromagnesian minerals are common and there is a small amount of sericitic matrix. The sandstone appears to be derived from an acid volcanic source, and is similar to the tuffaceous sandstone of the overlying Kana Formation.

The shale passes upwards rather abruptly into a dominantly arenaceous sequence. The transition is about 50 feet thick, and consists of light-grey to brown feldspathic sandstone and calcareous sandstone beds three inches to three feet thick, interbedded with subordinate thinly-bedded black and grey shale and siltstone. Thick beds of poorly-sorted quartz sandstone are found here, some crowded with well-rounded pebbles of black indurated shale. Coaly fragments, carbonaceous lenses, and small pieces of bone are found in many of the beds indicating, in the absence of graded bedding, a shallow-water environment.

Overlying the shale member is a sequence 1500 to 2000 feet thick, which though it forms the steep western slopes of the Yuat Valley, crops out only poorly. The only exposures seen were massive to thick-bedded tuffaceous greywacke which is green and highly indurated when fresh, and it appears that the whole section is made of similar rocks.

Highly sheared green and purple dacite, quartz feldspar porphyry, and volcanic pebble conglomerate are exposed in the lower part of the Yuat Gorge; their relationships with other units is not known, but as similar rocks underlie the Kana Formation in the headwaters of the Chim River 100 miles to the south-south-east, it is assumed that the volcanics of the Yuat River are part of the Triassic sequence. As they are the most easterly unit of the Triassic sequence, it would seem that they underlie the Yuat Beds, but as the critical contacts are covered by the Hagen Volcanics, this cannot be proved.

In thin-section most of the rocks are acid volcanic rocks consisting of phenocrysts of quartz, feldspar, and fragments of microdiorite, in a very fine-grained matrix which displays a marked foliation caused by shearing along the Jimi Fault: in most thin-sections the groundmass is recrystallised and consists of very fine-grained quartz, feldspar, sericite, and some epidote.

Kana Formation

The Kana Formation crops out along the divide between the Yuat and Tarua Rivers, and it is almost identical with the Formation in the type area in the head of the Jimi River. In both areas the Formation is about 2000 feet thick.

In the map area, the bottom half of the Formation consists mainly of tuffaceous sediments derived from acidic vulcanism, dacite pebble conglomerate, and some interbedded red siltstone. The top half is poorly exposed, but appears to be finer-grained; the conglomerate is less common, and red and grey siltstone and shale constitute a greater proportion of the unit.

The sandstone is fine to coarse-grained, and grades into pebble conglomerate. It is characteristically light green or grey, and almost invariably contains a large proportion of feldspar, commonly over half of the rock. It is a clean, well-sorted, tuffaceous sandstone, consisting of angular to rounded fragments of volcanic rocks, quartz, and sodic plagioclase (An_{30}). There are some minor fragments of sedimentary rocks and detrital biotite, and small patches of carbonate matrix. Some weathered beds containing very poorly preserved shells were seen in the lower part of the Formation, and the carbonate is probably derived from solution and deposition of similar fossils.

The conglomerate is a distinctive rock, and consists of well-rounded pebbles and cobbles of dacite tuff, and porphyritic dacite, in a coarse grained sandstone matrix similar to that of the tuffaceous sandstone, but less well sorted. One pebble from the conglomerate was examined in thin-section: it is a completely welded tuff consisting of fragments of quartz, plagioclase, and some fine-grained volcanic rock in a matrix of devitrified glass. The matrix now consists of poorly defined spherulites, and it displays a rudimentary flow banding.

The siltstone is massive, dark to light red, and grades into tuffaceous sandstone. It has not been examined in thin-section, but it appears in hand specimen to be tuffaceous.

The rocks are identical to those of the Kana Formation in the type area. Most of the detritus which forms the bulk of the unit was derived from nearby dacitic and possibly andesitic eruptions, which Dow and Dekker (1964) think were extruded at the same time as the Bismarck Granodiorite was intruded. No fossils were collected from the Formation in the map area, but it contains Upper Triassic fossils in the type area.

JURASSIC

Maril Shale

Massive light grey shale and siltstone found in the lower Sau River are called in this report, the Maril Shale (Rickwood, 1955). The name Labalam Beds was proposed by Dow (1961 unpubl.) for these beds, and later used by Dekker and Faulks (1964 unpubl.) because they contain a greater proportion of arenaceous beds than the Maril Shale in the type area. However, the arenaceous beds are apparently confined to the basal part and the upper part is identical with the Maril Shale of the type area. Contained fossils show the two units to be the same age, and in view of the general similarity of the two units it has been decided to call them both Maril Shale.

The formation crops out in the map area along the western side of the divide between the Yuat and Tarua Rivers. The northern extension of these beds is somewhat doubtful as the shales found in the head of the Lamant River are similar to both the Maril Shale and the younger Lagaip Beds.

The shale and siltstone are dark grey to dark blue, and are generally massive, though thin-bedding can generally be distinguished in good exposures; these unfortunately are rare. The beds are commonly calcareous, and in the vicinity of diorite intrusions, are highly silicified and generally contain scattered pyrite.

The areanceous sediments interbedded in the lower part of the unit consist of fairly clean, thinly-bedded, quartz sandstone, composed almost entirely of well rounded to subrounded grains of quartz and minor chert. A distinctive intraformational conglomerate consisting of subangular pebbles of dark coloured siltstone and shale and a fine sandy matrix, was seen in this part of the Maril Shale.

Buchia malayomaorica and Inoceramus sp. were found in the lower Sau River, indicating that the rocks are of Upper Jurassic age, and therefore correlatives of the Maril Shale mapped by Rickwood (1955), and Dow and Dekker (1964) to the south-east. The thickness of the unit in the map area is not known, but it is up to 3,700 feet in the type area (Rickwood).

The relationship of the Maril Shale to the Kana Formation is not known as the Maramuni Diorite obscures the contact in most of the map area, and in other places exposures are very poor. The region around Olimos and Yalifa was not visited during the field season, and as this area could contain critical exposures, it will be visited by helicopter during the 1967 field season.

CRETACEOUS

Kondaku Tuff

Beds doubtfully referred to the Kondaku Tuff were seen by Dow (1961) near the junction of the Sau and Lai Rivers. The name Kondaku Tuff was used by Rickwood (1955) for basic volcanic rocks of Lower Cretaceous age found in the Wahgi Valley to the south-east.

Only about 100 feet of section was examined, in which the rocks consist of green altered basalt lava and agglomerate, and minor interbedded tuff, which appear in this locality to have been deposited subaerially. Contorted and party assimilated lenses of coarsely crystalling calcite up to two feet thick are a feature of the lava and the agglomerate.

These beds are referred to the Kondaku Tuff on the basis of similarity with the rocks in the type area, and because they appear to overlie the Maril Shale, they need to be mapped in more detail before the correlation is certain.

<u>Keram Beds</u> (New Name)

Rock Type:	Basic to andesitic lava and agglomerate, siltstone, greywacke, and lenses of limestone.
Distribution:	East of the Yuat River. The full extent of the formation is not known.
Derivation of Name:	From the Keram River.
Type Area:	The headwaters of the Clay River, a tributary of the Keram River. No type section was measured.
Stratigraphic Relationships:	Not known. It is faulted against the Triassic rocks of the Yuat River and its eastern limit was not mapped. Correlated with the Kumbruf Volcanics (Dow and Dekker, 1964) on the basis of similar lithology.
Thickness:	Not measured, but is of the order of several thousands of feet.
Fossils and Age:	Foraminifera from one of the limestone lenses give the age as probably Upper Cretaceous.

Detailed Description:

Exposures of the Keram Beds are not good in the map area, and as the beds are highly altered, and complexely deformed, it was impossible to get more than a general impression of the sequence. Basic and intermediate volcanic rocks, though they make up less than half of the unit, are the most striking component. Shale, siltstone, and some greywacke form subordinate interbeds within the volcanics, but they also form thick sequences separating the main volcanic members. In a less complexely deformed sequence, these beds could probably be mapped separately.

The volcanics range in composition from basaltic to andesitic, and occur mainly in the form of agglomerate, which consists mainly of subrounded fragments of purple and green crystal tuff and lava, in a dark green highly indurated tuffaceous matrix. Glass shards and broken crystals of hornblende and pyroxene are prominent in the matrix. Dense welded tuffs, and possibly lava flows, showing prominent flow structures are also common, and a thick volcanic breccia composed mainly of large angular shale fragments was also seen.

Typical of the volcanic sequence is the following section examined on the eastern side of the divide between the Yuat and Clay Rivers,

	TOP
50 feet	Massive agglomerate, consisting of green and purple fragments of welded tuff in a crystal tuff matrix.
10 feet	Red, massive, siltstone.
2 feet	Subgreywacke, and pebble conglomerate.
25 feet	Light grey impure limestone.
50 feet	Agglomerate
10 feet	Volcanic breccia, and volcanic boulder conglomerate.
50 feet	Red siltstone, with an interbedded limestone about 15 feet thick.

The sedimentary rocks interbedded with the volcanic rocks are mainly red, green, and grey shale and siltstone, containing rare beds up to three feet thick, of green and grey highly indurated greywacke. Grey and pink, partly recrystallised limestone, occurs as lenses within the sedimentary rocks. Organic remains are rarely preserved but foraminifera and small shell fragments can be seen in the less altered rocks.

Dolerite and gabbro intrude the Keram Beds, and where the country rocks are highly altered, these intrusives cannot be distinguished from the volcanic rocks. Near the eastern margin of the area mapped the rocks are hydrothermally altered, apparently as a result of a nearby diorite intrusion, which can be seen on the airphotographs to the east as an area of close dendritic drainage.

The Keram Beds are very similar to the Upper Cretaceous Kumbruf Volcanics mapped by Dow and Dekker (1964) in the Simbai River 30 miles to the east, with which they were tentatively correlated in the field. A sample from a limestone lens within the Keram Beds was found by D. Belford (pers. comm.) to contain foraminifera tentatively identified as Marssonella. Thus the Keram Beds are probably Upper Cretaceous and can be correlated with the Kumbruf Volcanics.

Undifferentiated Mesozoic rocks

Very poorly exposed faulted wedges of sedimentary rocks within the Maramuni Fault Zone are probably mostly Mesozoic, and have been grouped as undifferentiated Mesozoic rocks. They are almost all grey and black shale and siltstone, and are generally moderately indurated. Probably both the Maril Shale and the Yuat Beds are represented, because poorly preserved macrofossils have been determined by S. Skwarko (pers. comm.) as Upper Jurassic, and some of the rocks contain impressions of a large almost flat, plate-like ?Ammonite identical with one found in the Yuat Beds (Fig. 7).

TERTIARY

Lagaip Beds

The Lagaip Beds were named by Dekker and Faulks (1964 unpubl.), and defined by Dow (in Belford, 1967).

In the map area the Lagaip Beds are a monotonous sequence of fine-grained sediments containing varying amounts of interbedded sandstone and some limestone.

In the area of good outcrop and simple structure to the south which was mapped by Dow (1961), and later Dekker and Faulks (1964 unpubl.), it was possible to separate out a coarser-grained unit called the Sau Beds, but to the north the structure is much more complex, and the outcrop very poor, and these beds could not be separated. It is therefore proposed that the definition of the Sau Beds be changed, and that it now be regarded as a member of the Lagaip Beds, called the Sau Greywacke Member.

An extensive bed of limestone in the Lagaip Valley has been mapped as the Yeim Limestone Member. The upper boundary of the Lagaip is generally gradational and in the field it is placed arbitrarily at the base of the first cliff-forming conglomerate bed of the Karawari Beds. In places volcanic rocks constitute the base of the Karawari Conglomerate and the boundary is better defined.

In the map area the lower part of the Lagaip Beds is composed almost entirely of fine-grained marine sediments, which are very commonly calcareous. They are mostly shale and siltstone which may be coloured dark or light grey, green, cream, or pink. They are generally massive, though coarser laminae can generally be distinguished where the rocks are not greatly jointed.

The degree of induration varies greatly and the rocks range from very hard silicified rocks near the Maramuni Diorite, to almost friable rocks in areas where they have been little deformed. Many show a marked axial-plane cleavage and in these cases the rocks are generally phyllitic.

Even in areas where the more competent sandstone are only gently folded, these finer sediments are highly contorted. The contortions are partly due to incompetent reaction to stress, and partly to subaqueous slumping.

There are some arenaceous beds in the lower half of the unit but they are not common. They are mostly light grey sandy marl, and calcareous quartz sandstone.

The proportion of arenaceous beds increases upwards and near the top the formation is composed of several thousand feet of muddy, and commonly carbonaceous sandstone, pebbly sandstone, and pebble conglomerate, interbedded with subordiante green and grey siltstone. These uppermost beds are probably equivalent to part of the Sau Greywacke Member, but only rarely is a good section exposed, and it was found impossible to map the Member north of the Karawari Fault Zone.

Lenses of limestone up to several hundred feet thick and several miles long occur throughout the sequence, but these are not common: most of those seen were massive, generally fine-grained, and commonly crowded with foraminifera. Some, such as that exposed at the head of the Wogupmeri River, are coarser-grained, and composed of small, well rounded shell fragments and benthonic foraminifera. These limestone beds generally contain bands of chalky marl and, they grade laterally into the marl and siltstone of the Lagaip Beds.

A thick, resistant limestone bed, which extends along the northern side of the Lagaip Valley in the south-western part to the map area, has been called the Yeim Limestone Member and it is described later.

The thickness of the Lagaip Beds is not known, but 8,000 feet are exposed in the Karawari River (estimated on airphotographs), and these are probably only a small part of the formation.

Diagnostic foraminifera are common both in the limestone beds, and the fine-grained sediments, and they show that the Lagaip Beds range in age from Upper Cretaceous to Lower Miocene (Tertiary e-stage).

The sediments exhibit marked lateral variation, especially in the top half of the unit. Most appear to have been laid down in shallow-water shelf environment, except possibly the finer grained sediments in the lower part.

There was a marked increase in tectonic activity in the Lower Miocene, and at least one period of erosion is evidenced by pebbles of Eocene limestone found in the upper part of the Lagaip Beds, and the Sau Greywacke Member. This increased tectonic activity culminated in the large scale faulting along the major fault zones, and the intrusion of the Maramuni Diorite at the end of the Lower Miocene.

<u>Yeim Limestone Member</u> (New Name)

A resistant limestone bed within the Lagaip Beds which forms hogbacks where steeply dipping and prominent cliffs were flat-lying, has been called the Yeim Limestone Member.

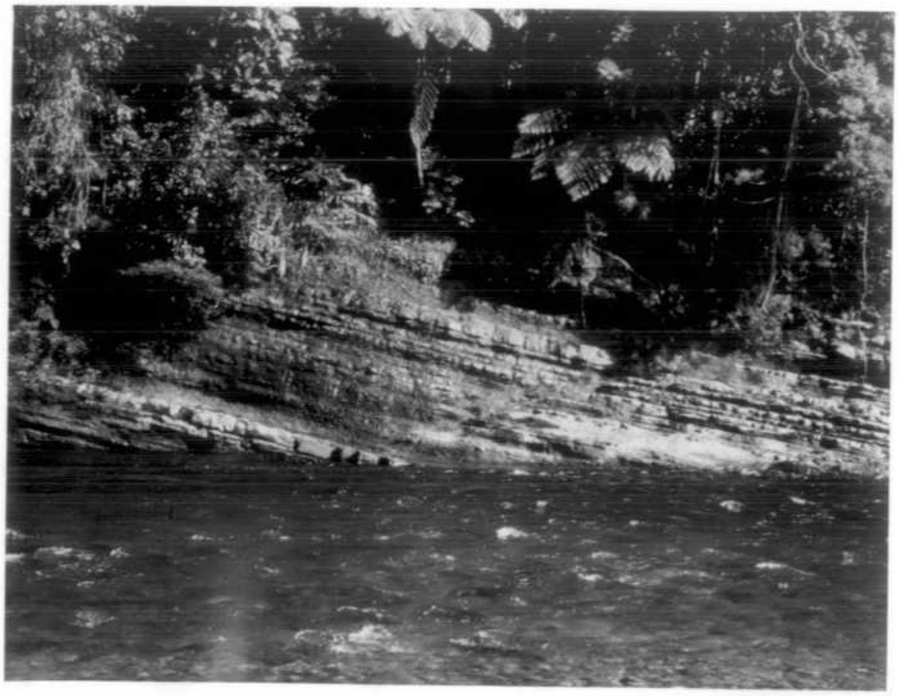


Figure 8: Gently dipping sandstone and siltstone of the Lagaip Beds in the Upper Karawari River.
(G9512)

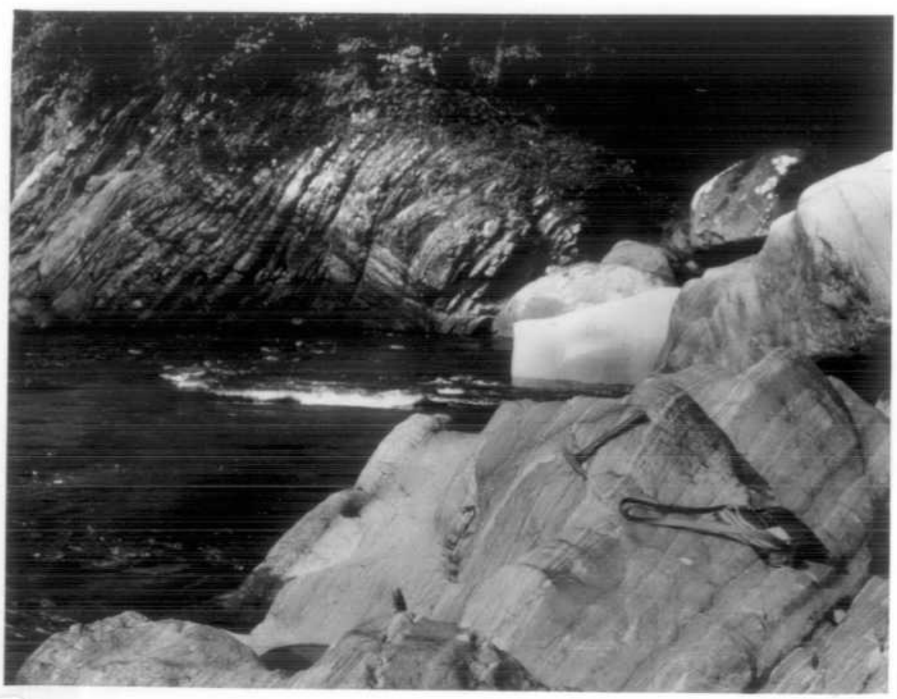


Figure 9: Indurated shale and siltstone of the Lagaip Beds in the Upper Karawari River.
(G9513)

Rock Type:	Fine-grained grey and cream crystalline limestone, chalky marl, and calcareous siltstone.
Distribution:	Crops out strongly along the northern side of the Lagaip Valley for a distance of at least 30 miles.
Derivation of Name:	From Yeim Village in the Lagaip Valley.
Type Area:	Lagaip Valley. No type section was measured.
Stratigraphic Relationships:	A bed within the Lagaip Beds.
Thickness:	Between 500 feet and 1000 feet.
Fossils and Age:	No diagnostic foraminifera were found in the Limestone, but the underlying sediments are Upper Cretaceous to Eocene, and those overlying are Lower Miocene. As Oligocene rocks are almost unknown in New Guinea, it would appear that the Yeim Limestone Member is Eocene, or less likely, lowermost Miocene.

Detailed Description:

The Limestone is characteristically fine-grained, massive, light grey, or less commonly cream, pink, or light green in colour, and contains abundant pelagic foraminifera. In places it is much harder than normal limestone, and here it is possibly slightly silicified. Small, ramifying, calcite veins are a characteristic feature of most of the Member.

The carbonate content of the Member varies quite considerably along strike and in places it grades into a marly siltstone. An unusual feature is the almost complete lack of bedding, indicating deposition in very quiet conditions: the very fine grain of the carbonate indicates that it could have been deposited chemically, though there are no structures such as ooliths to support this.

Sau Greywacke Member

The name Sau Beds was the name proposed by Dekker and Faulks (1964 unpubl.) for a thick sequence of arenaceous beds laid down in the southern part of the South Sepik Region. Similar beds are found to the north, but because of poor exposure and extreme lateral variation, they cannot be separated from the rest of the Lagaip Beds, and we have proposed that the Sau Beds be redefined as a member of the Lagaip Beds, called the Sau Greywacke Member.

Rock Type:	Greywacke, tuffaceous greywacke, siltstone and conglomerate. Some lenses of limestone.
Distribution:	As north-west-trending belts along the north and south sides of the Central Range.
Derivation of Name:	From the Sau River.
Type Area:	Along the Sau River downstream from Kompiam Patrol Post. No type section was measured.
Stratigraphic Relationships:	The Member overlies the Lagaip Beds possibly with slight unconformity. It is overlain, possibly unconformably, by the Tarua Volcanic Member and the Burgers Formation.
Thickness:	The Member has been estimated from the airphotographs to be about 14,000 feet thick (Dow 1961, unpubl.), but it is possible that some part of the Member could have been repeated by faulting.
Age:	There is no direct evidence of age for the Sau Member. It is overlain by the f_{1-2} stage Tarua Volcanic Member, and it overlies Lagaip Beds containing e stage foraminifera at several localities.

The Member has been described by Dow (1961 unpubl.), and Dekker and Faulks (1964 unpubl.).

Figure 10: Agglomerate member at the base of the Karawari Conglomerate on the eastern side of the Arafundi Valley.
(G95,1)

Karawari Conglomerate (New Name)

Though the Karawari Conglomerate crops out boldly in the headwaters of the Karawari River, comparatively little is known of the unit. This is because everywhere it forms unclimable vertical cliffs so that only the basal parts can be examined in outcrop. For information on the upper parts of the unit we had to rely on derived boulders, and obviously only the more resistant rocks survived the transport.

Rock Type:	Pebble and cobble conglomerate, and pebbly sandstone. There are thick lenses of basic intermediate volcanic rocks at the base of the unit.
Distribution:	The headwaters of the Karawari River.
Derivation of Name:	Karawari River.
Type Area:	The Arafundi River; no type section was measured.
Stratigraphic Relationships:	The relationships with other units is not clear (see later p.23). It is almost certainly the equivalent of the Tarua Volcanic Member and the Burgers Formation found in the south of the map area.
Thickness:	At least 2000 feet.
Fossils and Age:	No fossils were found in the unit. It overlies Lower Miocene (Tertiary e-stage) Lagaip Beds and is probably the same age as the Burgers Formation (uppermost Lower Miocene or Tertiary f_{1-2} stage).

Detailed Description:

The boundary between the Lagaip Beds and the Karawari Conglomerate appears to be gradational, and it is placed arbitrarily at the loweemost cliff-forming conglomerate, even though there are conglomerated beds within the Lagaip Beds. Where volcanic beds are present, the boundary is places at their base.

The Karawari Conglomerate consists mainly of massive pebble and boulder conglomerate, and basic and intermediate agglomerate, lava, and tuffaceous sandstone; it is however, a very variable unit, and contains patches and lenses of sandstone, pebbly sandstone, and siltstone.

The conglomerate is an extremely variable polymict conglomerate within which the larger components are generally well-rounded. The beds are characteristically massive, and form spectacular cliffs up to 2000 feet high, cleft by very narrow deep ravines. The only bedding is defined by vague lenses of sandstone, pebbly sandstone, and minor grey and red siltstone.

In the Arafundi region the conglomerate is composed almost entirely of volcanic components in a tuffaceous matrix, and it grades into agglomerate and crystal tuff. In the Karawari River, there are very few volcanic pebbles, and quartz, indurated sedimentary rocks, schist, limestone, and microdiorite make up the bulk of the rock.

The volcanic rocks are predominantly agglomerate consisting and angular to rounded fragments up to one foot across, of basalt, and andesite, set in a crystal tuff matrix. The presence of basalt lava flows is inferred from the abundant basalt boulders seen in many of the streams in the Arafundi River tributaries, but they were not found in outcrop.

Several thin-sections from the volcanic members have been examined; the rocks range in composition from basalt to andesite, basaltic andesite being the commonest. The basaltic andesite, consists of phenocrysts of plagioclase (An_{40-60}), orthopyroxene, and clinopyroxene, in a groundmass generally composed of glass, iron oxides, and microlites. Perlitic cracking has been noted in the more glassy varieties, and trachytic texture is common in the less glassy. These rocks grade on one hand into andesite, and on the other hand into olivine basalt. The andesite is very similar to the basaltic andesite and differs mainly in the composition of the plagioclase feldspar which is about An_{40}.

The basalt is porphyritic, consisting of plagioclase and clinopyroxene phenocrysts set in a crystalling matrix of feldspar and pyroxene, iron oxide, and generally olivine. The olivine is also commonly found as phenocrysts.

The relationships between the Karawari Conglomerate and the underlying units are rather puzzling. Much of the evidence indicates a large hiatus between the deposition of the Lagaip Beds and the laying down of the Karawari Conglomerate, but such a break is not reflected in the sediments, as there appears to have been continuous deposition.

The evidence for the hiatus is as follows:

1. The Maramuni Diorite intrudes the Lagaip Beds but not the Karawari Conglomerate.
2. Pebbles of microdiorite, almost certainly derived from the Maramuni Diorite are common in the Karawari Conglomerate in places.
3. The Karawari Conglomerate rests directly on schist near the Sepik Plain, showing that considerable faulting must have taken place between the deposition of the Lagaip Beds and the Karawari Conglomerate in order to bring the schist against the Lagaip Beds.

It seems possible that sedimentation continued in the downfaulted areas during Lower Miocene times when faulting was active and while the Maramuni Diorite was being emplaced at depth. The conglomerate beds would have resulted from the accelerated erosion which followed uplift of the horsts. At a fairly early stage erosion had exposed the upper parts of the Maramuni Diorite, thus giving the pebbles and boulders of microdiorite found in the Karawari Conglomerate.

The volcanic rocks at the base of the Karawari Conglomerate could have been the surface manifestation of the intruding diorite, and certainly the volcanic rocks show the same range in composition as the Maramuni Diorite.

Burgers Formation

Burgers Formation was the name proposed by Dekker and Faulks (1964 unpubl.) for shallow-water sediments of Middle Miocene preserved in the Lai Syncline.

It has at its base volcanic rocks which have been mapped as the Tarua Volcanic Member.

Rock Type:	Pebble and boulder conglomerate, tuffaceous sandstone, and greywacke.
Distribution:	The rocks form the Central Range between the Burgers Mountains and Mount Hagen.
Derivation of Name:	From the Burgers Mountains.
Type Area:	The Burgers Mountains. The type section was partly measured and partly estimated from air photographs, in the Burgers Mountains.
Stratigraphic Relationships:	The Formation overlies, possibly unconformably, the Lagaip Beds. The Tarua Volcanic Member is a conformable lens at the base of the Formation.
Thickness:	The type section is about 7800 feet thick, but the top is eroded.
Fossils and Age:	Foraminifera give the age of the bottom of the Formation as uppermost Lower Miocene. Foraminifera from the rest of the unit are indeterminate but show that it could range as young as Upper Miocene.

Detailed Description:

The basal part of the Burgers Formation has been examined only in the eastern part of the Central Range, and in the headwaters of the Maramuni River. Here the rocks are massive, resistant to erosion, and so form a prominent scarp along the northern face of the Central Range.

The rocks in this region are characteristically poorly-sorted, coarse-grained, and are composed largely of volcanic detritus. They show considerable variation so that cobble conglomerate grades both laterally and vertically into coarse tuffaceous sandstone, and into tuffaceous sandstone rich in coralline, bryozoan, and molluscan remains. Lenses of muddy, coralline limestone are common.

The conglomerate is massive, indurated, and consists of well-rounded cobbles and boulders of andesite and basalt, in a dark tuffaceous sandstone matrix. The sandstone is generally coarse-grained, tuffaceous, and cross-bedded; it contains a large proportion of ferromagnesian minerals and is commonly less well indurated than the conglomerate. Better-sorted, medium-grained sandstone is common, and consists of well-rounded quartz grains in an argillaceous matrix. It is generally light grey or cream, but it may also be dark grey; it is commonly calcareous and it also grades into medium-grained greywacke. Poorly preserved plant remains and gypsum nodules are common in the lower part of the unit, and there are clay beds containing silicified wood and limonitic horizons.

The upper part of the Formation, which is preserved only in the Burgers Mountains is much finer-grained, and consists of thin-bedded, medium-grained, friable siltstone which is generally micaceous. It contains calcareous horizons rich in badly preserved macrofossils, and thick beds of sandstone, greywacke, greywacke and conglomerate.

A section 3125 feet thick was measured in the Burgers Mountains, but unfortunately it was not possible to measure the base of the Formation. The generalized section is given below:

TOP

950 feet	Thin-bedded micaceous siltstone, with interbedded greywacke, and shelly beds.
550 feet	Coarse-grained tuffaceous, thin to thick-bedded sandstone, and conglomerate containing basic boulders. Some coral beds, and greywacke.
1100 feet	Grey, thin-bedded, micaceous siltstone.
125 feet	Tuffaceous, coralline limestone.
200 feet	Grey coralline limestone.
200 feet	Blue, coarse-grained tuffaceous sandstone.

The total thickness of the Burgers Formation in the Burgers Mountains is estimated on the airphotographs to be at least 7800 feet.

The Formation was laid down in a shallow-water, near-shore environment and it marks the end of marine sedimentation in the Western Highlands region. The Karawari Conglomerate is the equivalent of only the lower part of the Burgers Formation and it is most likely that the upper part was removed by erosion in the northern part of the map area.

Tarua Volcanic Member

The name Tarua Volcanics was proposed by Dekker and Faulks (1964 unpubl.), for basic and intermediated volcanic rocks in the southern part of the map area. We have incorporated the volcanics in the Burgers Formation, as a member.

Rock Type:	Basic and intermediate lava, agglomerate, and tuff; volcanic conglomerate.
Distribution:	Between Mount Hagen and the Burgers Mountains.
Derivation of Name:	From the Tarua River.
Type Area:	Where the headwaters of the Tarua river cut the volcanics. The type section was measured along the Tarua River.
Stratigraphic Relationships:	The Member occurs at the base of the Burgers Formation, probably as a conformable lens. It overlies the Sau Greywacke Member of the Lagaip Beds, possibly unconformably.
Thickness:	The type section is about 3000 feet thick, but the Member varies considerably in thickness.
Fossils and Age:	Foraminifera from the bottom of the Member give the age as uppermost Lower Miocene (Tertiary f_{1-2} stage). As the bottom of the Burgers Formation is the same age, the Tarua Volcanics must lie wholly within the Tertiary f_{1-2} stage.

Detailed Description:

The Tarua Volcanic Member consists mainly of volcanic rocks, agglomerate, bedded tuff, and lava. It appears to be entirely marine, and hence a considerable proportion of the sequence consists of reworked material; volcanic conglomerate and tuffaceous sandstone are common, and beds of shale and limestone are also seen. A noteworthy feature is that while the lavas and agglomerates are predominantly basaltic, the volcanic conglomerates contain a large proportion of andesitic material.

The type section was measured at the head of the Tarua River:

	TOP
750 feet	Coarse-grained olivine basalt containing phenocrysts of plagioclase; interbedded with small lenses of tuff.
1000 feet	Coarse-grained thick-bedded tuff, with minor beds of conglomerate and agglomerate.
750 feet	Basalt pillow lava and agglomerate.
500 feet	Massive unsorted conglomerate containing rounded to subrounded boulders and cobbles of basic volcanics. Matrix of tuffaceous sandstone. Minor tuffaceous sandstone and some agglomerate.
	BOTTOM

The Member shows extreme variability, both in thickness and rock type, and the measured section is of questionable worth. Thus the Member ranges in thickness from nothing in the east to over 5000 feet in the Burgers Mountains, and most rock types grade into one another, both laterally and vertically.

The agglomerate is blue or green, generally highly indurated, and massively bedded; it consists of angular to subrounded fragments of basalt up to two feet across in a crystal tuff matrix. Andesitic rocks constitute only a small proportion of the agglomerate. Basalt lava flows are found throughout the member, and commonly exhibit pillow structures.

The tuff is generally regularly bedded, but cross beds are quite common. It is well indurated, and appears to be predominantly basic in composition.

The volcanic rocks were examined in thin-section. Most are fine-grained porphyritic basalt consisting of phenocrysts of labradorite and clinopyroxene, in a groundmass of plagioclase, clinopyroxene, and iron oxides. Olivine is generally present in the groundmass, which is also commonly glassy. Interstitial calcite, chlorite, and zeolite are common. One thin section examined was of vesicular andesite; the rocks are porphyritic and consists of phenocrysts of altered plagioclase and clinopyroxene set in a glassy groundmass. The vesicles make up about one third of the rock and are lines with chlorite and filled with zeolite.

The Tarua Volcanic Member was laid down in a shallow marine environment during submarine and subaerial volcanic activity, under conditions which were probably similar to those found along the northern shore of New Guinea today. The vulcanism in the area in which the Member was laid down appears to have been mainly basaltic but andesitic eruptions were taking place further afield as shown by the large proportion of andesitic components in the conglomerates. The andesitic volcanics of the Karawari Conglomerate were laid down at the same time as the Tarua Volcanic Member, and they could have been the source of the andesitic material in the Tarua Member.

It is almost certain that the Tarua Volcanic Member is the equivalent of the volcanic rocks at the base of the Karawari Conglomerate, but no diagnostic fossils were found in the Karawari Conglomerate to confirm this. Foraminifera from the bottom of the Tarua Volcanic Member in the Maramuni River were dated as Tertiary f_{1-2} stage, and as the bottom of the overlying Burgers Formation is also Tertiary f_{1-2} stage. Thus the deposition of the whole of the Volcanic Member must have occupied only a short period of time.

QUATERNARY

Hagen Volcanics

Hagen volcanics is the name proposed by Dow 1961 for volcanic material deposited over much of the Western Highlands probably in Quaternary times. Much of the material originated in the shield volcano of Mount Hagen, but the large volcanoes to the south, such as Mount Giluwe also contributed.

The Hagen Volcanics in the map area originated in the Mount Hagen Volcano, and were transported, probably by lahars, which filled the Lai, Yuat and Jimi valleys to a depth of several hundred feet. Even 70 miles downstream where the Yuat River debouches onto the Sepik Plain, the valley has been filled to a depth of about 100 feet. The lava flow on which the Patrol Post of Kompiam is built originated in an eruptive centre about four miles to the south-east, and there is some evidence that there were some small vents which gave rise to lava flows in the Yuat Gorge but these were not located.

The deposits filling the Yuat Gorge are a chaotic mixture of agglomerate, volcanic breccia, conglomerate, sandstone, and lenses of basalt lava. Many of the deposits are massive, almost completely unsorted, and consist of volcanic fragments up to six feet across and randomly distributed in a tuffaceous matrix. There is generally an admixture of normal river gravels most of which are well rounded and in places these form large lenses.

Patches of basalt lava up to several hundred feet long are exposed at many places in the Yuat Gorge, and though these are almost invariably badly broken up and commonly highly contorted, it is almost inconceivable that they could have travelled 70 miles from Mount Hagen. They are much more likely to have been extruded from vents in the area, and to have flowed down to the Yuat River, finally being incorporated in the lahar deposits. Small remanants of basalt lavas are found capping some of the ridges west of the Yuat Gorge, and it is possible that these have the same origin.

Five samples of the Hagen Volcanics have been examined in thin-section; these range in composition from olivine basalt to basaltic andesite.

The olivine basalt was collected from the lava flows in the Yuat Gorge; it is porphyritic and consists of phenocrysts of plagioclase (An_{64}), clinopyroxene, and olivine in a groundmass of feldspar, pyroxene, and iron oxides. A large proportion of the volcanic fragments in the breccias are porphyritic andesite consisting of phenocrysts of plagioclase (An_{60-65}), hornblende, and some pyroxene, in a fine-grained groundmass of plagioclase, pyroxene, microlites, and iron oxides. Some have a strongly trachytic texture.

The greater incidence of andesitic rocks in the breccias is probably due to the explosive nature of andesitic eruptions, and hence the greater likelihood of their being incorporated in the lahars.

Alluvium

The Sepik Plain is composed of an unknown thickness of fine-grained alluvium. Grey and black carbonaceous silt makes up most of the exposures seen in the river banks, but the composition of the underlying sediments is not known.

Brown tuffaceous sandstone forms the banks of much of the Yuat River in the Sepik Plain. It is composed of clay, quartz grains, glass shards, and broken ferromagnesian minerals, most of which apparently was derived from the Hagen Volcanics. Near the mountains fine gravel and pebbly beds are predominant.

East of the Yuat River the alluvium of the Sepik Plain has been uplifted about 30 feet, and it is now dissected by a fine dendritic drainage. It is possible that this uplift was due to recent movement on the Jimi Fault.

INTRUSIVE ROCKS

Maramuni Diorite

Maramuni Diorite is the name proposed for intrusive rocks in the South Sepik Region ranging in a composition from ultramafic to acidic. Dow (1961 unpubl.) proposed the name Timun Intrusives for a stock mapped near Kompiam, but as this stock is not representative of the larger intrusives, and also because the intrusives have proved very extensive and warrant naming after a feature of more regional importance, we decided to name them after the Maramuni River.

The intrusive bodies range in size from batholiths, 30 miles to 40 miles long, to dykes only a few yards across. Most are of very variable composition and there is evidence of multiple injection of magmas of different composition. However, in many of the bodies, changes in composition are gradational, and it is thought that contamination of the original magma played a large part in forming the different rock types. In places there is evidence of considerable assimilation of the country rocks.

The bodies also vary greatly in grainsize; the larger bodies are granitic in texture, and are generally fine-grained, but medium-grained granodiorite is not uncommon. The stocks and marginal portions of the larger bodies are generally porphyritic while the small dykes commonly have a very fine-grained, and even glassy groundmass.

The Maramuni Diorite is described below under two headings: the Yuat Intrusives which are mainly microgranodiorite, and crop out between the Yuat and Maramuni Rivers; and the Karawari Intrusives, which are mainly diorite and crop out in the headwaters of the Maramuni and Karawari Rivers. These two groups show fairly consistent differences and they could have been formed from different magmas, but as each intrudes different rock types (Lagaip Beds in the case of the Karawari Intrusives, and mainly Kana Formation and Maril Shale in the case of the Yuat Intrusives), the differences may be due to the contamination of the same magma.

(1) Yuat Intrusives

Two large bodies and several apophyses make up the Yuat Intrusives. The northernmost one, in the lower reaches of the Maramuni River has been systematically sampled at quarter mile intervals across the body from east to west. The other body, which is to the south between the Yuat and Sau Rivers, was not sampled systematically, but a reasonably representative collection was made.

The two bodies are composed predominantly of microgranodiorite containing minor diorite phases, and small remnants of crystal tuff which are found within the northern body. The apophyses are almost all intermediate porphyry.

The microgranodiorite is a fairly uniform hornblende-biotite microgranodiorite with a typically plagidiomorphic texture (Raguin, 1965, p.16).

A typical modal analysis is:
quartz 21.6% plagioclase 43.4% K feldspar 12.3% mafics 21.3% and accessories 1.4%.

Quartz: is allotriomorphic, its form being moulded by the other crystals and to some extent interstitial. In the case of this rock type the quartz is not strained except in specimens collected in the vicinity of the many faults that transgress the body. In some specimens there occur graphic intergrowths of quartz and K feldspar (66520218). Raguin (P13) calls this texture micropegmatite and suggests that it is due to corrosion of the feldspar by quartz.

Plagioclase: occurs mainly as idiomorphic and subidiomorphic tabular crystals. These crystals are crazed and slightly sericitised from the core outwards. Normal and oscillatory zoning is present and in some cases it is quite pronounced. The plagioclase is labradorite in the range An_{51-54} (as determined by albite-carlsbad twinning and +ve optic axis figure). Grainsize 1.0-3.0mm.

K feldspar: which occurs mainly as irregular grains moulded on plagioclase crystals and in part intergrown with quartz, is predominantly orthoclase with minor microperthite and a small percentage of microcline. Light to heavy kaolinisation has occurred on the orthoclase but its development on the microcline is considerably less.

The K feldspar was stained with sodium cobaltinitrite solution to facilitate identification.

Mafics: consist of partially and completely chloritised and epidotised hornblende and biotite. The hornblende grains are slightly more numerous than the biotite grains. The secondary alteration product - chlorite (penninite) shows bright anomalous "Berlin blue" colours and is intimately associated with granules of epidote and sphene.

Accessory minerals: include iron ore, small discrete grains of sphene, zircon and apatite.

Alteration: of the constituent minerals varies from specimen to specimen but is in general moderately developed. The hornblende and biotite appear most altered whilst some of the plagioclase crystals are almost completely made over to sericite and much of the K feldspar is heavily kaolinised.

Textural variation: in this rock type is particularly low, but is noticeable towards the margins of the mass where the rock is finer grained allotriomorphic to hypidiomorphic granular and tending to be mildly porphyritic.

The existence of a large number of strongly zoned plagioclase crystals and the quartz-feldspar intergrowths suggest rapid cooling of the magma and possible high level emplacement.

The microgranodiorite grades into diorite which is almost identical, except for the lack, or virtual lack, of quartz, and generally finer grain-size.

The rocks of the apophyses have not yet been examined in thin-section. They are fine-grained andesite porphyry consisting of phenocrysts of feldspar, hornblende, and commonly biotite, in a fine-grained highly altered groundmass. Pyrite is common in these rocks, both as veinlets, and as scattered crystals.

(2) Karawari Intrusives

The Karawari Intrusives are much more variable than the Yuat Intrusives, and though they are made up predominantly of rocks of intermediate composition, basic rocks constitute quite a large proportion of most of the intrusions. The body in the Timun River described by Dow (1961) is predominantly basic.

The Karawari Intrusives occur as a batholith, 35 miles long by 15 miles wide in the headwaters of the Karawari River, and as stocks up to 10 miles across to the north and east.

Dioritic rocks make up the bulk of the intrusives. Pyroxene, quartz, diorite is a major rock type, and consists of tabular labradorite crystals (An_{60-64}), irregularly-shaped grains of clinopyroxene, and small amounts of interstitial quartz and kaolinized feldspar. Opaque minerals make up 2 percent to 5 percent of the rocks. The rocks are even-grained (hypidiomorphic granular), and are similar in texture to the finer grained varieties of the Yuat intrusives. However, they differ from the microgranodiorite of the Yuat Intrusives in that they contain no hornblende or biotite, have a more basic plagioclase, and contain no pyroxene.

These rocks grade into porphyritic quartz diorite which consists of phenocrysts of andesine (An_{45} (core) to An_{15} (rim)), in a finer-grained groundmass of quartz, ferromagnesian minerals, and small granules of opaque minerals. Hornblende and pyroxene are almost invariably present, while biotite is generally present in subordinate quantities. In rare cases biotite is predominant.

Altered Diorite porphyry is another variant, and consists of phenocrysts of labradorite (An_{50-55}), and pyroxene set in a finely crystalline groundmass of altered feldspar, chlorite, opaque minerals, and commonly epidote. Quartz is absent. There is a leucocratic variety which has no pyroxene.

Basic rocks are an important constituent of the Karawari Intrusives, and they range in composition from pyroxenite to gabbro.

Anorthite gabbro is the most common rock type, and is almost identical to gabbro associated with the April Ultramafites. It has a distinctive gabbroid or granulitic texture, and is composed of anorthite (An_{95-100}), augite partly or wholly altered to hornblende, blebs and aggregates of magnetite, and accessory sphene, apatite, and epidote.

Hornblende gabbro, hornblendite, and pyroxenite phases are common. Many large boulders show evidence of multiple injection and brecciation of several of these rock types, but there is no evidence of their relationship with the intermediate rocks.

Age of intrusion of the Maramuni Diorite

The Karawari Intrusives are known to be at least as young as Lower Miocene, but the Yuat Intrusives could be older.

The Karawari Intrusives have invaded the Lagaip Beds (Lower Miocene, Tertiary e stage), but nowhere are they known to intrude younger rocks. Diorite pebbles in the Karawari Conglomerate (uppermost Lower Miocene, Tertiary f_{1-2} stage), were probably derived from the Karawari Intrusives, thus fixing the intrusion of the Karawari Intrusives as probably Lower Miocene.

The Yuat Intrusives could possibly be older for over most of the region they intrude only Mesozoic rocks. Only the north-western part of the northern batholith is known to intrude Lagaip Beds, and here the rocks are not typical of the Yuat Intrusives, and could possibly belong to the Karawari Intrusives. Of course it could be equally well argued that contamination by the assimilated Lagaip Beds has caused the slightly different composition in this restricted area.

Outcrops in this area are poor and there is little hope that further field work would resolve the problem. Samples will be collected in the 1967 field season for isotopic age determination.

April Ultramafites

Serpentinite and minor anorthite gabbro found in the headwaters of the Wogupmeri River have been named the April Ultramafites. The name is taken from the April River to the west of the map area where a brief reconnaissance in 1966 showed the presence of large intrusions of similar serpentinite. These intrusions will be mapped in detail in 1967.

The April Ultramafites in the map area are exposed as a body over 8 miles long in the middle reaches of the Wogupmeri River, and as several faulted lenses in the headwaters of the Korosameri River which were too small to show on the geological map.

The rocks are enclosed by Lagaip Beds, but no contacts were seen. However, they are much sheared and they include lenses up to several hundred yards across of sheared and recrystallized limestone, and it is suspected that they were emplaced by faulting.

The rocks are almost all serpentinite, which rarely contains relicts of the original rock forming minerals. Thin-section examination shows relict orthopyroxene, clinopyroxene, and olivine, in some of the rocks and it is concluded that they were originally pyroxenite and peridotite. The anorthite gabbro was sampled, but because of poor exposures its relationship to the serpentinite is not known. It has a granulitic texture identical with that of the gabbro in the Karawari Intrusives, and consists of anorthite and pyroxene (orthopyroxene and clinopyroxene) in equal proportions, with a small proportion of opaque minerals. The ferromagnesian minerals are generally partly or wholly serpentinised, and some of the serpentine may be replacing olivine.

The April Ultramafites were probably emplaced at the same time as the Maramuni Diorite in the Lower Miocene.

STRUCTURE

Faulting dominates the structure of the region, and there is evidence that it partly controlled sedimentation as far back as the Upper Cretaceous. The faults are almost invariably straight or slightly curved, and can be traced for very many miles (the Lagaip Fault for instance, has been traced between Wabag and the April River, a distance of about 100 miles). Most of the faults are best termed fault zones, for the total displacement is generally distributed over several faults in a zone several miles wide.

The fault zones are susceptible to erosion, and hence they seldom crop out. Thus their attitude is generally not known, but the fact that their trace is not deflected appreciably by large changes in relief indicates that most are vertical or steeply-dipping.

Jimi Fault

The Jimi Fault is exposed in the Yuat Gorge, and here it forms a zone, at least a quarter of a mile wide, of highly sheared volcanic rocks, cataclasite, and less commonly, mylonite. The foliation produced by the shearing is parallel to the fault (trending north-north-west), and invariably dips within a few degrees of vertical. This fault is assumed to be the north-westerly extension of the Jimi Fault mapped by Dow and Dekker (1964) in the Bismarck Mountains. Though the intervening area has not been mapped, sufficient is known of the area to allow the two extremities to be joined with confidence.

The vertical displacement of the Jimi Fault is reasonably well known, and it forms the northern boundary of the Jimi Horst, an upthrown block which is the only place Triassic rocks are exposed in eastern New Guinea. The displacement in the Bismarck Mountains is estimated at 14,000 feet, downthrow to the north-east (Dow and Dekker). In the Yuat River, the downthrow is of a similar order, but it is probably somewhat less.

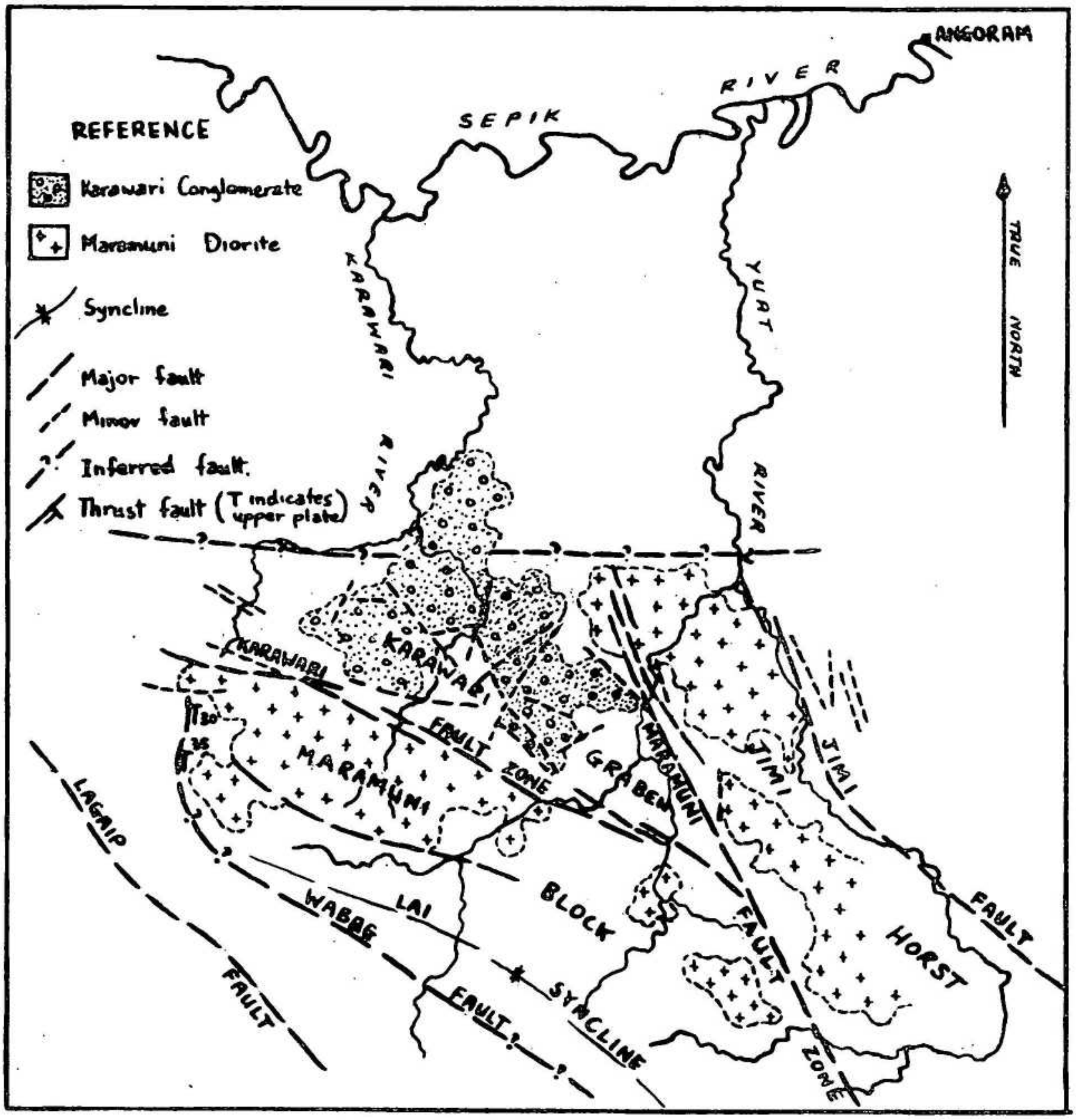
FIGURE 11

STRUCTURAL SKETCH MAP

of part of the

SOUTH SEPIK REGION

0 20 40 Miles



Though the Keram Beds are displaced by the fault, there is some evidence that movement on the fault began before the Beds were laid down, and it appears to have marked the edge of the continental shelf in the Bismarck Mountains during Upper Cretaceous and Lower Tertiary times. Eugeosynclinal sediments of this age were being laid down to the north while shelf sediments were being laid down in the Wahgi Valley to the south (Dow and Dekker). The same relationship between the eugeosynclinal Keram Beds to the north-east, and the Lagaip Beds to the south-west holds in the map area.

Though the vertical displacement on the Jimi Fault can be determined, there is no evidence of any horizontal displacement. However, it is suspected that the horizontal is considerable, and might even be predominant.

Maramuni and Karawari Fault Zones

The Maramuni and Karawari Fault Zones are the north-westerly extension of the Bismarck Fault Zone mapped by Rickwood (1955). These fault zones have broken the western half of the area mapped into two fault blocks: the Karawari Graben on the north, and the Maramuni Block on the south. Unlike the Jimi Fault in which most of the displacement appears to have been confined to one major fault, in the Maramuni and Karawari Fault Zones the movement is distributed over several faults in a zone several miles wide. Most of the faults cannot be traced for their full length, so it is not known if they are distributed en echelon, or whether they are an anastamosing set of faults similar to the Bundi Fault Zone mapped by Dow and Dekker to the east.

The Maramuni Fault Zone forms the south-western boundary of the Jimi Horst, and in the north appears to have a vertical displacement of about 10,000 feet.

The Karawari Graben is a downfaulted block bounded by the two fault zones: it probably formed a restricted basin in late Lower Miocene times in which the Karawari Conglomerate was deposited.

The block south of the Karawari Fault Zone is called the Maramuni Block: it is downfaulted against the Jimi Horst on its south-eastern side, but its north-western extremity is upthrust, exposing a batholith of Maramuni Diorite.

Wabag Fault

The Wabag Fault can be traced from Mount Hagen to the south-east of the map area, to the Burgers Mountains, a distance of about 80 miles. Though the fault has not been seen in outcrop, it stands out on the airphotos as a straight scarp along which evidence of recent movement can be seen, such as the impounding of alluvium in one of the streams draining the south face of the Burgers Mountains. To the south-east, the fault can be seen plainly on the vertical and oblique airphotographs as a marked lineation.

The displacement on the fault is not known; it appears to have a vertical throw of over 5000 feet, but the horizontal movement is not known, even within very broad limits.

The Wabag Fault probably extends northwards to join with a low-dipping fault which forms the western boundary of the Maramuni Block; however, this is not certain as there is a gap in the airphotographs just west of the Burgers Mountains.

The low-dipping fault is well exposed in places between Kasagari and the Korosomeri River (Plate 1), as a zone of at least 100 feet wide, of intensely sheared and mylonitised shale, which dips eastwards at 30° to 35°. This fault is one of very few gently-dipping faults mapped in the Western Highlands of New Guinea, and it is probably a low-angle thrust fault (see later p. 40).

Lagaip Fault

The Lagaip Fault follows the north side of the Lagaip Valley for about 30 miles where it is marked by a zone several hundred feet wide of intensely sheared shale and limestone containing rare lenses of sheared serpentinite. The fault has been traced north-westwards on the airphotographs as a vague lineation, to the lower reaches of the April River (to the west of the map area), where it was seen in outcrop during a brief reconnaissance in 1966. There the fault is very well exposed for a distance of several miles and consists of a zone up to $\frac{1}{4}$ mile wide, of sheared shale and serpentinite, mylonite, and cataclasite. Where seen the shear zone of the Lagaip Fault was within a few degrees of vertical.

The south-eastern extension of the fault is not well exposed, for it traverses an area of low relief, in which only a few low scarps, which are possibly recent fault scarps, can be seen on the airphotographs. Lakes Iviva and Birip, (to the south of the map area) are on the line of the Lagaip Fault, and they have probably been formed by recent movement on the Lagaip Fault.

Inferred Sepik Fault

Schist crops out near the junction of the Wogupmeri and Karawari Rivers, and at isolated localities along the Wogupmeri River. It is also known at widespread localities to the north and west of the map area, and as it is probably pre-Mesozoic basement, its presence can only be explained by the existence of a fault of great vertical displacement near the southern margin of the Sepik Plain.

The vertical displacement on the fault is probably about 20,000 feet, but it may be considerably greater. All this movement must have taken place before the deposition of the Karawari Conglomerate as there is no sign of dislocation in this formation.

Exposures of rocks at plain level are rare, and even these are invariably weathered, so there appears to be little hope of obtaining further information except by geophysical means. A proposal for a regional gravity survey of the Sepik Plain and the South Sepik Region has been put up to the Geophysical Branch of the Bureau for consideration.

Evidence of Horizontal Movement on the Faults

Though there is no direct evidence of horizontal displacement on the faults of the South Sepik Region, their characteristic great lateral extent, straight or slightly curved trace, and steeply-dipping shear zones, all suggest predominantly transcurrent faults. Large transcurrent movements on similar faults have been recognised in other places in New Guinea (Dow and Davies 1964, and Dow and Dekker 1964), but only in places where recent movement has dislocated topographical features. No geological features have been found as points of reference to measure the larger movements which must have taken place.

Thus in the South Sepik Region, any horizontal displacement along the faults is at present conjectural. It is possible that the uplifted western end of the Maramuni Block has been raised to its present position by upriding of the Block on the probable low angle thrust which forms the northern end of the Wabag Fault. Such movement could have been caused by westward movement of the Maramuni Block relative to the rest of the area.

Over most of the area the rocks are only broadly folded, though examination of only the less competent beds would give an erroneous idea of complex folding. Over large areas these rocks are highly contorted, in places because of shearing, but mostly due to the effects of slumping before the beds were consolidated. Incompetent reaction to stress of these finer-grained beds must also have played a part.

The Mesozoic rocks of the Jimi Horst dips consistently to the south-west, generally at about 40°, except near the Jimi Fault where they are highly sheared and steeply dipping. The competent members of the Lagaip Beds such as the Sau Greywacke Member and its equivalents to the north are broadly folded along north-north-westerly-trending axes. The fold axes are horizontal, and the beds dip generally between 20° and 50°.

The younger rocks, the Karawari Conglomerate and the Burgers Formation are very competent units, and they are folded into very shallow basins or synclines. In addition, the Karawari Conglomerate is broken by a great number of block faults rarely exceeding 200 feet vertical displacement.

ECONOMIC GEOLOGY

In view of the difficulty of access of the whole of the map area, there appears to be little hope of finding economic deposits of minerals, expecially those such as base metals in which freight makes up such a large proportion of the cost of winning the metals.

Gold and platinum are the only minerals produced in the map area. Shortly after World War II, N. Rowlands and the two Wilson brothers worked alluvium of the Timun River for poor returns of gold and platinum.

The metals apparently originated in the Maramuni Diorite, which in this area is a very complex mixture of diorite, gabbro, and serpentinite. Only small concentrations of the precious metals were shed directly by the Diorite, but by a fortuitous set of circumstances, they accumulated in thin, rather restricted lake beds near the head of the Timun River. These beds now give only very poor prospects, but the concentrating action of the Timun River and its tributaries has made the recent river gravels worth working. The returns as recorded in the Mines Division, Konedobu, Papua, show that only a few ounces of gold and platinum were produced each month.

In 1959, Dow (1961) discovered gold in the Lamant River, an eastern tributary of the Tarua River. M. Wilson later worked the alluvial flats for several years, but the returns show that little gold was won. Work had ceased by the time the claim was visited in 1966. Gold is being shed over a considerable area, and alluvial mining should afford the local people a good income for a number of years. Dow (1961) recommended prospecting the margins of the intermediate porphyry intrusives of the area for lode gold, and it is considered that the prospects of finding an economic deposit are reasonably good.

Gold is carried by almost all the streams draining the Maramuni Diorite, but none seen offered economic prospects, generally because the amount of gold shedding is very poor, but also because the streams are almost invariably steep. Before World War II a rich gold strike was reported in the Lower Yuat River, and several prospectors visited the area, but no mining was done. Probably as a result of the rumours, the alluvium of the Maramuni River above its junction with the Yuat River was tested by percussion drilling (L. Schmidt pers. comm.), but very little gold was found.

Copper: disseminated copper mineralization was found at several localities in the map area, but none seems worthy of further attention. However, the geological setting of two of the occurrences is sufficiently promising to warrant geochemical prospecting of the two areas.

Both are areas where intermediate or acid plutons intrude basic volcanic rocks, geological circumstances which the senior author considers favourable for the mobilisation and perhaps concentration of the copper contained in the volcanic rocks.

The first locality is in the headwaters of the Clay River, where disseminated chalcopyrite was found in basic igneous rocks of the Keram Beds. Thin-section examination showed that the rocks had been metasomatically altered, probably by a more acidic pluton which is inferred by photo-interpretation 4 miles to the east.

The second locality is in the lower reaches of the Say River, where Dow (1961) found very sparse, disseminated chalcopyrite in granodiorite of the Maramuni Diorite. In this area, the Diorite is inferred to intrude the basic volcanics of the Kondaku Tuff, though no contacts were seen.

Both areas are therefore of interest, but no further work can be done until airphotographs have been taken of the area to the east of the Yuat River.

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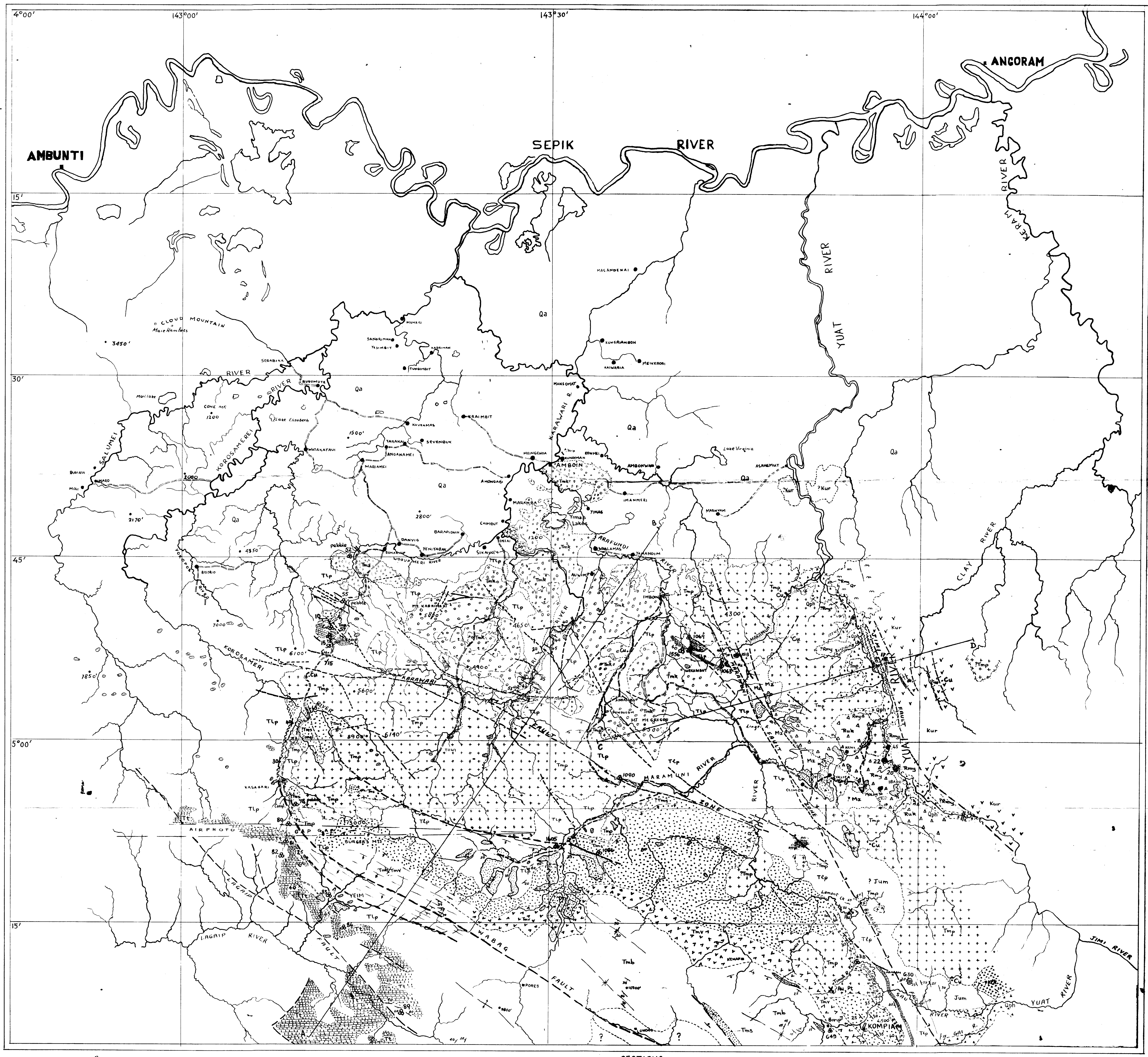

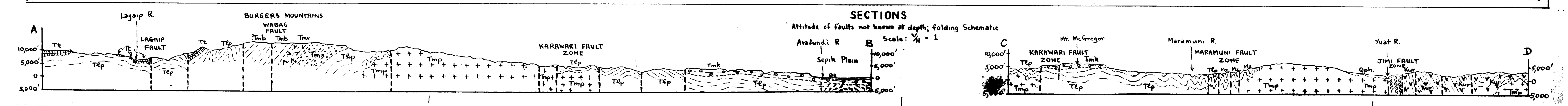

GEOLOGICAL MAP
OF PART OF THE
SOUTH SEPIK REGION
NEW GUINEA

Scale
1 : 250,000

5 0 5 10 15 MILES

Reference

CAINOZOIC	QUATERNARY	RECENT			Qa	*Clay, peat, sand, tuffaceous sand, and some gravel.*
					Qr	*Raised alluvial deposits.*
		PLEISTOCENE?		Hagen Volcanics	Qph	*Volcanic breccia and conglomerate, gravel, minor basalt lava flows.*
	TERTIARY	LOWER TO ?UPPER MIOCENE	f_{1-2} to ?g-stage	Burgers Formation	Tmb	*Greywacke, tuffaceous sandstone, conglomerate.*
				Tarua Volcanic Member	Tmv	*Tuff, agglomerate, pillow lavas.*
		LOWER MIOCENE	f_{1-2} stage	Karawari Conglomerate	Tmk	*Conglomerate, carbonaceous sandstone, basic and intermediate volcanic rocks.*
						Quartz mica schist of unknown age.
		LOWER MIOCENE		Maramuni Diorite	Tmp	*Diorite, granodiorite, intermediate porphyry, gabbro.*
				April Ultramafites	Tma	*Serpentinized pyroxenite and peridotite, anorthite gabbro.*
		UPPER CRETACEOUS TO LOWER MIOCENE		Lagaip Beds	Tlp	*Calcareous siltstone, shale, and sandstone, calcarenite.*
				Sau Greywacke Member	Tms	*Greywacke, siltstone, minor calcarenite.*
						Conglomerate.
				Yeim Limestone Member	Tt	*Calcarenite, marl.*
MEZOZOIC	CRETACEOUS	?UPPER		Keram Beds	Kur	*Basic and intermediate marine volcanics, tuffaceous sediments.*
		LOWER		Kondaku Tuff	Klk	*Basic agglomerate and tuff, tuffaceous sandstone.*
	TRIASSIC OR JURASSIC			Undifferentiated	Mz	*Shale, siltstone.*
	JURASSIC	UPPER		Maril Shale	Jum	*Shale, siltstone, some greywacke and quartz sandstone.*
	TRIASSIC	UPPER		Kana Formation	Ruk	*Tuffaceous sandstone, dacite pebble conglomerate, tuffaceous siltstone.*
		MIDDLE to UPPER		Yuat Beds	Rmy	*Shale, massive greywacke.*

Geological boundary
Anticline
Syncline
Fault
Where location of boundaries, folds and faults is approximate, line is broken, where inferred, queried
Shear zone
40 *Measured strike and dip of strata*
Prevailing strike and dip of strata
Vertical strata
Strike and dip of strata } *air-photo interpretation*
Trend lines } *air-photo interpretation*
Strike and dip of foliation

55 *Macrofossil locality*
1086 *Microfossil locality*

Au *Alluvial workings*
Cu *Minor mineral occurrence*
Au *Gold*
Cu *Copper*
Pt *Platinum*

Limit of navigability to jet boats

Foot track
Ground traverse (no track)
KOMPIAM *Administrative centre (Sub-district Office or Patrol Post)*
IMBOIN *Village*
Gardens and name of community
Airstrip
Helicopter landing site
1330' *Spot height in feet)*

To accompany record 1967/26

B54/A4/1