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BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

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1964/137

THE GEOLOGY OF THE WABAG AREA, NEW GUINEA.

by

F.E.Dekker and I.G.Faulks.

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THE GEOLOGY OF THE WABAG AREA, NEW GUINEA

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SUMMARY

The Wabag area lies about 50 miles north-west of the town of Mount Hagen in the Western Highlands of the Territory of New Guinea. It has a rugged topography, and ranges in altitude from about 3000 feet to 14,000 feet in the Burgers Mountains. The population of the two main valleys of the Lai and Lagaip Rivers is about 120,000. Large parts of the region have an unfavourable climate and topography, and are devoid of settlement.

Access to the area is either by road from Mount Hagen or by air from Mount Hagen or Madang. Travel within the region is best accomplished by four-wheel drive vehicle along the roads in the Lai and Lagaip valleys, but elsewhere traversing must be on foot along poorly defined native tracks. Native-built government rest-houses are common throughout the area. During October, the party used a helicopter to aid the mapping of remote areas in the Lagaip Subdistrict.

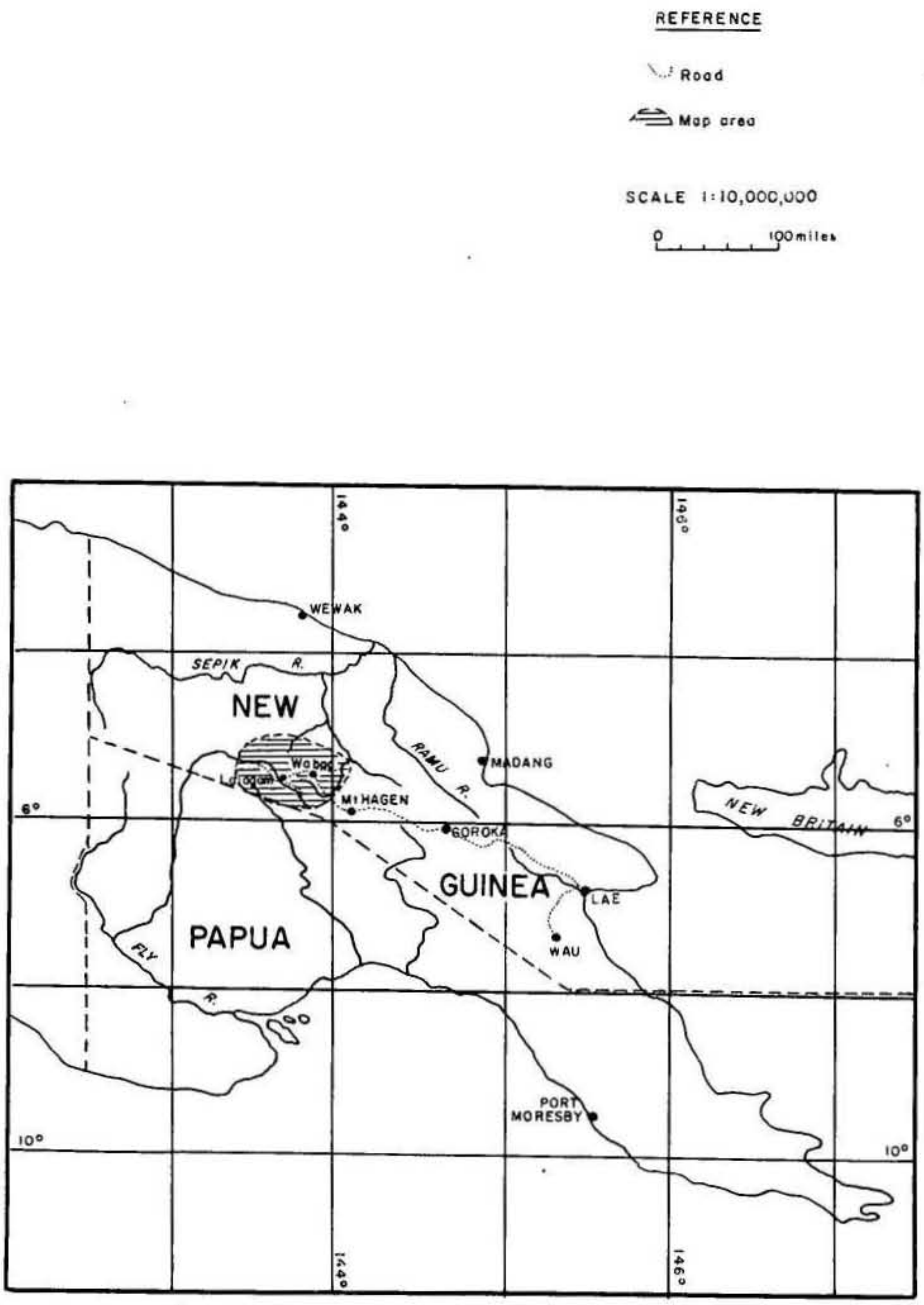
Little is known about the pre-Upper Cretaceous history of the area, and this period is only represented by the Jurassic Labalam Beds and the Lower Cretaceous Kondaku Tuff in the north-eastern corner of the map area.

The widespread marine deposition of the fine-grained clastic Lagaip Beds commenced in the Upper Cretaceous and continued through to the Lower Miocene. The Lower Tertiary is apparently missing in this sequence and probably represents a period of lesser deposition. Probably the Porgera Intrusives, which introduced gold mineralization in black shale in the Porgera Valley, were emplaced during this time. The coarse-grained Sau Beds were deposited during the lower Miocene in both shallow water and trough environments. During the same period the Tibinini Limestone formed in deep water in the south-west.

Late in the lower Miocene volcanic activity and uplift occurred in the north and the basic Tarua Volcanics were probably extruded contemporaneously with the intrusion of the basic to acid Timun Intrusives. The sands and the mud of Burgers Formation were laid down during the dying phase of this vulcanism. The Yangi Beds were deposited in the south-western part of the map area during most of the Miocene.

Uplift late in the Tertiary raised the area to near its present elevation, and was followed shortly afterwards by a period of intense vulcanism during which the Hagen Volcanics were extruded. This vulcanism died out during Recent times. Pleistocene to Recent lake deposits form terraces in the Laigap Valley, and valley fill in many parts of the Yangi Highlands.

Fig. 1



Locality Map

The rocks are gently folded along north-west-trending axes, and are disrupted by strike faulting north of the Lagaip River. Intense folding and faulting has contorted the Lagaip Beds and the Yangi Beds. The regional strike of the area changes at a line drawn roughly diagonally north-eastwards across the map area.

Small alluvial deposits of gold are worked in the Porgera and Timun valleys. The source of the gold in the Porgera Valley is at present being prospected. A reconnaissance stream sediment sampling programme over the area revealed high vanadium counts in the Tarua River. In the Wale-Tarma watershed basic to acidic intrusives, which elsewhere have caused gold mineralization, warrant a more thorough investigation. The area south-west of Laiagam is underlain by folded marine sediments which have a petroleum potential; at present, however, access to the area is difficult.

INTRODUCTION

Most of the Wabag and Lagaip Subdistricts of the Western Highlands, New Guinea, was mapped by a Bureau of Mineral Resources Geological Party between June and November 1963. The party consisted of F.E. Dekker and I.G. Faulks for the first three months of the survey; during October, a helicopter was used to aid the mapping of inaccessible areas in the Lagaip Subdistrict and Messrs. Thompson, Belford, and Horne joined the party for this period.

Results of earlier reconnaissance mapping in the area by Ward (1949) and Dow (1961) are included in this report. Palaeontological age determinations were done by D.J. Belford, and most of the petrography was described by I.G. Faulks. Detailed photo-interpretation on the Yangi Highlands in the south-western corner of the map area was done by J.E. Thompson.

Location

The area mapped during the 1963 field season covers about 3000 square miles between latitudes 5°S and 5°50'S and longitudes 143°E and 144°10'E; it is situated north-west of the town of Mount Hagen, which is the administrative centre of the Western Highlands. The area includes part of the Birap, Magare, Lake Iviva, Yogo, Mount Yangi, Wongum, Burgers Mountains, and Tarua River one-mile sheets. The region straddles the main divide; the Lai, Sau, Tarua and Maramuni Rivers join to form the Yuat River, which flows north into the Sepik Valley, and the Lagaip, Porgera, Andebare, and Wage drain to the Papuan coast in the south.

The area is completely covered by vertical aerial photography, and preliminary detail plots at a scale of 1:50,000 have been produced for most of the area by the Division of National Mapping. In the northern part of the map area uncontrolled compilations of air-photographs were used to complete the map.

Access

The Lae-Mount Hagen Highway extends beyond Mount Hagen into the Wabag and Lagaip Subdistricts, but in this area is suitable for light traffic only. Side roads to mission stations and patrol posts are numerous (see geological map) but are usually only passable to four-wheel-drive vehicles.

All administration posts and most mission stations in the area have airstrips; most of the supplies for European outposts are air-freighted from Madang. Wabag and Wapenamanda have three scheduled air services a week from Madang and Mount Hagen; the other centres are serviced by charter flights. Mission air strips at Yaramanda, Pomokos, Pawari, and Par are for light aircraft only, and prior permission to land must be obtained from the missions controlling the airstrips.

Native tracks and hunting pads are numerous, although these become very rough and ill-defined away from the main centres of population. Remote pockets of population can usually be reached by Administration walking tracks.

Population

The Wabag area supports a native population of about 120,000, most of whom speak the same language. Local variations in dialect are common. The natives in the Porgera Valley speak a different language.

The Lai and Lagaip Valleys are densely populated, but large areas of high elevation to the north and south are completely devoid of people. The district is administered from the Subdistrict offices of Wabag and Laiagam, and from patrol posts at Wapenamanda, Kompiam, and Porgera.

Lutheran, Roman Catholic, Seventh-Day Adventist, Apostolic, and Baptist missionaries have numerous stations throughout the populated valleys.

Industry

The inhabitants of the Wabag area have no local industries. They practise subsistence agriculture, and a small amount of market gardening supervised by the missions. The missions have installed small sawmills to provide timber for their own building requirements.

Small-scale gold mining operations are carried out in the Timun and Porgera Valleys. Messrs. L. and M. Wilson have been mining gold and platinum in the Timun River since 1949 for small returns. Mr. J. Searson holds a lease in the Porgera Valley, and enterprising natives are obtaining good returns from alluvial terraces in this valley.

Climate

The area mapped has an elevation of over 3000 feet, and the weather over most of the region is equable. Days are warm and nights are cold at this altitude, but in country above 8000 feet the climate is generally bleak and unpleasant. The rainfall is high over the whole area, and appears to be heaviest on the Sepik Fall in the north, and on the highlands to the south and south-west of Laiagam. There is no marked dry or wet season, and rain is an almost daily occurrence throughout the year.

Field Methods

The good access roads in the populated areas permitted the extensive use of a long-wheel-base Land-Rover for the positioning and supplying of local base camps. All geological traversing was done on foot; in remote areas, a carrier line of up to twenty natives was employed, and trips of one to two weeks away from base camp were made. During these excursions, food for the carriers was bought locally.

A helicopter was used for access to remote localities during October. Details of the operations are described in a separate report (Dekker, 1964).

Previous Investigations

The first geological investigation of the area was in 1948 by Ward (1949), who made reconnaissance traverses from Wabag to the Porgera and Timun Rivers, primarily to assess the discoveries of gold at these two localities. Rickwood (1955) in 1952 and 1953 extended his mapping of the Wahgi Valley over the Mount Hagen Range into the Lai Valley between Wapenamanda and Pawari. Dow (1961) mapped the country surrounding the Sau River, and his work is included in this report. In 1961, Dr. Bik of the CSIRO Division of Land Research and Regional Survey investigated the geomorphology of most of the Lagaip Subdistrict and the Lai Valley, but, to date, the results of his work have not been published.

PHYSIOGRAPHY

The area mapped lies almost wholly within the western Highlands of New Guinea and ranges in elevation from 3000 to 14,000 feet. It can be subdivided into the following physiographic units: Sepik Fall, Central Range, Lai Valley, Sirunki Highlands, Lagaip Valley, McNicoll Range, Yangi Highlands and Mount Hagen Range (Fig. 4).

The Sepik Fall

The Sepik Fall is the name given to the northern face of the Central Range and includes the watersheds of the Maramuni, Tarua, and Sau Rivers, which eventually join to form the Yuat River flowing into the Sepik Valley to the north of the map area. This region is deeply dissected and extremely rugged. The rivers, rising at approximately 10,000 feet above sea level, fall to less than 3000 feet in a horizontal distance of ten to fifteen miles. Lush rain forest covers this region which has a very high rainfall.

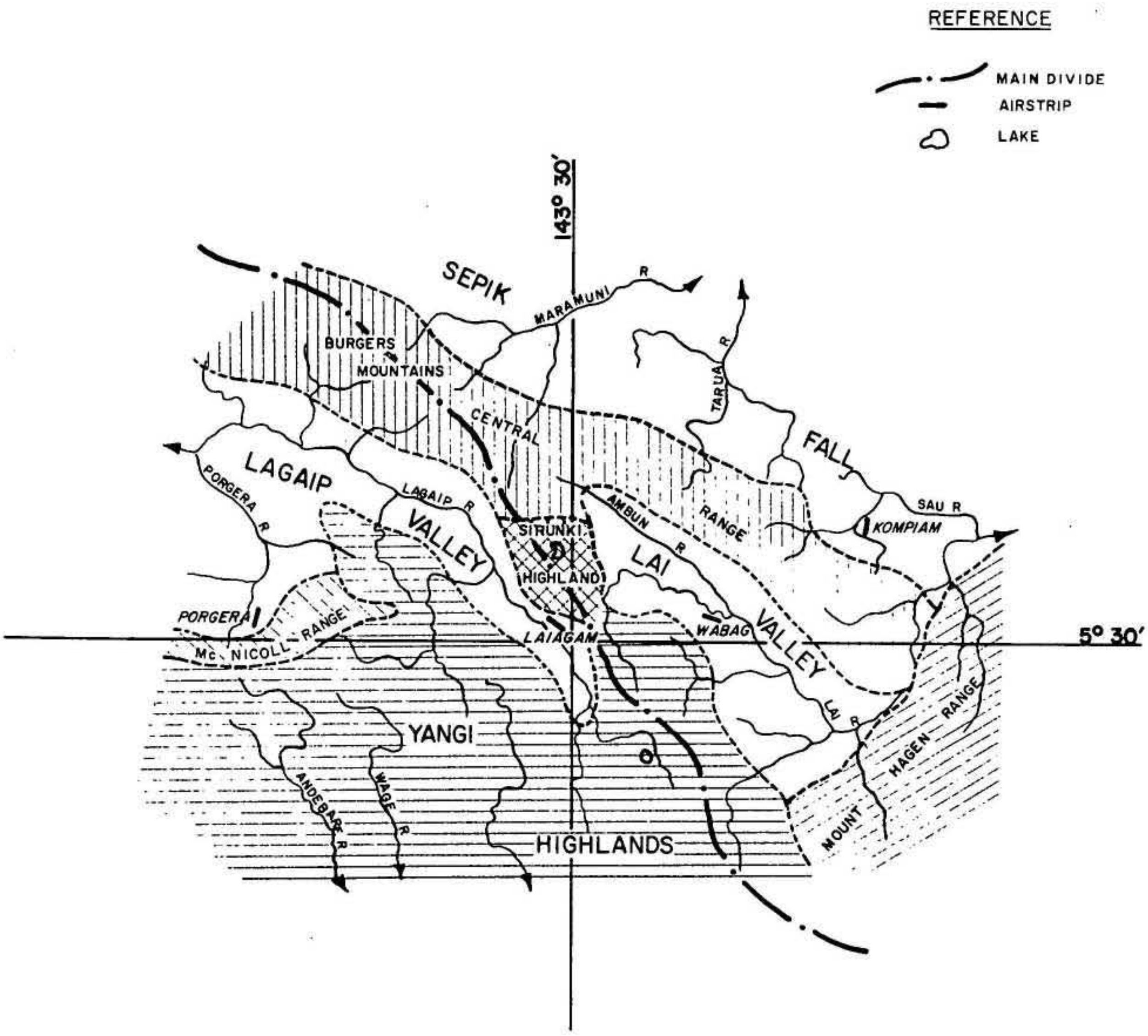
Central Range.

The Central Range is an offshoot of the north-west trending mountain chain which forms the main divide in this part of New Guinea. The range extends westwards from the Lai gorge and culminates in the Burgers Mountains approximately 14,000 feet above sea level about 25 miles north-north-west of Laiagam. The range is underlain by the Lai Syncline; cliffs up to 500 feet high are common along its northern face. North of the Lai Valley, the range consists of a narrow elongated plateau about 10,000 feet above sea level, and it is covered with dense moss forest.

Figure 2: A crater lake about 16 miles south-east of Laiagam

Figure 3: The lower Lagaip Valley looking west from near Muriaga; elevation approximately 6000 ft.

FIG. 4



WABAG AREA T.N.G.

PHYSIOGRAPHIC REGIONS

SCALE 1:1,000,000

10 0 10 20 30 Miles

To accompany Record No 1964/137

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS. FEBRUARY, 1964. B54/A8/5 M.E.N.

Figure 5: Sirunki Swamp near Lake Iviva with the Central Range in the background.

Lai Valley

This large open valley about 30 miles long and 5 miles wide contains most of the population in the area. The Lai River rises on the Sirunki Highland, is joined by the Ambun River at Wabag and thence flows south-eastwards for 16 miles. At Wapenamanda, the river turns at right angles and has cut through the ranges to the north in a deep gorge. The valley is filled with recent subaerial volcanic debris and late deposits, and vegetation consists of grass, 'pit-pit'-a type of reed, and secondary forest growth.

Sirunki Highland

The lowest part of the main divide in the map area is occupied by a small undulating grassy plateau between 8500 and 9000 feet above sea-level. Most of this region is swampy owing to the high rainfall, poor drainage rate and low evaporation (Fig.5). Lake Iviva, also locally known as Sirunki, is crescent-shaped and about one mile in diameter; it drains eastwards into the Lai River. The lake was apparently formed by the disruption of drainage, caused by both warping and the deposition of recent volcanic debris.

Lagaip Valley

The Lagaip and Porgera Rivers, flowing westwards to the Strickland gorge, traverse deeply dissected terrain (Fig.3), except near Laiagam, where the Lagaip River meanders in a narrow valley. Downstream, the river has incised a gorge about 2000 feet deep; dense rain forest covers the steep slopes, and the region is virtually impenetrable.

McNicoll Range

The northern edge of a large highland south of Porgera is rugged limestone country rising to over 12000 feet above sea level and culminating in Mount Kaijende, 5 miles east of Porgera (Fig.11). The northern face of the range has cliffs which fall sheer for more than 2000 feet, and the karst topography within the range is practically impenetrable.

Yangi Highlands

Large highlands covering most of the southern part of the map area range in elevation from 9000 to 11,000 feet. Relief is generally less than 1000 feet; the ridges are overgrown with dense stunted moss forest, the valleys are open and swampy, and support grass on the flanks and reeds in the swamps. Sinkholes, caves, lakes, and underground rivers are common in limestones of this region. The Andebare and Wage Rivers flow in open valleys over the highlands (Fig.7), but cascade through steep gorges off the highlands south of the map area. A crater lake within the highlands 16 miles south-east of Laiagam is about 1½ miles in diameter. The high rainfall and altitude of the highlands result in a cold and often dismal climate. Cold-air flow along the valleys has limited forest growth to the ridge tops.

Fig. 6. Andebare River flowing underground
15 miles south of Porgera.

Fig. 7. Meandering Andebare River on the
Yangi Highlands, looking south-eastwards.

Mount Hagen Range

The Mount Hagen Range is a large complexly dissected Pleistocene volcano which rises to about 13000 feet above sea level. The mountains, which have apparently been glaciated, consist mainly of semi-consolidated deeply eroded ash deposits. Large outwash fans have developed on the flanks of the range in the Lai gorge (Fig.13). The flanks are themselves deeply dissected.

GEOLOGY

A summary of the stratigraphy of the Wabag area is given in Table I.

Little is known about the pre-Upper Cretaceous history of the Wabag area: rocks of this age crop out only in the north-eastern corner of the map area, north of the Bismarck Fault Zone. In this area, the Lower Cretaceous Kondaku Tuff overlies Upper Jurassic sandstones and shales of the Labalam Beds.

Extensive marine deposition of the fine-grained Lagaip Beds commenced in the Wabag area during the Upper Cretaceous, and extended into the lower Miocene. The Beds consist mainly of grey shales and interbedded lenses of limestone. Greywacke, conglomerate and shale of the Sau Beds was deposited soon after in the northern part of the map area. A volcanic epoch accompanied by the basic to acid Timun Intrusive phase led to the extrusion of the basic tuffs and lavas of the Tarua Volcanics late in the Lower Miocene. The greywacke and tuffaceous sandstone of the Burgers Formation were subsequently deposited during the dying phase of the vulcanism. South of the present-day Lagaip Valley, the basinal Yangi Beds accumulated from Paleocene to late Miocene times. These Beds form a thick sequence of mudstone, limestone and sandstone.

A major orogeny during the Pliocene faulted and folded the sediments, and raised the Wabag area to near its present elevation. It was followed by extensive basic terrestial vulcanism from Pleistocene to Recent times.

STRATIGRAPHY

JURASSIC

Labalam Beds (New Name)

Labalam Beds is the unit name proposed by Dow (1961) for Jurassic sandstones and shales which crop out in the north-eastern corner of the map area. They are overlain by Cretaceous Kondaku Tuff to the north-east and are faulted against fine-grained Tertiary sediments in the south.

Dow describes the Labalam Beds as follows:

'Exposures are poor and only a general idea of the succession was obtained. The lower part is composed predominantly of arenaceous sediments, the most common of which is a laminated and thin-bedded quartz sandstone. The rock is indurated and consists predominantly of well-rounded grains of quartz, chert and fine-grained silicified siltstone. This sandstone grades into a distinctive fine-grained intraformational conglomerate which consists of elongated and subrounded

STRATIGRAPHY OF THE WABAG AREA

AGE	FORMATION NAME	LITHOLOGY	THICKNESS	REMARKS
Pleistocene to Recent	Alluvium	Mud, sand, conglomerate, peat		
	Hagen Volcanics	Tuff, agglomerate, basalt		Subaerial lacustrine
Strong uplift with widespread unconformity				
(?)Middle Miocene	Burgers Formation	Greywacke, tuffaceous sandstone	More than 8000 ft.	Shelf deposition
Unconformity in north of map area, Timun Intrusives emplaced				
Lower Miocene	Tarua Volcanics	Tuff, agglomerate, pillow lava	3000 ft.	
	Tibinini Limestone	Limestone	3000 ft.	Deep water deposit
Paleocene to Upper Miocene	Yangi Beds	Mudstone, limestone, sandstone	More than 8000 ft. Probably about 15000 ft.	Basinal beds
(?)Porgera Intrusives emplaced				
Upper Cretaceous to Lower Miocene	Lagaip Beds	Siltstone, shale, limestone, marl, calcarenite.	More than 3000 ft.	Shelf and basin deposition
Upper Cretaceous	Leanda Beds	Mudstone		
Lower Cretaceous	Kondaku Tuff	Basalt, agglomerate, tuff		
Jurassic	Labalam Beds	Sandstone, shale, siltstone.		

siltstone and shale pebbles in a fine sandy matrix. Grey and dark blue shale and siltstone are prominent in this section; they are micaceous, usually phyllitic, and have an incipient slaty cleavage parallel to the bedding. Fossils were found in the shale in one locality.

'Higher in the sequence, shale, siltstone and calcareous siltstone predominate. They are dark grey to dark blue, are indurated and generally phyllitic, and are indistinguishable from the (Tertiary) beds to the south-west.'

Dow recognized fossils of Buchia malayomaorica and Inoceramus from a locality 1½ miles north-east of Labalam, and he thus correllated these sediments with the Jurassic Buchia malayomaorica horizon recorded by Rickwood (1955) in the head of the Wahgi Valley about 30 miles to the south-east. This horizon, however, is predominantly shale with prominent masses of reef limestone, and hence a new name was proposed for the beds in the Wabag area.

CRETACEOUS (LOWER)

Kondaku Tuff

The name Kondaku Tuff was first proposed by Edwards & Glaessner (1953) for Lower Cretaceous volcanic breccia and tuff with interbedded marine sediments which are found in the Wahgi Valley 18 miles to the south-east of the map area. The basaltic volcanic rocks which overlie the Labalam Beds in the north-eastern corner of the area are tentatively correllated with the Kondaku Tuff.

Dow (1961) examined these volcanics near the junction of the Sau and Lai Rivers. At this locality, the volcanics consist of green altered basalt and conglomerate with minor interbedded fine-grained tuff. Contorted and partly assimilated lenses of coarsely crystalline calcite up to two feet wide are a feature of the lava and agglomerate. The volcanics were probably deposited subaerially.

(?)CRETACEOUS (UPPER)

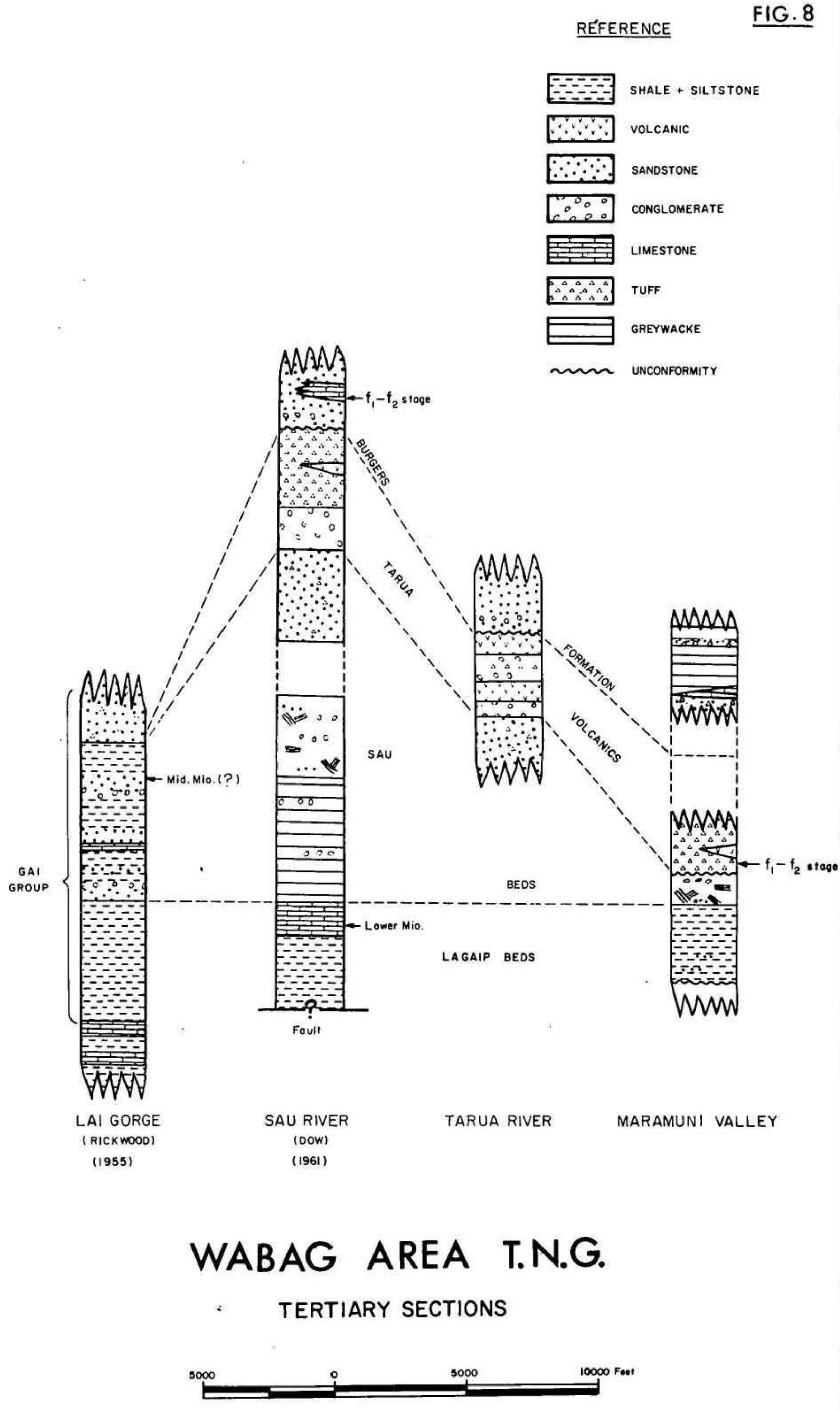
Leanda Beds (New Name)

Brightly coloured, fine-grained sediments found in the Maramuni Valley are here called the Leanda Beds. The rocks crop out in rugged country north of the Maramuni and Leanda Rivers, where they are apparently conformably overlain by siltstone of the Lagaip Beds. The Beds are highly contorted and sheared, and as they were seen only in a few places, no idea of the succession was obtained.

The Beds consist mainly of fine-grained, thin-bedded, green and red calcareous shale containing small lenses of fine-grained limestone up to three inches in length. The Beds are highly sheared along the Leanda River, and contain much calcite veining. Farther west in the headwaters of the Maramuni River, they are tightly folded and well indurated.

The thickness of the Leanda Beds is unknown. No fossils were found, but since they are overlain by the Lagaip Beds which are known to extend from the Upper Cretaceous to the Miocene, they have been given an Upper Cretaceous age, and are tentatively correllated with part of the Upper Cretaceous Chim Group described by Rickwook (1955) in the Wahgi Valley about 100 miles to the south-east.

FIG. 8



WABAG AREA T.N.G.

TERTIARY SECTIONS

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UPPER CRETACEOUS TO LOWER MIOCENE

Lagaip Beds (New Name)

Lagaip Beds is the name proposed for a sequence of fine-grained marine sediments cropping out over a large part of the map area. Deposition of these beds commenced during the Upper Cretaceous and continued well into the Lower Miocene, although sedimentation was apparently not prolific during the Lower Tertiary. The Mesozoic and Tertiary lithologies are indistinguishable in the field and these fine-grained rocks have been mapped as one unit.

The Lagaip Beds crop out in the Lagaip Valley, and also in the Maramumi, Lower Lai, Ambun, and Porgera valleys. They consist mainly of grey calcareous and fine-grained, laminated shale interbedded with lenses of massive to flaggy limestone and small beds of massive friable sandstone. Near Muriaga, highly calcareous shale contains abundant foraminifera of Upper Cretaceous age. Nodules of pyrites up to six inches in diameter are scattered through the shale in this area. In the Yeim area, north of the Lagaip River, large lenses of red and white marly limestone are comparatively resistant to weathering and form an extremely rugged topography in this region. Due to the intense contortion of the sediments along the Lagaip Valley, the succession of the Lagaip Beds in this area was not determined.

In the Porgera Valley, the Lagaip Beds consist of grey to black fine-grained thin-bedded shale with minor interbeds of sandstone and fine conglomerate bands. The beds are strongly folded along north-west-trending axes. They are conformably overlain by the Tertiary $f_1 - f_2$ stage Tibinini Limestone, and are intruded by small dioritic stocks of Tertiary age.

Belemnites found by Ward (1949) date the beds as Upper Cretaceous.

During the lower Miocene, thin-bedded sediments were deposited in a shelf environment in the northern part of the map area. The Lagaip Beds crop out as a north-west trending belt on the 'Sepik Fall', where they dip southwards into the Central Range.

In the Maramuni Valley, south of Biaka Rest House, 3000 feet of fine-grained, thin-bedded, calcareous and micaceous siltstone and coarse-grained, thick-bedded, calcareous grey shale are interbedded, and dip fairly uniformly southwards. Fine unsorted conglomerate bands up to ten feet thick containing well-rounded pebbles of quartz, gabbro and chert in fine-grained, micaceous greywacke matrix, occur locally near the bottom of the beds. At the base of the sequence the siltstone and shale contain small lenticular interbeds of grey crystalline limestone. A transition zone 100 feet thick at the top of the beds consists of thinly interbedded shale and coarse-grained sandstone (Fig. 9). Five miles east of Biaka Rest House, the shale and siltstone are interfingered with coarse sandstone and conglomerate of the overlying Sau Beds. The Lagaip Beds in this region apparently unconformably overlie the Leanda Beds.

Figure 9: Alternating sandstone and shale near the top of the Lagaip Beds in the Maramuni Valley.

Figure 10: Penecontemporaneous slump structures in calcareous mudstone, Porgera Valley.

Dow (1961) estimated the following section of fine-grained marine sediments in the Kompiam area, and named them the Linganas Beds. These sediments have a similar lithology to the Lagaip Beds, and they have been included in this unit.

TOP

350 ft.	Shale, siltstone, calcareous siltstone fine-grained greywacke.
700 ft.	Foraminiferal calcarenite
4500 ft.	Siltstone, shale, fine-grained calcareous greywacke, calcareous siltstone.

BOTTOM

They crop out as a narrow south-east-trending belt, turning south near the Lai River where the beds form the lowermost member of the sequence in the Lai Syncline. The beds are apparently faulted against Jurassic rocks to the north.

The beds below the calcarenite are mainly blue to dark grey micaceous siltstone and shale. They are indurated, have incipient slaty cleavage, and grade into phyllitic siltstone. Calcareous sediments are not common, but dark-coloured calcareous siltstone and fine-grained calcareous greywacke were seen. The beds are generally massive but thin-bedding and laminations are not rare.

In the Lamant River the beds below the calcarenite differ slightly from those near Linganas. Regular bedding, both laminated and thin-bedded, is more common and in addition colour-banding up to ½ inch wide in alternating light and dark grey bands is common. In this area quartz veins and pyrite mineralization occurs as joint linings and disseminated crystals near the porphyry intrusion.

The foraminiferal calcarenite is invariably fine-grained and massive and consists of rounded grains of calcite with abundant small pelagic foraminifera and subrounded shell fragments cemented by interstitial calcite. The bed is resistant to erosion and forms a prominent scarp throughout the area from near Pawari to the Lamant River where it lenses out. South of Pawari the bed becomes discontinuous, and is represented by large lenses of reef limestone.

Above the calcarenite, the shale, and siltstone are similar to the underlying beds, but contain bands of fine-grained dark-coloured greywacke up to four feet thick.

The calcarenite was mapped by Rickwood (1955) in the Lai gorge four miles south of Pawari, as a correlative of the Eocene Nebilyer limestone. Diagnostic lower Miocene foraminifera were found in a lens of limestone which is believed to be in the same stratigraphical position.

The Lagaip Beds on the southern side of the Central Range crop out in the Ambun River. Here, the beds consist of calcareous, thick-bedded shale and fine-grained siltstone, commonly with layers of calcite up to ¼" thick along the bedding planes. The beds are well-folded along north-west-trending axes.

The lithology of the Lagaip Beds is remarkably similar to that of the Asai Beds (Dow & Dekker, 1964) which crop out 100 miles east of the map area. The two units were deposited from Upper Cretaceous to lower Miocene times. The Asai Beds are incorporated in a zone of intense shearing, and they have been metamorphosed, whereas the Lagaip Beds have not suffered such a degree of alteration. The two units are correlated on a basis of their similar lithologies. Highly calcareous shale in the headwaters of the Lagaip River may be correlatives of the Mango Marls (Rickwood, 1955) from the Mendi area.

PALEOCENE TO MIOCENE

Yangi Beds

The Yangi Highlands in the south-western corner of the map area are underlain by a thick, strongly-folded sequence of basinal sediments ranging from Paleocene to Miocene in age. These sediments have here been called the Yangi Beds. The Yangi Beds probably conformably overlie the Lagaip Beds; they apparently interfinger with the Tibinini Limestone, and are unconformably overlain by Pleistocene terrestial volcanics.

In the McNicoll Range south of Porgera, thick limestone beds containing chert are interbedded with calcareous shale. Grey friable sandstone containing carbonaceous plant remains also contains thin interbeds of shale. Further to the south in the headwaters of the Andebare River, at least 8000 feet of interbedded mud, silt, sand, and chalk were measured. These sediments are exceedingly rich in foraminiferal remains. The chalky limestone has a distinctly fetid odour although on analysis, it was found to contain no hydrocarbons. The measured section in the Andebare River area apparently is not faulted and the total sedimentary sequence in this region is about 15,000 feet thick.

A reliable estimate of the thickness of the succession could not be made in the time available because of the extremely complicated tectonics in the area, and the lack of stratigraphic marker beds.

The Yangi Beds have a complicated structure and have been overfolded and thrust-faulted. South of the Porgera Valley, the beds display the regional west-north-west strike, but to the south-east the regional strike changes direction by almost ninety degrees.

Two distinct faunas, one of probable Paleocene age and the other lower Miocene, have been recognized from the Yangi Beds. These faunas are found in similar lithologies and the Yangi Beds have thus not been differentiated, and have been tentatively assigned a Paleocene to Miocene age. No Oligocene fauna have been recorded and it is therefore very likely that the area was emergent during this time as was most of the Papuan Basin to the south.

LOWER MIOCENE

Sau Beds (New Name)

The Sau Beds are a sequence of arenaceous marine sediments deposited over a large part of the Wabag area during the lower Miocene. The beds crop out in the Lai and Lagaip Valleys, and as a north-west trending belt on the northern face of the Central Range. Rickwood (1955) included these rocks in his Gai Group, and Dow (1961) described the sequence in the Kompiam area and named them the Kompiam Beds. To avoid confusion with the Kompiai Beds of the Bismarck Mountains (Dow & Dekker, 1964) the name has been changed to Sau Beds.

The section between Linganas and the overlying Tarua Volcanics near Kompiam was estimated by Dow (1961) from aerial photographs, and is given below:

Top

3500 feet Dark grey and blue, highly indurated, greywacke and tuffaceous sandstone which grades into water-laid tuff near the top. The most common rock type consists of subangular fragments of basic igneous rocks, feldspar, and ferromagnesian minerals chaotically dispersed in a fine-grained tuffaceous matrix. These beds range in grainsize from thin-bedded to massive and are interbedded with laminated and thin-bedded siltstone, which comprises about one third of the sequence. Small lenses of argillaceous limestone up to 30 feet thick containing gastropods, bryozoa, and foraminifera are common in this member near Kompiam.

2000 feet This interval is poorly exposed on the line of traverse. It consists mainly of arenaceous sediments similar to the above, intruded by many gabbro and dolerite dykes.

3000 feet Mainly conglomerate, with well-rounded pebbles of greywacke, siltstone, and quartz, in a sandstone matrix. Claystone and peaty siltstone containing wood fragments and other carbonised vegetable matter, which comprise nearly half this interval, are regarded as terrestrial beds.

5000 feet Mainly thick-bedded, coarse to medium-grained greywacke with thin interbeds of shale and siltstone. The greywacke is dark coloured and consists of subrounded fragments of greywacke siltstone, chert, and quartz in a fine-grained siltstone matrix. Thick conglomerate lenses are common and consist of schist, quartz, greywacke, and siltstone, in a sandstone matrix.

Bottom

A sequence of coarse-grained sediments conformably overlies the Lagaip Beds south of Biaka Rest House. A transition zone between the two units is 1200 feet thick and consists of alternating beds of shale and sandstone. The beds are overlain unconformably by tuff and basalt of the Tarua Volcanics, and they are hence correlated with the Sau Beds. The sequence consists of 1000 feet of coarse-grained, thin-bedded to massive, blue micaceous sandstone containing scattered conglomerate bands with well-rounded components. Minor beds of fine-grained greywacke, which are indurated in places, occur in the sequence. In places the sandstone is cross-bedded, and poor plant remains are commonly found. The lithology of the Sau Beds in this area suggests a nearby coastline during their deposition.

North of the Lagaip River near Muriaga, coarse-grained thin-bedded greywacke is interbedded with calcareous shale, fine-grained blue sandstone and fine unsorted conglomerate bands containing well-rounded pebbles of quartz, chert, and shale. The beds are predominantly micaceous. Ripple marks, cross-bedding, and worm tracks indicate shallow water environment. In this area the beds are unconformably overlain by coarse-grained, feldspathic sandstone of the Burgers Formation.

The Lai Valley is apparently underlain by a faulted asymmetrical syncline of the Sau Beds. In the southern limb, the Sau Beds conformably overlie calcareous grey shale correlated with the Lagaip Beds, and on the northern side of the valley, they are unconformably overlain by the Burgers Formation.

The Tarua Volcanics immediately overlying the Sau Beds in the Maramuni Valley have been dated as Tertiary $f_1 - f_2$ stage, and lenses of limestone in the older Lagaip Beds in the Lai gorge also contain lower Miocene fossils. The faunal content of the Sau Beds suggests that they were deposited contemporaneously with the Tibinini Limestone, although the lithologies of these two units, which are less than 10 miles apart, are completely different. The explanation proposed is that the Tibinini Limestone was deposited considerably farther south, and that compression across the present-day Lagaip Valley brought the two units into such close proximity.

<u>Tibinini Limestone (New Name)</u>

The Porgera Valley is bounded on its southern and eastern sides by spectacular limestone cliffs of the Tibinini Limestone (Fig. 11). This unit underlies the rugged karst topography of the McNicoll Range immediately to the south. Outcrops of the limestone are in inaccessible country. Floaters found at the base of the cliffs, features observed from a distance, and photo-interpretation form the basis for this description.

The Tibinini Limestone consists of about 3000 feet of thick-bedded, fine-grained, grey-white limestone with highly fossiliferous chalky bands. It was probably deposited in a deep-water environment. The limestone conformably overlies grey calcareous and black shale of the Lagaip Beds in the Porgera Valley, but its relationships with the older units along the Lagaip Valley are uncertain. To the south of the McNicoll Range, the limestone apparently interfingers with and is overlain by mudstone and sandstone of the Yangi Beds. A thin transition zone between the Tibinini Limestone and the underlying Lagaip Beds consists of grey-green, fine-grained marl and limestone and marks the bottom of the Tibinini Limestone in the Porgera Valley.

Dr. Bik of the CSIRO Land Research and Regional Survey collected two samples of limestone from boulders at the base of cliffs in the Porgera Valley. Fossils in these specimens were identified as being of the Tertiary $f_1 - f_2$ stage. An outcrop of marl on the Timandan-Tibinini track sampled by Bik yielded middle to upper Miocene microfossils. This latter specimen is believed to have come from below the Limestone. During the present survey, lower Miocene foraminifera were recognized in a floater of limestone. Since the Lower Tertiary is apparently only very poorly preserved in this part of New Guinea (Australian Petroleum Company, 1961) a lower Miocene age has been postulated for the Tibinini Limestone.

Tarua Volcanics (New Name)

Tarua Volcanics is the name proposed for a sequence of predominantly submarine basic volcanics cropping out along the "Sepik Fault". The name is derived from the Tarua River at approximately 143°47' and 5°15'S, where these volcanics are well developed. In the Kompiam area, Dow (1961) included these volcanics at the top of his Kompiam Beds.

The volcanics generally conformably overlie the Sau Beds, but a small angular unconformity separates the two units in the Maramuni Valley. The Burgers Formation unconformably overlies the volcanics, and basic to acid plutonic rocks of the Timun Intrusives intrude the sequence in the Wale River.

The Tarua Volcanics crop out on the northern limb of the Lai Syncline and form a continuous belt from the Ninimb River in the east to west of the Burgers Mountains. The volcanics are missing on the southern side of the Lai Syncline and have probably been removed by faulting and erosion, prior to deposition of the Burgers Formation in this area. The topography along the outcrop is extremely rugged.

The section found in the type locality at the head of the Tarua River is as follows:

Top

Thickness	Description
750 feet	Coarse-grained olivine basalt containing phenocrysts of feldspar and interbedded with small lenses of tuff.
1000 feet	Coarse to medium-grained thick-bedded tuff, with minor conglomerate and agglomerate.
750 feet	Basaltic pillow lava and agglomerate.
±500 feet	Massive unsorted conglomerate containing rounded to subrounded boulders and cobbles of basic volcanics, and intrusives with a coarse-grained indurated matrix. Minor sandstone and agglomerate.

Bottom

Figure 11: Cliffs of Tibinini Limestone in the Porgera Valley. Mount Kaijende in background.

Dow (1961) observed the following section near Kompiam and estimated the thicknesses from aerial photographs.

Top

Thickness	Description
3000 feet	Mainly basaltic lava, tuff, and agglomerate. The agglomerate contains angular fragments of basalt and andesite up to 2 feet across in a tuff matrix; it grades into a coarse-grained boulder conglomerate with subrounded basalt boulders and cobbles in a tuffaceous matrix.
1500 feet	Mainly dark-coloured indurated conglomerate with subrounded to rounded basalt cobbles and boulders in a tuffaceous matrix. The conglomerate grades into subordinate fine-grained basalt agglomerate.

Bottom

At the head of the Maramuni River below the Burgers Mountains, 1500 feet of the bottom part of the sequence consists of coarse-grained purple crystal tuff, green olivine basalt, blue indurated agglomerate, and minor fine-grained indurated grey mudstone and coral-rich tuff beds. Thin interbeds of blue tuffaceous sandstone are ripple-marked, and minor local unconformities are present in the sequence. The full thickness of the volcanics here is estimated to be about 5000 feet.

The volcanics represent a line of shallow submarine and subaerial offshore volcanic activity similar to that found on the northern shore of New Guinea today.

Fossils at the bottom of the Tarua Volcanics in the Maramuni Valley were dated as Tertiary f_1- f_2 stage. Tertiary f_1-f_2 stage fossils were recognized near the bottom of the Burgers Formation in the Sau Valley and thus the volcanics appear to be wholly limited to the upper half of the lower Miocene. (Sample locality F 329).

(?)MIDDLE MIOCENE

Burgers Formation (New Name)

The name, Birip Beds was proposed by Dow (1961) for shallow water, off-shore sediments lying in the Lai Syncline. However, because the beds are poorly exposed near Birip, and a good section of these rocks was mapped in the Burgers Mountains, the alternative name, Burgers Formation is proposed and this has been nominated as the type locality.

The Formation crops out as a north-west trending belt in the high and inaccessible country of the Central Range.

The Burgers Formation is generally unconformably underlain by the Tarua Volcanics, but in the east near the Lai gorge, both the volcanics and the older Sau Beds are not represented, and the Formation unconformably overlies the Lagaip Beds. The top of the Formation was not observed at any locality, but the rocks are covered by a thin layer of Pleistocene volcanics in the Sau Valley.

The section, partly measured and partly estimated from air-photographs in the Burgers Mountains is as follows:

Top

4000 feet±	Estimated thin-bedded micacecus greywacke containing shelly bands.
500 feet	Coarse-grained tuffaceous sandstone, conglomerate and coral beds.
1000 feet	Fine-grained micaceous greywacke.
300 feet	Grey reef limestone
2000 feet±	Coarse-grained blue tuffaceous sandstone

Bottom

The upper part of the Formation consists predominantly of thin-bedded, medium-grained, micaceous friable greywacke containing calcareous horizons rich in badly preserved fossils. The greywacke is immediately underlain by a zone of coarse-grained, tuffaceous sandstone, conglomerate and coral beds. The conglomerate contains large well-rounded boulders of basic intrusives and volcanics set in a coarse, tuffaceous, sandstone matrix. Coarse-grained, cross-bedded, tuffaceous sandstone containing a large percentage of ferromagnesian minerals comprises the lowest part of the Formation. Beds of reef limestone and tuffaceous sandstone rich in coral, bryozoan and molluscan fragments are common in this section. The sandstone forms a prominent scarp along the face of the Central range.

In the Kompiam area, conglomerate is predominant in the upper part of the Formation, and is interbedded with thin shale and siltstone. The conglomerate is indurated, and consists of well-rounded cobbles and boulders of andesite and basalt in a dark sandy matrix. Some clay beds with silicified wood, and limonitic horizons which could be old lateritic profiles, were seen in the uppermost beds. These beds suggest terrestial conditions during deposition.

The lower part of the Formation includes argillaceous sandstone, argillaceous calcarenite, and minor conglomerate. The sandstone is generally light-coloured, friable, and consists of well-rounded quartz grains in an argillaceous matrix, but it ranges considerably from a black calcareous, argillaceous sandstone, to a cleaner and better sorted sandstone. The calcarenite is coloured light cream and is composed of shell fragments in a marly matrix. The conglomerate consists of well-rounded pebbles and cobbles of andesite in a sandstone matrix. Gypsum nodules and patches are fairly common in the fine-grained sediments.

The Burgers Formation is uniformly folded along north-west trending axes: dips are seldom steeper than 60° and there is no apparent overfolding. In the Burgers Mountains, the thickness of the Formation is estimated at about 8000 ft. Dow (1961) estimated a thickness of at least 2500 feet in the Kompiam area, and the presence of terrestial deposits in this area can account for thinness of the Formation here.

The deposition of the Burgers Formation is regarded as having taken place in a shallow-water, off-shore environment. The vulcanicity represented by the underlying Tarua Volcanics was in its dying phase during this time.

Part of the intensely folded Yangi Beds consisting of deep-water mudstone and limestone to the south of the Lagaip River is regarded as the time equivalent of the Burgers Formation. Near Kompiam, a lens of limestone 800 feet above the bottom of the Formation yielded fossils of Tertiary $f_1 - f_2$ stage. Miocene forams were also recognized in the type section. The Burgers Formation is thus considered to be of middle Miocene age.

PLEISTOCENE TO RECENT

Hagen Volcanics

Ward (1949) referred loosely to outcrops of basalt, agglomerate, and volcanic ash on the Lai River as the 'Mount Hagen Volcanics'. Dow (1961) proposed the name 'Hagen Volcanics' for the volcanic material deposited over a large part of the Wabag area. The name is derived from the Mount Hagen Range, which lies on the eastern margin of the map area and consists almost entirely of these rocks.

The Hagen Volcanics were deposited on an extremely rugged land-surface which was underlain by strongly folded Tertiary marine sediments. Large areas of the volcanics have been stripped off and the pre-volcanic topography has been exposed.

The volcanic detritus of the Mount Hagen Range apparently blocked the Lai River below Wapenamanda, and created shallow lakes and swamps along the Lai Valley upstream from this locality. Several small foci of eruption appeared here late in the vulcanism, and material from these vents was deposited both subaerially and in lakes in the valley. A similar environment existed in the Tichak valley. Small isolated volcanoes at Kompiam, Linganas, and Kepilam, and larger centres at the head of the Lai River east of Laiagam, and 16 miles south-east of Laiagam (Fig.1) are believed to have appeared late in the volcanic epoch. Ward (1949) mentioned outcrops of andesite and basalt in the Timun River, and numerous boulders of tuffs, agglomerate, and breccia in the Porgera Valley. The former occurrence belongs to the Taruu Volcanics of lower Miocene age, but no volcanic rocks were found in the Porgera Valley during the present survey.

The larger portion of material extruded during this epoch was clastic and resulted in unconsolidated ash and interbedded basaltic agglomerate. The ash is generally buff-coloured, has a variable grainsize and degree of sorting, and was predominantly subaerially deposited. Cross-bedding, cut and fill structures, and graded bedding are common; and contorted bedding and minor faulting indicate penecontemporaneous slumping. Both lateral and vertical grading of the ash was observed.

Blocks of lava and bombs are numerous throughout the deposits, and range in size from inches to 20 feet in diameter. The larger ones show columnar jointing perpendicular to the surface of the bomb. Pieces of wood and plant fragments are abundantly scattered throughout the ash at certain localities.

Basaltic agglomerate, interbedded with the ash deposits near the centres of vulcanism, consists of large angular to subangular fragments of basalt with lesser sandstone and shale chaotically set in a coarse-grained unsorted matrix. Piedmont aprons of the Mount Hagen Range contain mostly angular volcanic detritus which ranges from true conglomerate to redistributed outwash deposits.

In the Lai Valley, thin interbeds of flat-lying, unconsolidated black carbonaceous mudstone occur at random in the ash deposits, and indicate periods of relative volcanic quiescence during which lakes formed. Their bedding is slightly undulating. Small coarse-grained sandy bands and fine conglomerate contain angular pebbles of shale and sandstone up to 3 inches in diameter. These probably represent stream outlets into the Lai Valley basin during the Pleistocene epoch.

Lava flows are common throughout the ash deposits. They display strong columnar jointing and are usually less than 100 feet thick. In the Mount Hagen Range, some flows are conformable with the slope of the piedmont aprons; this shows that the volcano was still active during the deposition of the aprons.

The lava is generally a porphyritic olivine basalt which can contain as much as 80 percent feldspar. Phenocrysts of olivine and augite comprise up to 40 percent and 15 percent respectively, and magnetite and apatite occur as accessory minerals.

Rickwood (1955) and Dow (1961) both regarded the Hagen Volcanics as being of Pleistocene age on the evidence of the glaciation and deep dissection of Mount Hagen. Small cones found by the writers were almost unaffected by erosion, and it is believed that the vulcanism commenced during the Pleistocene and died out in Recent time.

Small thermal springs at the head of the Ambim River and near Taramanda are the present-day remnants of this volcanic epoch.

<u>Alluvium</u>

In spite of the highly dissected topography and youthful drainage of the region, alluvial flood-plain deposits are found in the Wabag area.

The large alluvial plain of the Lower Lai and Jimi Rivers, part of which was seen in the north-eastern corner of the map area, has resulted from the accumulation of volcanic detritus from the Mount Hagen Range in late Pleistocene time. In the map area, the alluvium consists mainly of boulders of basalt in a matrix of redistributed tuff. Rare boulders of limestone and other sedimentary rocks occur. This alluvium ranges considerably in thickness, but seems to have a maximum of about 1000 feet.

A mature river profile in the Lagaip Valley near Laiagam resulted in the deposition of a large amount of debris under marshy conditions in the valley. The alluvium here consists mainly of thin-bedded, blue and red, poorly consolidated mudstone, with discontinuous beds, up to one foot thick, of laminated brown coal and peat. Medium-grained sand with thin lateritic horizons up to one inch thick are interbedded. Near the edges of the depositional basin, the beds become coarser and consist of well-sorted gravel containing rounded pebbles of quartz in a sandy matrix, and unconsolidated blue cross-bedded, fine-grained sandstone containing plant remains and small mudstone layers. The beds are generally horizontal although they are locally tilted at angles of 30 degrees.

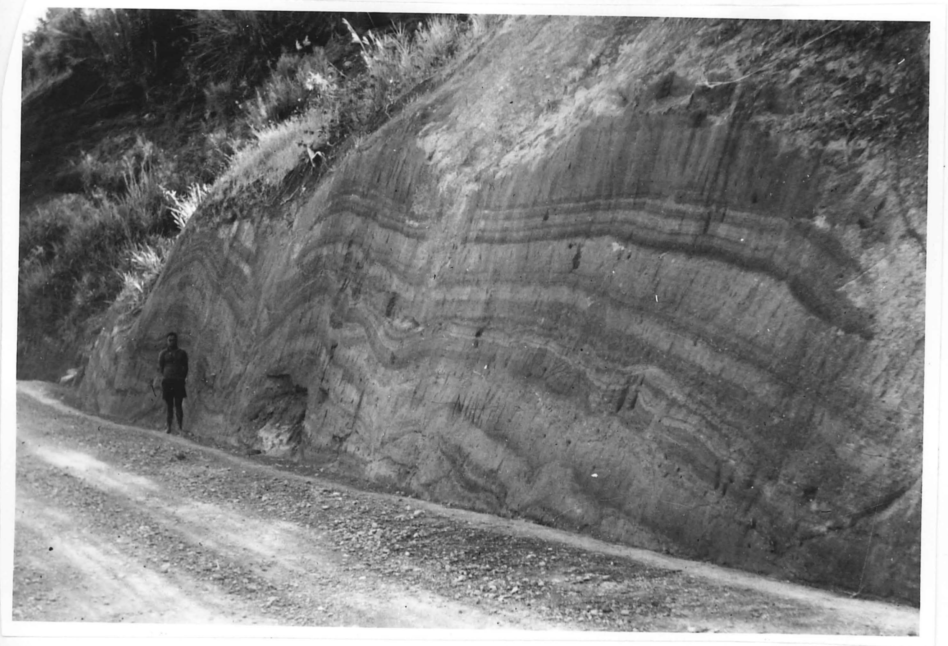


Figure 12: Subaerially deposited Hagen Volcanics in the Lai Valley

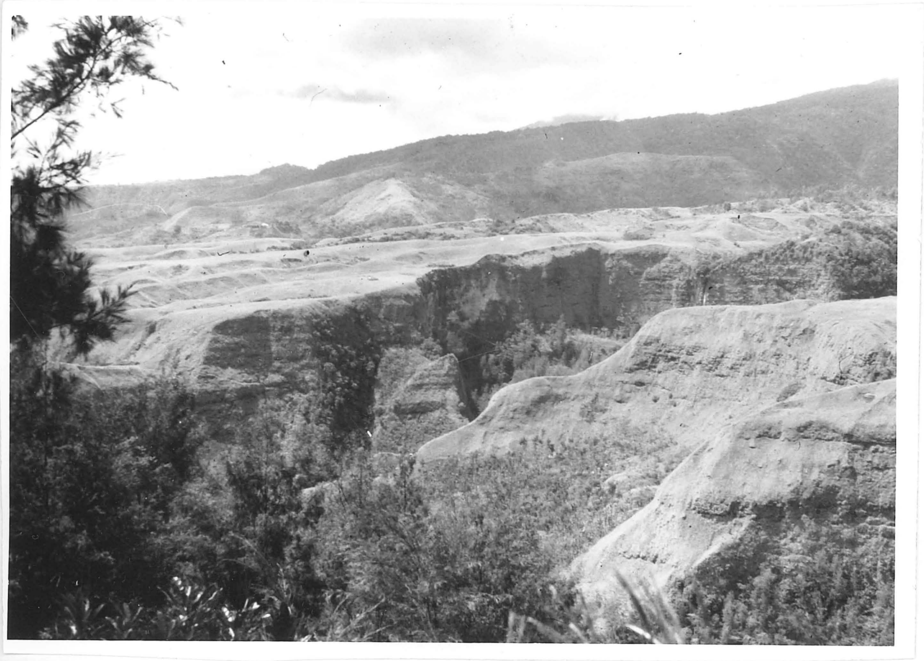


Figure 13: Deeply dissected outwash fans on the flanks of the Mount Hagen Range. Lai Gorge in foreground.

Upstream from Laiagam, the probable collapse of a limestone tunnel dammed the Lagaip River near Kepilam. Lacustrine deposits up to 200 feet thick were deposited on a well-dissected land-surface. The beds consist of ill-sorted fine conglomerate containing angular to rounded pebbles of shale, quartz and sandstone, and interbedded with poorly consolidated sandstone commonly stained by iron-rich solutions. Thin beds of brown mudstone are interbedded with sandstone and have been deformed by repeated minor faulting and folding due to slumping.

In the Maramuni Valley, the blocking of the Leanda River by movement on a fault, and of the Sui River by a probable landslide resulted in small chaotic deposits of angular to rounded boulders up to 20 feet in diameter, with small horizons of poorly consolidated thin-bedded, fine to coarse-grained sandstone and mudstone containing plant remains.

A swampy environment around Lake Iviva, and badly drained patches of grassland on the Yangi Highlands are leading to the accumulation of similar deposits to those found near Laiagam. The flat open valleys on the Yangi Highlands probably contained lakes until recently, when they were emptied by the rejuvenated drainage.

INTRUSIVE ROCKS

LOWER TERTIARY(?)

Porgera Intrusives

A number of small, irregular stocks and dykes of intermediate position intrude black Upper Cretaceous shale in the Porgera Valley about one mile west of the Patrol Post. The shale has been mineralized, and gold is shedding from stockworks of quartz veins in the country rock.

The most predominent rock type is a porphyritic micro-diorite. Minor differentiates of monzonite and soda trachyte occur at random. The rocks consist of phenocrysts of plagioclase, basaltic hornblende, and diopsitic augite set in a groundmass consisting predominantly of feldspar. Quartz generally forms a minor constituent of the rocks, and apatite, sphene, iron oxides, and zeolites occur as accessory minerals. The intrusions are generally highly altered; epidote, sericite, biotite, and chlorite are common constituents of most of the rocks.

The intruded shale apparently ranges in age from Upper Cretaceous to lower Miocene. The intrusives were not seen in contact with the lower Miocene Tibinini Limestone, and therefore it is possible that intrusion occurred before deposition of this unit. Rickwood (1955) states that 'The Pliocene intrusions of the Western Highlands may be responsible for the mineralization of the parent rocks of the gold-bearing alluvials in the Kuta area'. The rocks described by Rickwood, the Ga Intrusives, have a wide range in composition and probably represent a different phase of intrusion. The Porgera Intrusives are thus tentatively dated as Lower Tertiary. Although they are nowhere found intruding rocks younger than Mesozoic, the Intrusives may have been emplaced as late as the Pliocene.

LOWER MIOCENE

Timun Intrusives

The name Timun Intrusives was proposed by Dow (1961) for predominantly basic igneous rocks which intrude Miocene and older sediments north of the Lai River. The name is derived from the Timun River near Kompiam, where an irregular, igneous body 14 miles long by 6 miles wide intrudes the lower Miocene Sau Beds and the overlying Tarua Volcanics. The term is here used to include the intrusions described by Dow in the Kompiam area, together with dykes which crop out in the Sau River (and are too small to be represented graphically), small intermediate intrusions along the divide between the Lai and Tchak Valleys, and rare small sills in the Maramuni Valley.

The intrusion in the Timun River consists mainly of basic rocks and ranges in composition from olivine dolerite and gabbro with minor serpentinite, to granodiorite. The granodiorite grades to medium-grained diorite and constitutes about one third of the intrusion. Some andesite porphyry also occurs rarely.

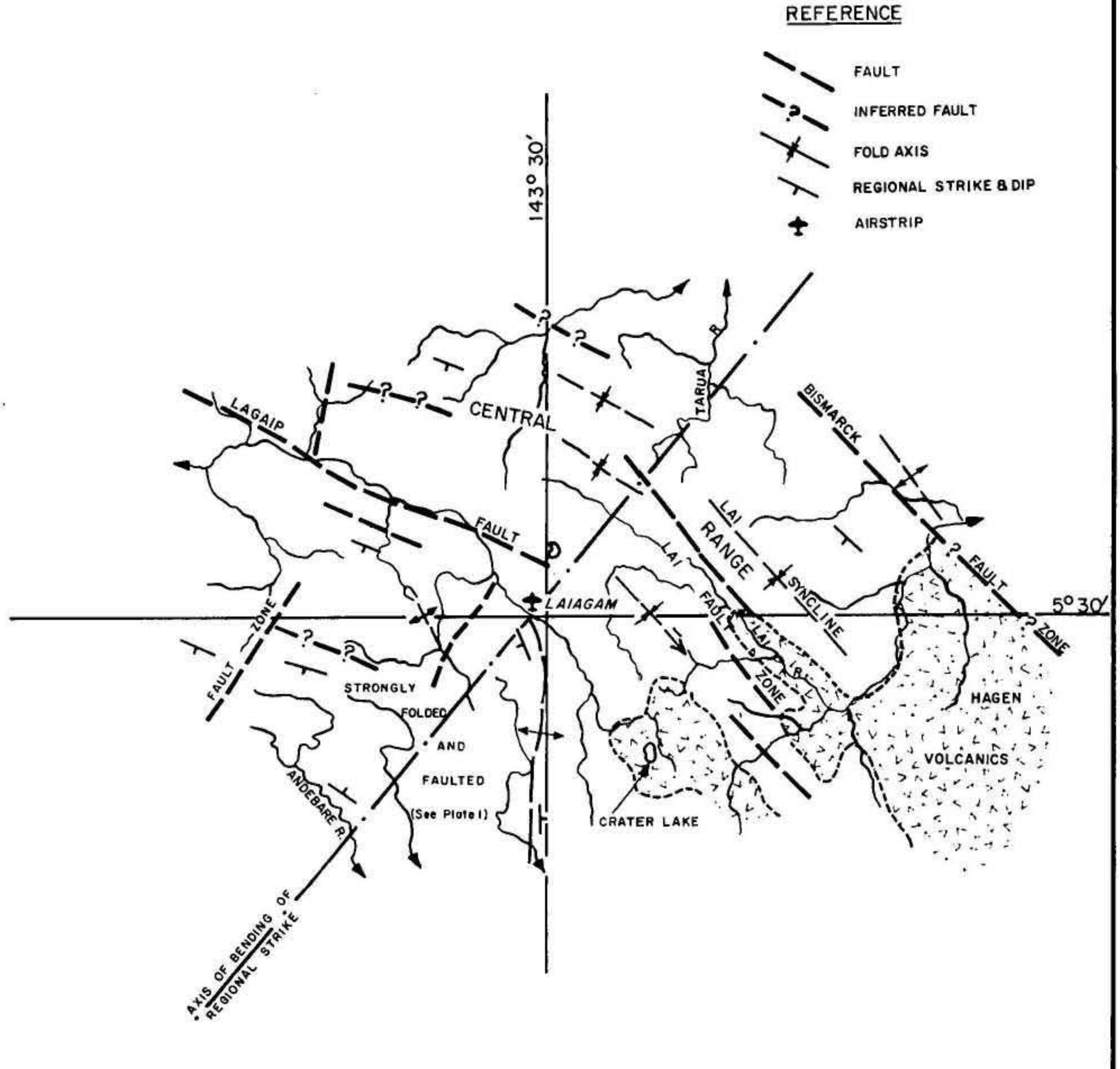
A small stock of andesite porphyry about three miles long by one mile wide, which grades to fine-grained diorite, crops out in the headwater tributaries of the Lamant River. This porphyry contains about 50 percent angular shale fragments in a marginal zone for about 20 feet from its intrusive contact. A roughly banded volcanic rock with rounded and angular pumiceous fragments up to half an inch across is associated with this porphyry.

A large boey of medium to coarse-grained granodiorite with dolerite and gabbro differentiates intrudes Mesozoic rocks north of the projected Bismarck Fault Zone in the north-eastern corner of the map area. Another intrusion composed of dolerite and granodiorite occurs in the Lower Lai Valley immediately above its junction with the Sau River. These two bodies are tentatively referred to the Timun Intrusives because of similar lithology, although nowhere are they known to intrude the sediments younger than the Cretaceous.

Rare small concordant sills intrude the Lagaip Beds in the Maramuni Valley near Pasalagus and south of Biatea Rest House. They are composed of medium-grained gabbro and green porphyritic dolerite with phenocrysts of olivine. The intruded shales are highly indurated for a few feet from the sharp contacts. Boulders of serpentinite were found on the divide between the Leanda and Sui Rivers. They probably represent altered ultrabasic dykes intruded along the shear zone in the Leanda River. Dykes up to 100 feet wide intrude the Sau River beds in the Sau River; they have intruded in two sets with strikes of 020° and 135°, and dips of 60° east and 75° north-east respectively. The latter set has roughly the same strike as the sediments and is intruded at right angles to their bedding. The dykes range in composition from dolerite to granodiorite.

A number of small stocks of hornblende diorite which grades into granodiorite and granite intrude Lower Miocene beds along the Lai Fault Zone south of the Lai Valley near Wapenamanda. These plutonic rocks were originally thought to represent the Palaeozoic basement (Rickwood, 1955). The intrusion of these rocks and the faulting in this area are probably closely related.

FIG. 14



WABAG AREA T.N.G.

STRUCTURAL SKETCH MAP

SCALE 1:1,000,000

10 0 10 20 30 Miles

To accompany Record No 1964/137

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS. FEBRUARY 1964.

B54/A8/6 M.E.N.

Rocks included as Timun Intrusive range in composition from gabbro, dolerite and minor serpentinite through diorite and andesite porphyry to granodiorite, adamellite, and granite. The most basic rocks examined in thin section contain 10 percent by volume of olivine, with labradorite, augite, and some iron minerals. With decreasing olivine and augite and the incoming of quartz and hornblende, the rocks range in composition from ultrabasic to acid types containing up to 20 percent quartz. Most of the rocks are slightly altered, but some of the diorites have suffered extensive deuteric alteration to become propylites. The plagioclase feldspars of the intermediate and acid rocks are usually zoned, either rhythmically, normally, or both together.

The youngest beds intruded by the Timun Intrusives are the Tarua Volcanics which are assigned to the Tertiary $f_1 - f_2$ stage. The intrusions appear to be restricted to the north-eastern half of the map area. This area has been mildly deformed compared with the intensely contorted province south of the north-west to south-east diagonal of the map area. It is postulated that intrusion accompanied the uplift and vulcanism which took place along the present position of the Central Range during the lower Miocene. The Ga Intrusives described by Rickwood (1955) along the Bismarck Fault Zone in the Wahgi Valley have a similar composition and degree of alteration to the Timun Intrusives. The Oipo Intrusives in the Bismarck Mountains (Dow & Dekker, 1964) are apparently associated with intense shearing along the Bundi Fault Zone. These occurrences, which were tentatively dated as Miocene, range in composition from ultrabasic to acidic. The Timun Intrusives are believed to have been emplaced during the same lower Miocene phase of basic intrusion as the Ga and Oipo Intrusives.

STRUCTURE

The regional strike of the rocks in the area mapped is similar to that found elsewhere in the highlands of New Guinea; the strata are generally folded along north-west-trending axes, and are dislocated by faults parallel to this trend. However, the main feature of the area is the abrupt change in regional strike about a north-easterly axis through the centre of the map area. In the north-western half of the area, the structural grain is west-north-westerly whereas in the south-eastern half, it is dominantly north-north-westerly. This change is well-demonstrated in the photo-interpretation of the structure in the Yangi Highlands (Plate 1): in this area tight steeply plunging folds and complex faulting occurs along the north-easterly axis of bending of the regional structure.

The area can be divided into three major structural units, which are separated by zones of intense faulting. These zones, although well-defined in places, are often obscured by a thick cover of later volcanics and extrapolation of the individual faults is thus difficult.

The Bismarck Fault Zone as described by Rickwood (1955) in the Wahgi Valley apparently extends into the north-eastern corner of the map area, where Mesozoic rocks abut against a predominantly Tertiary sequence. A vague lineation on the air-photographs, coinciding with this contact, was interpreted by Dow (1961) as representing the fault zone.

Extensive faulting along the Lai valley is mostly obscured by Recent volcanics. The faults in this area have disrupted competent blocks of the Sau Beds, but the vertical movement on these faults is apparently small.

The well-defined Lagaip Fault can be traced for approximately 30 miles along the Lagaip valley. A marked facies change in Miocene sediments occurs across the position of the Lagaip Fault and it is possible that this structure influenced deposition during this time. Considerable lateral movement on the fault could however, account for the juxtaposition of the two facies.

Little is known about the structure of the Mesozoic rocks to the north of the Bismarck Fault Zone, but they are apparently gently folded along a north-west trending anticlinal axis.

The Central Range lying diagonally across the map area is a slightly deformed zone. This coincides with what was probably a stable offshore shelf during the Upper Tertiary as evidenced by the rock types found here. The sediments are openly folded along axes which trend roughly north-west and change direction by 30° at the line between Laiagam and the Tarua River. In the east, the Tertiary section is folded into the Lai Syncline (Rickwood, 1955) with dips ranging from 50° near the bottom of the section to about 10° in the uppermost Burgers Formation. In the western Central Range, a number of parallel folds have limbs which generally dip between 30° and 50°.

The area to the south of the Lagaip Fault was the zone of basinal deposition during the Upper Tertiary, and the rocks have subsequently undergone intense contortion. Deformation is the most intense where the change in direction of the regional strike is almost 90 degrees. Folding and faulting is extremely complex in this region and only the major structures interpreted from air-photographs are shown on the geological map.

GEOLOGICAL HISTORY

Widespread marine transgression began in the Upper Jurassic over much of the Western Highlands of New Guinea. This resulted in the deposition of the Maril Shale (Rickwood, 1955) which has a fairly constant thickness and remarkably uniform lithology over a large area. A remote, low relief source of detritus was postulated by Dow & Dekker (1964) to explain the fine grain-size of the sediments in the Wahgi and Jimi Valleys. The Labalam Beds, which are correlated with the Maril Shale, are slightly coarser, and probably represent a shallow-water facies nearer the source of the detritus.

During the Lower Cretaceous, extensive vulcanism in a zone of island arcs to the north of the map area led to the deposition of the Kondaku Tuff in a miogeosynclinal environment. (Edwards & Glaessner, 1953). The subsequent record of deposition up to the Upper Cretaceous is not represented in the map area, but in the Bismarck Mountains (Dow & Dekker, 1964) it consists of marine volcanics and fine-grained sediments.

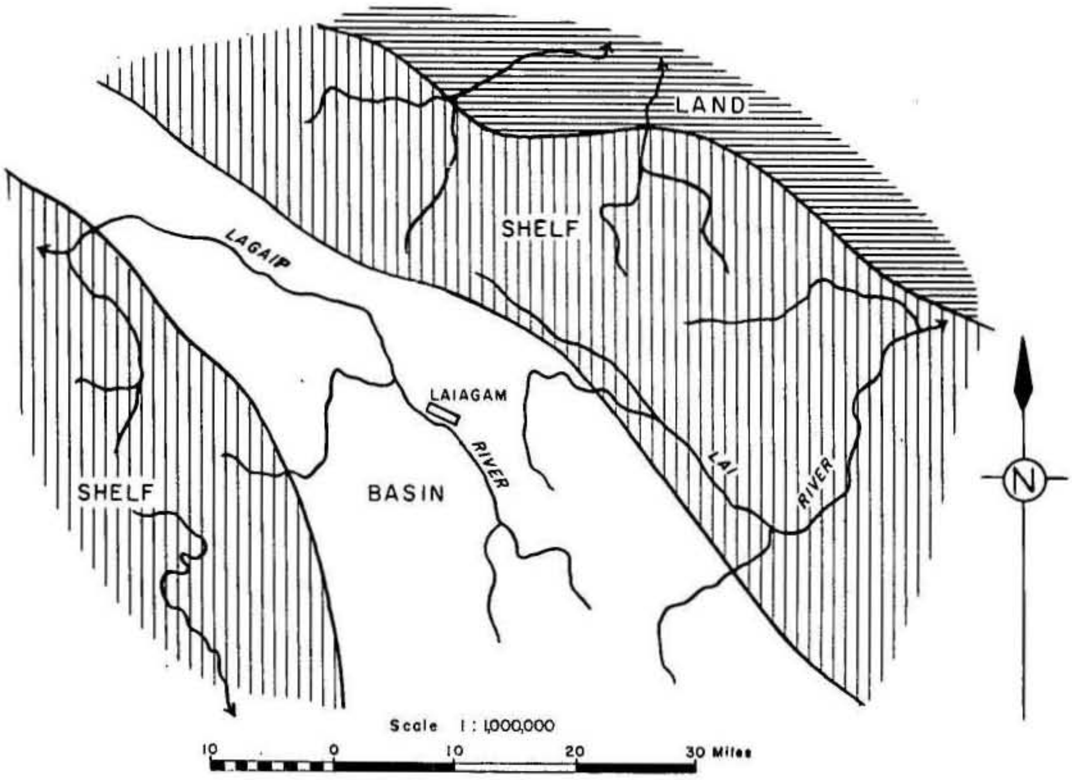


Fig 15. Paleogeographic map of the Wabag area from Upper Cretaceous to Lower Miocene

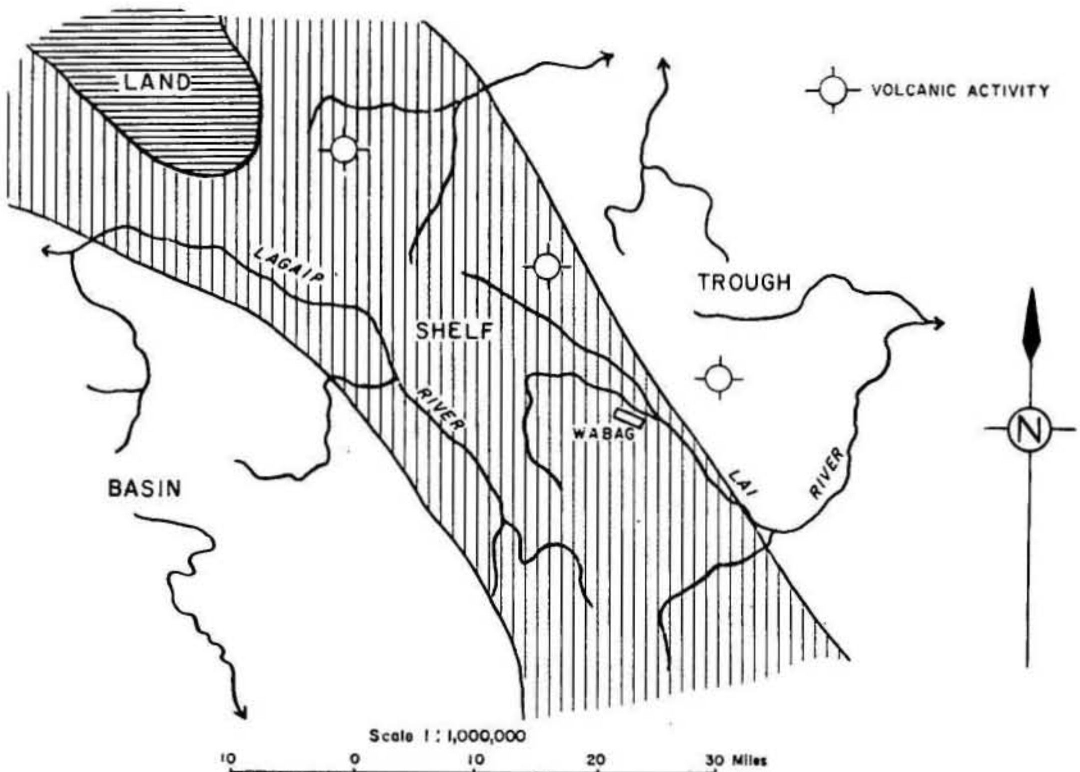


Fig 16. Palaeogeographic map of the Wabag area during the Miocene

The Lagaip Beds were deposited during an uninterrupted phase of marine deposition extending from the Upper Cretaceous to the lower Miocene. However, the Lower Tertiary is poorly represented and possibly was a period of poor sedimentation, although there is apparently no break in the sequence (Australasian Petroleum Company, 1961). A fairly stable shelf environment existed in the northern part of the map area, and fine-grained sediments of uniform nature were deposited. Large masses of limestone near Yali and Minyamb Creek, and fossil burrows of the pelecypod, Solan, in the Maramimi Valley attest to the moderately shallow nature of the sea in this area. Large masses of deep-water limestone interbeds in the Lagaip Valley suggest deep basinal conditions in this area (Fig.15).

The landmass which supplied material during this time was uplifted in the early Tertiary, and the large amount of coarse detritus of the Sau Beds was deposited in a deep trough in the present-day Kompiam area. Elsewhere, shallow-water conditions prevailed and a lesser thickness of sediments accumulated.

A mild orogeny late in the lower Miocene raised the northern portion of the map area to near sea level. Extensive vulcanism along a belt immediately north of the present Central Range, produced the Tarua Volcanics during this period. The orogeny was also accompanied by the intrusion of the Timun Intrusives. The Burgers Formation was subsequently deposited during the dying phase of the vulcanism. The presence of reefs choked by ash, apparent soil profiles, and minor unconformities in the formation suggest that parts of the area of deposition were alternatively above and below sea level.

The southern half of the map area subsided during the Lower Miocene. Thick deep-water limestones and interbedded fine-grained muds indicate a basin environment which probably lasted until upper Miocene.

No apparent reason was found for the absence of debris of the Tarua Volcanics in the southern part of the map area. Erosion probably removed the Volcanics on the south side of the Central Range prior to the deposition of the Burgers Formation directly on top of the Sau Beds. This explanation is not valid south of the Lagaip Valley, because no break in deposition from Upper Cretaceous to upper Miocene is apparent in this area. The deposition of the beds cropping out in this area may have taken place much further south than where they crop out today, and hence they may have been distant from the volcanic activity during the Miocene. North-south compression of the incompetent Lagaip Beds along the Lagaip Valley during the late Tertiary orogeny can account for the present-day position of the Yangi Beds. This hypothesis also satisfactorily explains the intense contortion of the sediments along the Lagaip Valley.

Considerable strike slip along the Lagaip Fault could also account for the lack of volcanics south of the fault.

Strong uplift late in the Tertiary ended marine sedimentation in the area. Intense contortion of the poorly consolidated geosynclinal sediments in the south took place during this time. The sediments to the north were gently folded and raised to near their present altitude of about 10,000 feet. The area became volcanically active late in this orogeny, and the large amount of debris of the Hagen Volcanics was extruded. Rivers were dammed by volcanic detritus and lakes and swamps developed. Terrestial volcanics filled up basins such as the Lai Valley, and a thin veneer of ash covered most of the area. The Mount Hagen Range was formed by the most active group of vents in the area, and the range was glaciated after volcanic activity lessened. Numerous other centres throughout the area were active into Recent times, although only a few thermally active areas are known to exist in the area to day.

ECONOMIC GEOLOGY

Gold, silver, and platinum

Alluvial gold in the Porgera Valley was first officially reported in 1938. After the Second World War, these alluvial deposits were worked by several prospectors, but by December 1948, during the visit of Ward (1949), Mr. J. Searson was the only European miner in the area. Several officers of the Papua and New Guinea Administration Department of Lands, Surveys and Mines subsequently visited the area, and the gold was traced to its origin.

The gold together with silver is shedding from stockworks of quartz veins in the Cretaceous black shales near the margins of small dioritic intrusions. Sphalerite, pyrite, galena, and chalcopyrite are commonly associated with the gold mineralization. Much of the goldfield is covered by colluvium shedding from the cliffs to the south of the field. Horne (in prep.) of the Wau Resident Geological staff made a systematic study of the area, and the reader is referred to his report for further information. A preliminary assessment by Horne indicated that the lode-mining potential of the goldfield was limited.

Gold was discovered in the Timun River near Kompiam in 1948. Ward (1949) and Dow (1961) have described this occurrence and the following excerpt has been taken from the latter report:

'The Timun Intrusives have been a source of gold and platinum. Gold is almost invariably found in streams draining the dioritic phases of the intrusions, though most of the stream gradients are too steep for economic concentrations to form.

Messrs. L. and M. Wilson are working alluvium of the Timun River for poor returns of gold and platinum, which have been derived from the Timun Intrusives. Near the head of the Timun River are fairly extensive lake beds composed mainly of gravels and conglomerate containing poor gold and platinum which have been reconcentrated in the flat bed of the Timun River below the lake beds.'

The Lamant River has several small alluvial flats in its upper reaches. These contain fair gold prospects, but the amount of auriferous gravel is small and is not likely to be worked, except by local natives. The gold in this case originated in an andesite porphyry intrusion, whose margins warrant further prospecting for gold lodes. Basic intrusions in the headwaters of the Wale River have caused minor gold mineralization. The possibility of economic gold bearing terraces below the junction of the Wale and Lamant Rivers exists, although this area carries no population and access is difficult.

Copper

Dow (1961) found traces of copper in the north-eastern corner of the map area:

'Diorite near the margin of a large intrusion, seven miles to the east of Labalam village, in a tributary of the Sau River, contains scattered chalcopyrite. Further investigation for economic copper mineralization near the margin of this intrusion may be warranted. Access to the area is very difficult.'

Small nodules of bornite occur in reddish marl in the Lagaip River between Laiagam and Mutiaga. A selected sample assayed 2.95 percent copper although no anomalous copper value showed in the analysis of a geochemical stream sample taken in the same creek.

Coal

Thin laminated beds of peaty brown coal in lake alluvium in the Lagaip Valley near Laiagam represent swampy conditions here during Pleistocene and Recent times. The beds, which are up to one foot thick, are generally horizontal, but locally they are tilted up to 30°. The deposits are small and of poor quality. An analysis of one sample gave the following composition:

Moisture	6.79%
Volatile matter	30.81%
Fixed carbon	12.58%
Ash	43.82%
	97.00%

The coal has been used on a small scale by the Apostolic Mission Station at Laiagam, and by local natives.

Petroleum

Petroleum may occur in the folded and faulted marine Miocene sediments of the Yangi Highlands. However its high elevation, deep dissection and the probability of extensive freshwater flushing lessen the attractiveness of this area for petroleum exploration. The inaccessibility and latitude of the region are formidable barriers to economic petroleum exploration.

Limestone

Large hard limestone lenses are common in the Lagaip Beds in the Wabag area, and generally form prominent topographic features. The rocks are resistant to mechanical weathering, and crushed limestone aggregates are used for road and airstrip surfacing throughout most of the area.

Specimens of limestone from various localities (Plate 2) were analysed. The results are given in Table 2.

Table 2

Sample number	Insoluble fraction	$CaCO_3$-content	$MgCO_3$ content
	percent	percent	percent
F 179	9.15	88.7	0.38
F 194	20.8	70.5	1.27
F 223	6.6	90.0	0.85
F 231	13.8	82.1	2.40
F 260	8.7	88.1	0.45

The limestones generally contain a fairly high argillaceous fraction, but nevertheless are suitable for local lime-burning.

Geochemical Sampling Programme

A reconnaissance programme of stream sediment sampling was carried out in conjunction with the regional mapping. Samples were only taken at stream crossings on geological traverses. A total of 168 samples were taken over an area of approximately 3000 square miles, giving a sample density of about one sample per 18 square miles. The programme, therefore, only indicates possible areas for further investigation.

Sediments were wet-sieved on the sampling spot through 1/80 inch mesh and the 'fines' were sealed in plastic sample bags. The samples were analyzed spectrographically in the laboratory of the Bureau of Mineral Resources in Canberra. [redacted] and the sample localities are shown on Plate 2.

Few anomalous results were obtained: these are briefly described below:

Streams draining the Tarua Volcanics on the northern side of the Central Range contain sediments which generally have a high vanadium count. Samples F 265, F 266, and F 267 taken on the Lower Tarua River about 10 miles downstream from the outcrop of the volcanics and the overlying sheared black shales have still higher vanadium counts. Sample F 265 contains in excess of 2000 parts per million of vanadium. Specimens of black shale and basic intrusives were analysed, but showed no anomolous metal contents. Results of these analyses are given at the end of Appendix I.

Nickel counts between 100 and 200 parts per million in the rugged Lower Lagaip Valley are distinguished from an average background of about 30 parts per million. No reason for these high values is apparent.

Various isolated samples with high counts for certain metals were found throughout the map area. These are probably due to minor concentrations of mineralization in the underlying Tertiary sediments.

ACKNOWLEDGEMENTS

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APPENDIX II

PETROGRAPHY OF SAMPLES FROM THE WABAG AREA

Porgera Intrusives*

RH5: TS 11505

Locality: Porgera Valley

This is an altered, porphyritic microdiorite. Phenocrysts of plagioclase, augite, and hornblende are embedded in a fine to medium-grained groundmass containing the above minerals as well as opaques and carbonate .

Plagioclase is the predominant constituent. Both the phenocrysts and groundmass crystals are in the calcic-oligoclase to sodic-labradorite range. Host plagioclase crystals are euhedral or subhedral in shape and some show distinct zoning. The phenocrysts are often partially replaced by sericite and a carbonate mineral. Augite is a minor constituent, occurring as altered phenocrysts or groundmass grains which are weakly pleochroic from colourless to very pale green or yellow-brown. Most grains have been replaced or partially replaced by carbonate, chlorite, and sericite. Hornblende occurs as anhedral phenocrysts, pleochroic from pale yellow-brown to yellow-brown. Most grains appear to have been altered to chlorite group minerals and a carbonate. Quartz is a minor constituent, occurring as anhedral grains rather like phenocrysts. However, it is intimately associated in aggregates with a carbonate mineral and both minerals appear to have formed by deuteric alteration of primary constituents rather than as primary pyrogenetic minerals. The carbonate also occurs as patchy replacements of plagioclase and as anhedral grains replacing groundmass minerals. Accessory minerals are euhedral to subhedral opaques and acicular apatite.

RH 8: TS 11508

Locality: Porgera Valley.

This is a highly altered, medium-grained igneous rock. The original rock contained phenocrysts of pyroxene and hornblende set in a plagioclase-rich groundmass. The predominance of sodic-plagioclase and the abundance of ferromagnesians indicate that the rock is between syenite and diorite in composition. Possibly it could be classified as a monzonite. Deuteric or hydrothermal alteration has caused the formation of epidote-group minerals, chlorite, sphene, biotite, and a zeolite. This alteration has been rather irregular because some parts of the rocks are less altered than others.

Plagioclase is the predominant constituent. The composition appears to be in the albite range but may have been more calcic (i.e. oligoclase) before alteration. The laths are euhedral or subhedral in shape and show an intergranular texture. Many grains are altered to sericite or epidote (pistacite) but some show only slight alteration. Colourless diopside or augite is a minor constituent, occurring as

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* Petrographic determination by Australian Mineral Development Laboratories, Adelaide.

phenocrysts or as occasional smaller grains. Most grains are unaltered although some show slight alteration to chlorite. Another more diopsidic pyroxene surrounds the colourless pyroxene.

Brown hornblende, which is a minor constituent, has been mostly altered to aggregates of chlorite and sphene. The chlorite has anomalous birefringence and is probably the penninite variety. Both epidote (pistacite) and clinozoisite occur in minor amounts: pistacite commonly replaces plagioclase or occurs interstitially to it, and the clinozoisite forms fibrous aggregates interstitial to feldspar grains. Biotite occurs as irregular laths, pleochroic from light to dark brown: it has formed later than the chlorite but earlier than the epidote. A zeolite mineral, probably chomsonite occurs as anhedral aggregates replacing plagioclase. An anhedral carbonate mineral occurs interstitially to most other minerals. Accessory minerals are thick prismatic apatite grains, magnetite or ilmenite and rare pyrite.

RH 26: TS 11521

Locality: Porgera Valley

This is an altered, porphyritic, fine-grained igneous rock - a sodic trachyte. Phenocrysts of plagioclase are abundant, and smaller altered ferromagnesian phenocrysts occur in lesser amounts in the fine-grained groundmass.

Plagioclase phenocrysts are euhedral or subhedral in shape. Multiple twinning of grains is common, and the composition of the plagioclase is in the albite range. Most grains are replaced or partially replaced by sericite and a carbonate mineral, thus the feldspar may have originally been slightly more calcic. Pre-existing ferromagnesian phenocrysts are indicated by aggregates of chlorite and carbonate presumed to have formed from them. Amphibole predominates, and many of the grains show typical amphibole habit. These have altered to a chlorite mineral, carbonate, and sphene. Grains with pyroxene habit have altered to chlorite and carbonate. The groundmass is composed predominantly of minute sodic plagioclase laths, with chlorite, carbonate, and accessory acicular apatite and opaques. Occasionally large anhedral carbonate grains have replaced portions of the groundmass. Pyrite occurs sparsely with the opaques.

TARUA VOLCANICS

F 56 (R 15773, 11341) Basalt

Locality: Airphoto Birap 1/5013 Ninimb River.

Occurrence: Lava Flow

Grainsize: Very fine-grained; mostly less than 0.1 mm.

Texture: Vesicular - hyalopilitic.

Mineralogy: 50% labradorite
5% clinopyroxene
2% olivine
15% glass
25% vesicles

The labradorite occurs as tiny laths, some of which show normal zoning, with random orientation. Both the clinopyroxene and the olivine occur as tiny granules interstitial to the plagioclase laths. Plagioclase, augite, and olivine occur in a glassy groundmass charged with opaque minerals. Some of the vesicles are lined with very small crystals of chlorite with their long axes at right angles to the wall of the vesicle.

F 97 (R 16563, 11834) Porphyritic Basalt

Locality: Airphoto Magare 5/5013 Wale River

Occurrence: Lava flow

Grainsize: Phenocrysts, average diameter 2 mm. Groundmass, less than 0.05 mm.

Texture: Porphyritic, pilotaxitic

Mineralogy: 20% Phenocrysts
70% Groundmass
90% plagioclase
3% augite
3% altered olivine
5% unidentified opaque minerals

Plagioclase phenocrysts are anhedral to subhedral and have a composition of about An_{60}. They show resorbtion textures and are thus apparently out of equilibrium with the groundmass, which is probably more sodic. Plagioclase in the groundmass occurs as tiny laths with random orientation. They are less than 0.05 mm. in length. Their composition was not determined. Augite occurs as subhedral phenocrysts and as anhedral granules in the groundmass. Unidentified opaque minerals occur as anhedral phenocrysts and as tiny granules in the groundmass. A hydrous iron mineral occurs in the groundmass and is probably an alteration of olivine - some patches of this mineral show an outline typical of that of olivine and show structures which are similar to the fracture pattern of olivine.

F 106 (R 16564, 11835) Vesicular Andesite

Locality : Airphoto Magare 2/5073, Head of Tarua River.

Occurrence : Lava flow

Grainsize : Very fine-grained; phenocrysts up to 4 mm. Groundmass less than 0.05 mm. average diameter.

Texture : Vesicular - hyalopilitic

Mineralogy : 15% feldspar - phenocrysts
5% augite
50% glassy groundmass
35% vesicles

Phenocrysts:

The feldspars are plagioclases (composition was not determined). They are euhedral to subhedral and are strongly resorbed and altered. The augite occurs as euhedral phenocrysts which are quite fresh.

Groundmass and Vesicles:

The vesicles are quite large, being up to 2 mm. in diameter and of fairly uniform size. They are nearly all lined with chlorite and filled with zeolite (heulandite?).

The groundmass is made up of small feldspar laths in an iron oxide charged glass.

F 11 (R 16565, 11836) Basalt

Locality : Airphoto Magare 2/5073. Tarua River.

Occurrence : Pillow lava

Grainsize : Groundmass less than 0.05 mm. Phenocrysts - Plagioclase 0.5 to 1 mm. and Pyroxene - 0.5 to 3 mm.

Texture : Porphyritic Hyalopilitic

Mineralogy : 7% feldspar
10% pyroxene
10% calcite
1% chlorite(?)
70% groundmass
1% Iron minerals as phenocrysts.

The feldspar phenocrysts are sodic labradorite. They range in diameter from 0.5 to 1.0 mm., and occur as euhedral crystals which may show normal zoning, rhythmic zoning, or rhythmic zoning superimposed on normal zoning. Alteration is slight, the alteration product being kaolin. The pyroxene phenocrysts are a pale green augite, which occurs as euhedral crystals often weakly zoned. The crystals range in diameter from 0.5 to 3.0 mm. Calcite occurs as ragged anhedral crystals up to 3 mm. in diameter. They are sometimes moulded around feldspar and augite crystals, and may represent limestone which was picked up by the ascending magma, melted, and now crystallized. Phenocrysts of unidentified iron minerals occur through the rock. A mineral, possibly chlorite occurs in some vesicles in the rock. The groundmass consists of tiny crystals of feldspar randomly oriented in an iron oxide charged glass containing tiny granules of pyroxene.

TIMUN INTRUSIVES

F40 (R 15781, 11348) Diorite

Locality : Airphoto Birap 3/5059. Aiyeli Creek.

Occurrence: Small irregular intrusions.

Grainsize : Coarse, generally greater than 5 mm.

Texture : Hypidiomorphic granular.

Mineralogy: 2-3% quartz
40 % andesine
10 % augite + alteration product antigorite (bastite)

The remaining 50 percent of the rock has been hydrothermally altered so that individual grains are almost unrecognizable. It consists of clear anhedral grains of quartz in a heavily kaolinized feldspar, probably orthoclase, shreds of antigorite, and scattered anhedral grains of magnetite. Apatite occurs as an accessory.

Andesite occurs as large laths and some crystals show an oscillatory zoning. The augite is pseudomorphed by antigorite to give bastite, and only occurs in occasional unaltered residual cores of crystals.

F 89a (R 16561, 11832) Dolerite

Locality : Airphoto Magare 2/5077, Mamba Creek

Occurrence : Boulders shedding from large intrusion

Grainsize : Ferromagnesians - diameter lies between 1 and 4 mm.
Feldspar - average diameter 1 mm.

Texture : Gabbroic

Mineralogy : 60% augite
20% labradorite
15% olivine
3% unidentified opaque minerals
biotite) Minor amounts
chlorite)

The augite occurs as anhedral grains whose diameters range from 1 to 4 mm. Anhedral grains of iron ore and feldspar are included in many of the grains giving a poikilitic texture. In places they show slight alteration to biotite and chlorite.

The feldspar is a plagioclase with composition about that of sodic labradorite and ocurs as euhedral grains interstitial to augite and olivine, and as inclusions in augite. The olivine occurs as anhedral grains. In places they show the characteristic incipient alteration along fractures to serpentine minerals and tiny euhedra of magnetite. Undifferentiated opaque minerals occur as anhedral grains about 0.3 mm. diameter scattered through the rock, and as inclusions in pyroxenes. Magnetite is present as a secondary mineral along fractures in olivine. Biotite occurs as a secondary mineral - product of alteration of augite. In places the biotite has been partly altered to chlorite. Chlorite also occurs as a direct alteration product of augite.

F 89B (R 16562, 16833)

Locality : Airphoto: Magare 2/5077 Mamba Creek

Occurrence : Boulders

Grainsize : 1-3 mm. average diameter

Texture : Hypidiomorphic granular

Mineralogy : 5% quartz
80% plagioclase
5-10% orthoclase
5% hornblende
1% unidentified opaque minerals
myrmekite, apatite } in accessory amounts

Plagioclase is a calcic albite or a sodic oligoclase as euhedral crystals. In places, it is slightly cloudy because of incipient alteration to kaolin. Intergrowths with quartz give rise to myrmekite, usually occurring adjacent to orthoclase, but myrmekite is very minor. Quite a number of the plagioclase crystals show rhythmic zoning. Orthoclase occurs as anhedral grains interstitial to plagioclase crystals. It is cloudy owing to incipient alteration to kaolin. Quartz occurs in small quantities interstitial to the feldspars. Green hornblende occurs as anhedral grains against plagioclase and as euhedral crystals where adjacent to quartz or orthoclase. Sphene, apatite, and unidentified opaque minerals occur as accessories.

F130 (R 16570, 11841) Serpentinite

Locality : Airphoto Tarua R. 3/5081 Milaku Rest House

Occurrence : Small dykes along fault zone.

Grainsize : Up to 2 mm.

Texture : Majority of section shows a mesh structure.

Mineralogy : 95% Serpentine minerals.

The rock is made up of antigorite, serpophite, bastite (antigorite after enstatite). Scattered through these serpentine minerals are extremely tiny subhedral to euhedral crystals of iron oxide. The iron oxide is a product of the serpentinization of pyroxenes and olivines.

F 133 (R 16572, 11843) Altered Dolerite

Locality : Airphoto Tarua R. 3/5081 Pasalagus

Occurrence : Small stock.

Grainsize : 0.5 to 2 mm.

Texture : Hypidiomorphic granular

Mineralogy : 80% plagioclase
10% augite
3% chlorite
2% biotite
2% unidentified opaque minerals

The plagioclase occurs as euhedral and anhedral crystals which are strongly normally zoned. Some compositions determined optically in the one crystal varied from An_{70} to An_{50}. Much of the plagioclase is kaolinized, particularly cores of crystals and in some cases, some of the inner zones. The augite, which occurs as euhedral and anhedral crystals, is also zoned. Many crystals show alteration to biotite, with some of the biotite appearing to be in the process of alteration to chlorite. The edges of some of the unaltered augites show resorbtion. Chlorite occurs and probably represents completely altered augite crystals. Unidentified opaque minerals occur as anhedral grains scattered through the rock. Apatite crystals occur in accessory amounts.

F 149 (R 16574, 11845) Altered Andesite.

Locality: Airphoto Tarua 3/5083. Lent Creek.

Occurrence: Concordant Sill.

Grainsize: Fine - average grain diameter 0.4 mm.

Texture : Hypidiomorphic

Mineralogy :

Feldspar - outlines only, completely altered to kaolin, chlorite and calcite.

50% (Calcite / Kaolin) mostly intergrown and microcrystalline

20% chlorite (pennine)

15% augite - granules plus a few phenocrysts

5% unidentified opaque minerals

3% prehnite

The feldspar is completely altered to a mixture of kaolin, calcite and chlorite (pennine). Outlines of larger crystals are still visible but the intervening areas, which presumably were filled with smaller feldspar crystals, are a mixture of chlorite, kaolin and calcite. Augite occurs as euhedral phenocrysts and anhedral grains. Chlorite (much of the chlorite in the groundmass is pennine) occurs as aggregates in the groundmass. Prehnite appears to occur as a secondary cavity filling. Calcite occurs as microcrystalline grains in the groundmass and in places as large crystals. Tiny anhedral grains of unidentified opaques occur scattered through the rock.

F 534 (TS 13161, R 17437) Andesite Porphyry.

Locality: Airphoto Birap 3/5061. Lai Valley.

Occurrence: Phenocrysts: feldspar, average diameter 3 mm. Chlorite, average diameter 1.5 mm. Groundmass is a glass.

Texture : Porphyritic.

Mineralogy: 40% plagioclase (sodic andesine)

5% chlorite after hornblende

55% glass containing microlites

The plagioclase occurs as phenocrysts with a composition about sodic andesine. They show rounding of the corners, embayment of the sides, and some phenocrysts contain rounded blebs of glass; all these indicate that the plagioclase is out of equilibrium with the glassy groundmass. Chlorite phenocrysts with the outlines of amphibole are probably pseudomorphs after hornblende.

The groundmass is a dark glass containing microlites which have not been identified.

F 536 (R 15776, 11344) Hornblende granite.

Locality : Airphoto Birap 3/5061. Tchak Valley, on side of ridge between the Lai and Tchak Rivers.

Occurrence: Small intrusion.

Grainsize : Coarse, average grain diameter 4mm.

Texture : Allotriomorphic granular.

Mineralogy: 20% quartz
60% orthoclase
15% albite-oligoclase
5% hornblende

The quartz occurs as anhedral grains interstitial to plagioclase and orthoclase. Orthoclase occurs as subhedral and anhedral grains usually heavily kaolinized. The plagioclase occurs as laths up to 8 mm. in length and is approximately albite - oligoclase in composition. The hornblende occurs as subhedral grains. Magnetite anhedra, apatite needles and sphene crystals occur as accessories.

F 551 (R 15771, 11339) Hornblende diorite

Locality : Airphoto Birap 3/5061. Lai Valley, on the ridge between the Lai and Tchak Rivers.

Occurrence: Small intrusion.

Grainsize : Coarse with the average grain diameter 5 mm.

Texture : Hypidiomorphic granular.

Mineralogy: 5% quartz
60% andesine
20% augite
5% orthoclase
5% hornblende

Accessory minerals include unidentified opaque minerals apatite and sphene.

Quartz occurs as interstitial grains and in myrmekitic intergrowths with orthoclase. The orthoclase is heavily kaolinized. The plagioclase which is about andesine in composition, occurs as large crystals often greater than 5mm. in length. Some of the crystals show oscillatory zoning, and nearly all are in various stages of alteration to kaolin and sericite. Calcite as an alteration product is present in minor quantities. Fresh augite is seen occasionally but is nearly always altered to antigorite; where it does occur fresh it is usually as residual cores. Pale green hornblende occurs as quite fresh anhedral to subhedral grains. Accessory minerals include unidentified opaque minerals as enhedral grains, apatite needles, and subhedral sphene.

F 650 (R 16579, 11850) Very fine grained dolerite

Locality : Airphoto Magare 4A/5141 Sau River.

Occurrence : Dyke

Grainsize : 0.5 to 3 mm.

Texture : Porphyritic, panidiomorphic.

Mineralogy : 30% Phenocrysts

25% augite

5% olivine

Plagioclase negligible amount.

70% Groundmass.

The augite occurs as euhedral to subhedral crystals 1.0 to 10 mm. in diameter. Quite a lot of the crystals show twinning and some show resorbtion along crystal edges. The olivine occurs as euhedra.. up to 3 mm. in diameter. They are in various stages of alteration to serpentine. Some crystals are quite fresh whilst others are completely serpentinized. Others show various stages of alteration along fractures. The plagioclase is anhedral and is probably labradorite; however, no determinations could be made. The groundmass consists of tiny interlocking plagioclase crystals, mostly slightly altered to kaolin, augite and unidentified opaque granules. Quite a lot of the groundmass is made up of chlorite, probably pennine as it shows anomalous blue under crossed nicols.

F 652 (TS 13162, R 17438) Andesite

Locality : Airphoto Magare 4A/5141 Sau River.

Occurrence : Dyke.

Grainsize : Phenocrysts - maximum diameter of 1 mm.

Groundmass - average diameter less than 0.1 mm.

Texture : Porphyritic.

Mineralogy : 65% plagioclase (oligoclase)

3% pyroxene

2% quartz

25% chlorite

3% unidentified opaque minerals

The plagioclase is oligoclase in composition and occurs as euhedral crystals ranging in diameter from less than 0.1 mm. to 1.0 mm. The crystals are stumpy, and the larger phenocrysts are crossed by numerous fractures. Many plagioclase crystals show normal zoning, with no preferred orientation obvious in thin section. The quartz occurs as isolated anhedral grains scattered through the section. The pyroxene which is probably augite occurs as tiny euhedral grains scattered through the section. Unidentified opaque minerals occur as tiny anhedral grains. Chlorite is abundant and occurs as a groundmass.

G7. Andesine porphyry

Locality : Airphoto Magare 4A/5145. Linganas Rest House

Occurrence : Irregular intrusive body.

Grainsize : Phenocrysts - average 2-3 mm. in diameter - maximum 4 mm.

Groundmass - 0.1 to 0.3 mm. diameter.

Texture : Panidiomorphic - porphyritic

Mineralogy : 10% green hornblende

15% plagioclase phenocrysts

70% groundmass feldspar presumed to be sodic andesine in composition.

Accessories include apatite and unidentified opaque minerals.

The phenocrystic feldspars show strong zoning, both oscillatory and normal. They have a typical lath shape, whereas the feldspars of the groundmass tend to have an almost square section. The majority of the groundmass feldspar shows incipient alteration, and among the phenocrysts particular zones in the crystal are often kaolinized. Among the groundmass feldspars, many have a core much more calcic than the border. The hornblende is green and occurs as phenocrysts scattered through the rock. Anhedral opaque granules are also present.

G 17. Dolerite.

Locality : Airphoto Magare 2/5077. Wale Valley.

Occurrence : Large intrusive body.

Grainsize : Average grainsize 1 to 2 mm.

Texture : Hypidiomorphic.

Mineralogy : 70% labradorite

20% augite

3% olivine

5% unidentified opaque minerals

The labradorite occurs as euhedral laths and anhedral grains. Some crystals show normal zoning, and a number of the larger grains have a poikilitic texture, with rounded grains of augite and magnetite included in the crystal. Augite occurs as rounded grains, and larger subhedral grains which are often poikilitic in plagioclase, olivine, and unidentified opaque minerals.

The olivine occurs as rounded grains scattered through the rock. Rounded blebs of unidentified opaque minerals range in diameter from 0.1 mm. to 5 mm. The larger grains often contain rounded inclusions of feldspar and pyroxene.

G 26 Diorite

Locality : Airphoto Magare 1/5089. Lamant River

Occurrence : Small intrusive body (stock).

Grainsize : Phenocrysts - occasional plagioclase reach 6 mm. in diameter as do corroded quartz crystals - the average diameter is about 2 mm.
Groundmass - feldspar has an average diameter of 0.1 mm.

Texture : Hypidiomorphic granular - porphyritic.

Mineralogy : 2% to 3% quartz
85% feldspar (calcic oligoclase)
10% hornblende (green)
3% unidentified opaque minerals.
Apatite occurs as an accessory.

The quartz occurs as large anhedral, corroded phenocrysts - some crystals show a poikilitic texture and enclose hornblende and feldspar crystals. Elongate crystals of hornblende are scattered through the rock with random orientation. The feldspar occurs as euhedral phenocrysts which often show normal zoning, and also occurs as tiny anhedral to subhedral, equidimensional grains in the groundmass. The groundmass feldspar makes up about 40% of the rock. Unidentified opaque mineral is seen along occasional fractures, and as anhedral grains filling interstices between feldspar crystals. Apatite occurs as tiny euhedral crystals scattered through the rock in very small amounts.

G 29 Propylite

Locality : Airphoto Magare 1/5089 Lamant River.

Occurrence : Small stock.

Grainsize : Phenocrysts - average diameter 3 mm. - maximum 6 mm.
Groundmass - 0.1 mm. diameter or less.

Texture : Porphyritic, panidiomorphic granular.

Mineralogy : 3% quartz
50% feldspar
10% chlorite (pennine)
35% calcite
2% magnetite
Accessories include sphene and apatite.

Quartz occurs as corroded phenocrysts. Feldspar occurs both as phenocrysts and as tiny anhedral grains in the groundmass. The groundmass feldspars are probably albite in composition, whereas the phenocrysts are calcic oligoclase or sodic andesine. Some of the phenocrysts have been completely altered to a microcrystalline mixture of calcite and albite, but in most cases only the borders show alteration. Hornblende has been completely altered to pennine, calcite and magnetite together with very small amounts of sphene. Magnetite occurs as both a primary and a secondary mineral. The primary magnetite occurs as relatively large euhedral crystals, 0.2 mm. average diameter, while the secondary magnetite occurs as tiny anhedral grains in the chlorite. Apatite and sphene occur in accessory quantities.

G 35 Adamellite

Locality : Airphoto Magare 3/5003 Lower Sau Valley.

Occurrence : Dyke near large intrusion.

Grainsize : Average grain diameter, 4 mm.

Texture : Panidiomorphic granular.

Mineralogy : 35% quartz
25% orthoclase
25% plagioclase
10% hornblende

Accessory amounts of sphene, apatite and unidentified opaque mineral.

Quartz occurs as large anhedral crystals, some of which show undulatory extinction. The orientation of the large laths of plagioclase is random, and they have a composition of sodic andesine. Some of these crystals show both oscillatory and normal zoning. The orthoclase occurs as anhedral shaped grains and has been slightly kaolinized. Euhedral microcline crystals are present but are rare. Green hornblende occurs as elongate crystals of which occasional ones have been biotized, and chloritization of some of the biotite has commenced. Unidentified opaque minerals occur as anhedral to subhedral grains.

HAGEN VOLCANICS

F 19 (R 15778, 11346) Porphyritic olivine basalt.

Locality : Airphoto Birap 2/5101 Lai River.

Occurrence : Lava Flow.

Grainsize : Phenocrysts - average diameter 1 to 3 mm.
Groundmass - average diameter 0.5 mm.

Texture : Intergranular and porphyritic

Mineralogy : 70% feldspar
10% olivine
10% augite
5% magnetite
Apatite occurs as an accessory.

The olivine occurs as phenocrysts, which are subhedral to euhedral. Tiny granules are also present in the groundmass. Tiny laths of feldspar sometimes show rhythmic zoning, and occasional reverse zoning. The augite occurs as euhedral phenocrysts some of which show rhythmic zoning. Incipient grains and granules are present in the groundmass. Tiny magnetite euhedra are scattered throughout the rock and apatite is present in accessory amounts.

F 514 (R 15775, 11343) Porphyritic olivine basalt (Pirite basalt)

Locality : Airphoto Birap 6/5135 10 miles south of Wapenamunda on the Wabag - Mount Hagen road.

Occurrence : Lava flow.

Grainsize : Phenocrysts - range from 1 to 5 mm., average diameter 2 mm.

Groundmass - Average diameter 0.1 mm.

Texture : Intergranular and porphyritic

Mineralogy : 45% feldspar

40% olivine

10% augite

Olivine occurs as euhedral to subhedral phenocrysts whose diameters range from 1 to 5 mm. The feldspar, a labradorite in composition, forms tiny laths with random orientation. The laths are approximately 0.1 mm. in length. The augite occurs as euhedral phenocrysts whose diameters average 2 mm. in length, and as tiny granules amongst the feldspar. Magnetite euhedra are scattered through the groundmass in accessory amounts (average diameter 0.1 mm.). Tiny apatite crystals are also present.

F 538 (R 15770, 11338) Porphyritic basalt.

Locality : Airphoto Birap 5/5035. 5 miles south of Pomokos up Tchak River.

Occurrence : Lava flow.

Grainsize : Phenocrysts - average diameter 0.5 mm.

Groundmass - less than 0.1 mm. diameter.

Texture : Porphyritic and intergranular

Mineralogy : 80% feldspar

5% olivine

15% augite

The olivine occurs as subhedral phenocrysts. Anhedral and subhedral phenocrysts of augite tend to occur in groups, and the pyroxene is also present as anhedral granules in the groundmass. The feldspar occurs as tiny laths with a random orientation and comprises about 80 percent of the groundmass. Apatite and magnetite are accessory minerals.

G9 Olivine basalt

Locality : Airphoto Magare 4A/5145. Linanas.

Occurrence : Lava flow.

Grainsize : Very fine - less than 0.1 mm.

Texture : Hyalopilitic

Mineralogy : 5% olivine

60% labradorite

10% pyroxene

20% glass

5% unidentified opaque minerals.

The olivine occurs as euhedral to subhedral grains which are up to 1 mm. in diameter; although the average diameter is 0.4 mm. Much of the olivine shows alteration to the reddish brown mineral iddingsite, particularly along fractures and around the borders. Tiny granules of pyroxene are scattered among small laths of labradorite. Unidentified opaques form tiny euhedra, and the interstices between plagioclase, pyroxene and unidentified opaque minerals are filled with glass.

LAGAIP BEDS

F 21. (15779, 11347) Argillaceous limestone.

Locality : Airphoto Birap 4/5023. Tchak Valley.

Grainsize : Extremely fine - approximately 0.01 mm. This rock consists of a few foraminiferal fragments scattered through a very fine-grained matrix of silt-sized particles and calcite.

F 23. (R 15780) Fine-grained sandstone.

Locality : Airphoto Birap 4/5025. Taia River.

Grainsize : Average approximately 0.2 mm.

Degree of Sorting: The grains are well sorted within a particular layer, each layer being up to 2 mm. in thickness.

Degree of Rounding: Grains are mostly subrounded.

Fragments : 15% Quartz

40% altered feldspar

5% volcanic fragments

10% shreds of sericite

The shreds of sericite have been pinched between grains in many places.

Matrix : Appears to be a mixture of chlorite and clay size particles and makes up about 30 percent of the rock.

F 52. (R15772, 11340) Shale.

Locality : Airphoto Birap 1/5011. Ninimb River.

Grainsize : Average grainsize is less than 0.01 mm.

Degree of Sorting: Very good.

This rock is a very fine-grained argillaceous rock consisting of tiny fragments of quartz, chert, opaques, carbonaceous material, shreds of sericite, and very occasional Foraminiferal fragments.

F 131. (R 16571, 11842) Shale.

Locality : : Airphoto Tarua River Run 3/5081. Sui River.

Grainsize : Extremely fine-grained - less than 0.01 mm.

The rock contains well to poorly rounded grains of quartz set in an extremely fine-grained iron-stained matrix containing tiny shreds of sericite and chlorite. The rest of the matrix is too fine-grained to identify.

A weathering pattern visible to the naked eye in thin section appears to be due to slightly different concentrations of iron-staining.

F 752 (R 16580, 11851) <u>Very fine-grained conglomerate</u>

Locality : Airphoto Lake Iviva Run 4A/5127. Rama Creek.

Grainsize : Two average sizes can be recognized and the sorting into these sizes is fairly good.

(a) Lithic fragments - average diameter 3 mm.
(b) Mineral fragments- average diameter 0.5 mm.

Rounding : Rounding of the larger fragments (dominantly lithic) is good but in the smaller fragments, it ranges from good to poor.

Fragments : Lithic - 50%

25% altered volcanics (andesite

10% fossil fragments

10% recrystallized limestone

5% chert

Minerals : 5%

4% quartz

1% unidentified opaque minerals.

chlorite, brown garnet, and sericite.

Cement : 45 percent. At least two generations of calcite.

F 753 (R 16581, 11852) <u>Marl</u>

Locality : Airphoto Lake Iviva Run 4A/5127. Rama Creek. The rock consists of tests of <u>Globigerina</u> held in a calcareous mud together with ragged subrounded grains of chert approximately 0.05 mm. in diameter. There is no calcite veining of the rock.

F 772. (R 16582, 11853) <u>Globigerina limestone</u>.

Locality : Airphoto Lake Iviva 4A/5125. Sirunki.

In thin section, the only things to be seen are a few tests of <u>Globigerina</u> set in a calcareous mud. The rock itself is veined by calcite. Occasional veins show two generations of calcite, and two generations of veining appear to have taken place as indicated by the offsetting of certain veins by others.

G 12. <u>Foraminiferal calcarenite</u>

Locality : Airphoto Magare 4A/5143

Occurrence : Continuous bed.

Grainsize : Medium to fine (0.5 - 0.1 mm.).

Degree of Sorting : Fair

Degree of Rounding: Poor

Fragments : 45% foraminiferal remains

50% calcite cement

3% angular quartz fragments

G26A <u>Fine-grained conglomerate</u>

Locality : Airphoto Magare 1/5089

Occurrence : Bedded.

Grainsize : Largest fragments are 10 mm. in diameter - the average is about 3 mm.

Degree of Sorting: Poor.

Degree of Rounding: Mineral fragments are generally angular some subangular. Lithic fragments are subangular to subrounded.

Bedding : There is none obvious in thin section.

Types of fragments:
- 16% plagioclase
- 6% quartz
- 1% altered pyroxene
- 1% epidote
- 1% unidentified opaque minerals
- 33% shale
- 17% volcanic
- 5% chert (well rounded)

Matrix : Makes up about 15% of the rock, but in places the rock is held together by a chert cement, which makes up no more than 5% of the rock. The matrix is made up of clay particle-size material, together with some slightly larger recognizable fragments of quartz and feldspar.

<u>SAU BEDS</u>

F.12 (R15777, 11345) <u>Fine-grained lithic sandstone</u>

Locality : Airphoto Birap 2/5101. Ninim Creek.

Occurrence :

Grainsize : Uniform within a particular layer - 0.05 mm. - 0.2 mm.

Sorting : Very good within a particular layer.

Rounding : Grains are mostly subangular.

Fragments :
- 15% Mineral fragments
- 75% Lithic fragments

The mineral fragments are mainly feldspar with a few augite. The lithic fragments are all volcanic, and all are in various stages from almost complete chloritization to incipient chloritisation.

Matrix : The matrix makes up less than 10 percent by volume of the rock in the coarser beds, and is a mixture of feldspar, and quartz fragments together with carbonaceous material which occurs as shreds in places. Carbonaceous shreds in the finer-grained beds shows pinching between the grains indicating that there has been considerable compaction.

F 57 (R 15774, 11342) Coarse-grained lithic sandstone

Locality : Airphoto Birap 1/5013. Ninimb River.

Occurrence :

Grainsize : Average grain diameter is about 2 mm., though some are larger than this.

Degree of Sorting: Good.

Degree of Rounding: The majority of the fragments are subrounded to subangular.

Cement : Small amount of calcite cement - less than 5% by volume.

Fragments : 10% mineral fragments.
85% volcanic fragments.

The mineral fragments are feldspar and augite, the feldspar making up about 70 percent of the mineral fragments, and augite the rest. The lithic fragments are all rather weathered volcanic fragments.

F 81 (R 16559, 11830) Feldspathic Sandstone.

Locality : Airphoto Lake Iviva 4A/5129. Ambun Valley

Grainsize : 0.25 mm. to 1 mm.

Sorting : Good.

Rounding : Subrounded to angular.

Fragments : 60% feldspars altered and fractured
5% sphene, apatite, unidentified opaque minerals } Angular

Matrix : 5% clay

Cement : 25% chlorite with about 5% calcite cement.
Neither grading nor bedding is obvious in thin section.

F 83 (R 16560, 11831) Coarse Siltstone.

Locality : Airphoto Lake Iviva 4A/5129. Ambun Valley.

Grainsize : Less than 0.05 mm.

Sorting : Very good.

Rounding : Rounded to subangular.

Fragments : 10% altered feldspars
2% subrounded quartz
2% unidentified opaque minerals
1% calcite grains
chlorite grains
Occasional foraminiferal remains.

Matrix : 85% extremely fine-grained clay size matrix holds the fragments together. There is no cement. Neither bedding nor grading are seen.

F 123B (R 16566, 11837) <u>Fine Grained Siltstone</u>

Locality : Airphoto Tarua River 3/5079. Leanda Creek.

Grainsize : Less than 0.1 mm.

Sorting : Good

Rounding : Fair to poor. From rounded to angular.

Bedding : Bedding is marked by (i) slightly different grainsize between beds (ii) different colour of a bed due to different concentration of elongate carbonaceous material which lies with its long axes parallel to the bedding.

Fragments : Calcite from 5% to 30% in some beds

Quartz 5% to 10%

Feldspar 5% to 15%

Lithic fragments 5% to 10%

Unidentified opaque minerals less than 1%.

The lithic fragments are probably very fine-grained altered volcanics.

Matrix : Extremely fine-grained clay size material from 5% to 20% depending on bed.

F 634 (R 16578, 11849) <u>Andesite</u>

Locality : Airphoto Magare 4/5129. Sandover River.

Occurrence : Boulder in conglomerate bed

Grainsize : Phenocrysts up to 4 mm. in diameter.

Groundmass less than 0.05 mm.

Mineralogy : Phenocrysts

15% plagioclase

15% amphibole

60% groundmass

2% unidentified opaque minerals

The <u>plagioclase</u> phenocrysts are a calcic andesine or a sodic labradorite in composition they are euhedral, complexly twinned and zoned. They show some signs of resorbtion and some kaolinization has taken place in some of the outer zones of crystals. The amphibole is recognisable only by its outline. It is completely altered to an unidentified opaque mineral and an unidentified colourless mineral. The unidentified opaque minerals occur as subhedral crystals scattered through the rock. The groundmass consists of extremely fine-grained feldspar crystals, mostly kaolinized, granules of augite and granules of unidentified opaque minerals.

APPENDIX IV

PRINCIPAL RESULTS OF THE WESTERN HIGHLANDS SURVEY, 1963

by

J.E. Thompson.

The 1963 survey in New Guinea covered, by reconnaissance, about 3000 square miles of very mountainous country between Hagen and Porgera in the Western Highlands District. Within the mapped area, elevations range from 3000 to 13,000 feet above sea level. Native population, administrative centres and mission stations are concentrated in the principal valleys and on the lower slopes of their flanks; the higher country is unpopulated and trackless. Geological observations in the mountains, above the level of the population, were made with the aid of a Chartered Bell 47G3B1 (supercharged) helicopter available from 3rd to 26th October.

The Bismarck Fault which strikes north-north-westerly across the north eastern corner of the mapped area is a profound lineament which separates Jurassic and Lower Cretaceous marine sediments and volcanics on the north-east from a complexly folded and faulted thick (+20,000 ft.) accumulation of marine Upper Cretaceous and Tertiary clastic sediments, limestones, and submarine volcanic deposits. The area mapped was almost entirely on the south-western (down) side of the Bismarck Fault, in the folded and faulted complex of Upper Cretaceous and Tertiary rocks. In the south-eastern part of the area Quaternary fragmentary volcanic deposits, and some basaltic lavas, are widespread and dominate the landscape. At the eastern extremity of the area, near Porgera, high-level plug-like intrusions of microdiorite, probably emplaced in Pliocene time, have locally mineralized (gold, silver, pyrite and quartz) sediments of Upper Cretaceous to lower Miocene age.

Topographically and geologically the area is divided diagonally by the contiguous valleys of the west-north-west flowing Lagaip River and the east-south-east flowing Lai Rivers. Discordant structure and strongly contrasting facies in Miocene sediments of comparable age across these valleys strongly suggest that the valleys occupy a zone of faulting along which considerable strike-slip displacement has taken place in Pliocene to Recent time. The regional swing of fold axial trends in Miocene sediments south of this valley system, from meridional in the east to west-north-westerly in the west, is consistent with left lateral displacement along the Lagaip-Lai fault zone.

When planning the survey it was hoped that further information on the newly Triassic sediments might be obtained. These sediments were not seen and it is assumed that they do not crop out south of the Bismarck Fault Zone.

It was also hoped that further evidence would be found of the Mesozoic/Tertiary unconformity represented throughout the Papuan Basin by sporadic and thin sedimentation from Upper Cretaceous (Senonian) through to the upper Eocene, whereafter there is no record of sedimentation until lower Miocene time. While it is almost certain that there is at least one major unconformity within the area mapped, none could be definitely identified on the ground because of complicated tectonics, limited exposure and comparable facies in both

Cretaceous and Miocene sediments. However, micropalaeontological studies to date by D.J. Belford have revealed Upper Cretaceous (Maestrichtian) and Paleocene fauna but, as elsewhere in the Papuan Basin, no Oligocene representation. Thus it appears that the Kutubu Trough (A.P.C. 1961) may be a north-westerly plunging embayment of a pre-Oligocene orthogeosyncline with an axis roughly parallel to the Lagaip-Lai-Wahgi valley system. A possible unconformity interpreted from airphotos on the southern flank of the Lagaip Valley near Laiagam could represent the elusive Oligocene hiatus in sedimentation. However, this possible unconformity was only detected on detailed photo-interpretation after the survey and could not be checked in the field.

Before this survey the extent of upper Miocene transgression into the central mountainous part of New Guinea, either northwards from the Papuan Basin or southwards from the Northern New Guinea Basin, was not known. The recognition during this survey of upper Miocene (?Pliocene) fauna in lenses of shoal limestone at 13,000 feet above sealevel on Mount Burgers in the Central Range, suggests that upper Miocene seas of both basins may have been linked through shallow areas, and points with certainty to the magnitude of the vertical component of orogeny since the upper Miocene. The component of lateral shift during this same time is unknown but dislocation of fold axes in the Yangi Highlands suggests that it has been at least 30 miles in a left-lateral sense.

It was thought that the middle to upper Miocene reef and shoal limestones of the southern shelf of the Papuan Basin may have extended into the southern part of the map area. This was not so; the only Miocene limestones in the area were deep basinal marls of similar facies to the Puri-type limestones of the south-eastern flank of the Aure Trough.

During the helicopter phase of the survey several stratigraphic sections were measured and sampled for later palaeontological study. This work has been rewarding in that a Paleocene microfauna and an assemblage of lower Miocene (Aquitainian/Burdigalian) planktonic foraminifera not hitherto recorded from New Guinea, have been identified. These findings, while not of particular importance within the boundaries of the mapped area, are valuable in the palaeo-geographic reconstruction of the total Papuan Basin.

No new information was obtained on gold and silver mineralization in the Porgera Valley, and the analyses of stream sediment samples taken over most of the area have not indicated any anomalously high metal concentrations.

The robustly folded and faulted Paleocene to middle Miocene marine sequence in the southern half of the area has all the primary ingredients for oil and gas generation and accumulation,but two superimposed factors seriously impair the attractiveness of this area for oil search. They are: firstly, inaccessibility - the area is mostly unpopulated and between 8000 and 12,000 feet above sea level; and secondly, the probability of deep flushing of any indigenous fluids by groundwater in this area of high relief, high rainfall and deep dissection.

Bureau of Mineral Resources, Geology and Geophysics   April 1964   To accompany Record No 1964/137   B 54/A8/8

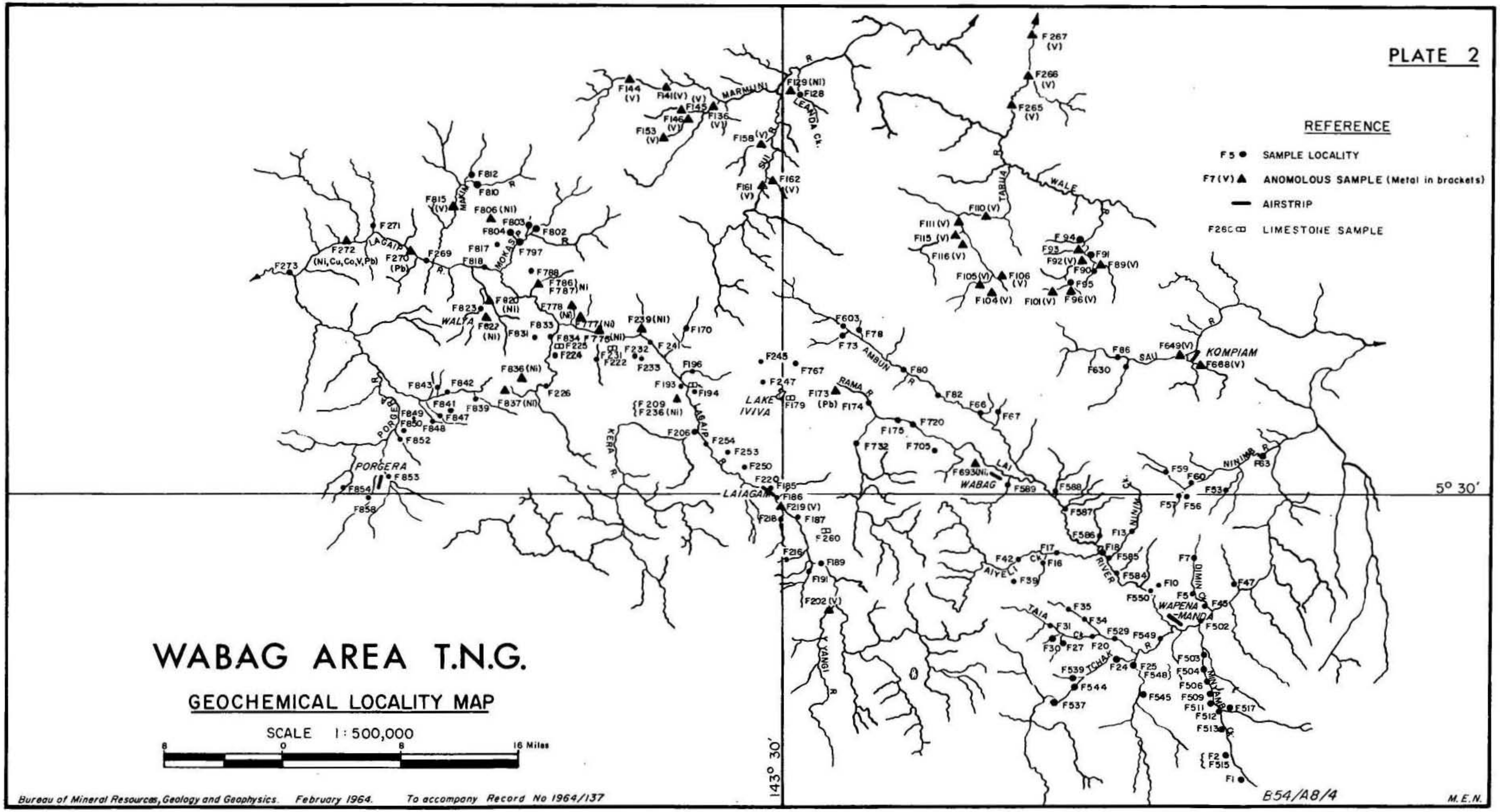
PLATE 2
WABAG AREA T.N.G.
GEOCHEMICAL LOCALITY MAP
SCALE 1 : 500,000
8 0 8 16 Miles
REFERENCE
F5 SAMPLE LOCALITY
F7 (V) ANOMOLOUS SAMPLE (Metal in brackets)
AIRSTRIP
F26C LIMESTONE SAMPLE
5° 30'
143° 30'
LAIAGAM
WABAG
KOMPIAM
PORGERA
WAPENA
MANDA
LAKE IVIVA
LAGAIP R.
LAIAGAM
MARMUNI
LEANDA CK.
SUI R.
TABUA R.
WALE R.
SAU R.
AMBUN R.
RAMA R.
LAI R.
NINIMB R.
LAGAIP R.
KERA R.
PORGERA R.
MAKIM
MOKAS
WALYA
AIYELI CK.
RIVER
TAIA CK.
TCHAK R.
YANGI R.
DIMIN
MINYAMBI
F272 (Ni, Cu, Co, V, Pb)
F270 (Pb)
F173 (Pb)
F129 (Ni)
F219 (V)
F202 (V)
F649 (V)
F668 (V)
F267 (V)
F266 (V)
F265 (V)
Bureau of Mineral Resources, Geology and Geophysics. February 1964. To accompany Record No 1964/137
B54/A8/4
M.E.N.

Plate 3

SECTION I . MARAMUNI VALLEY

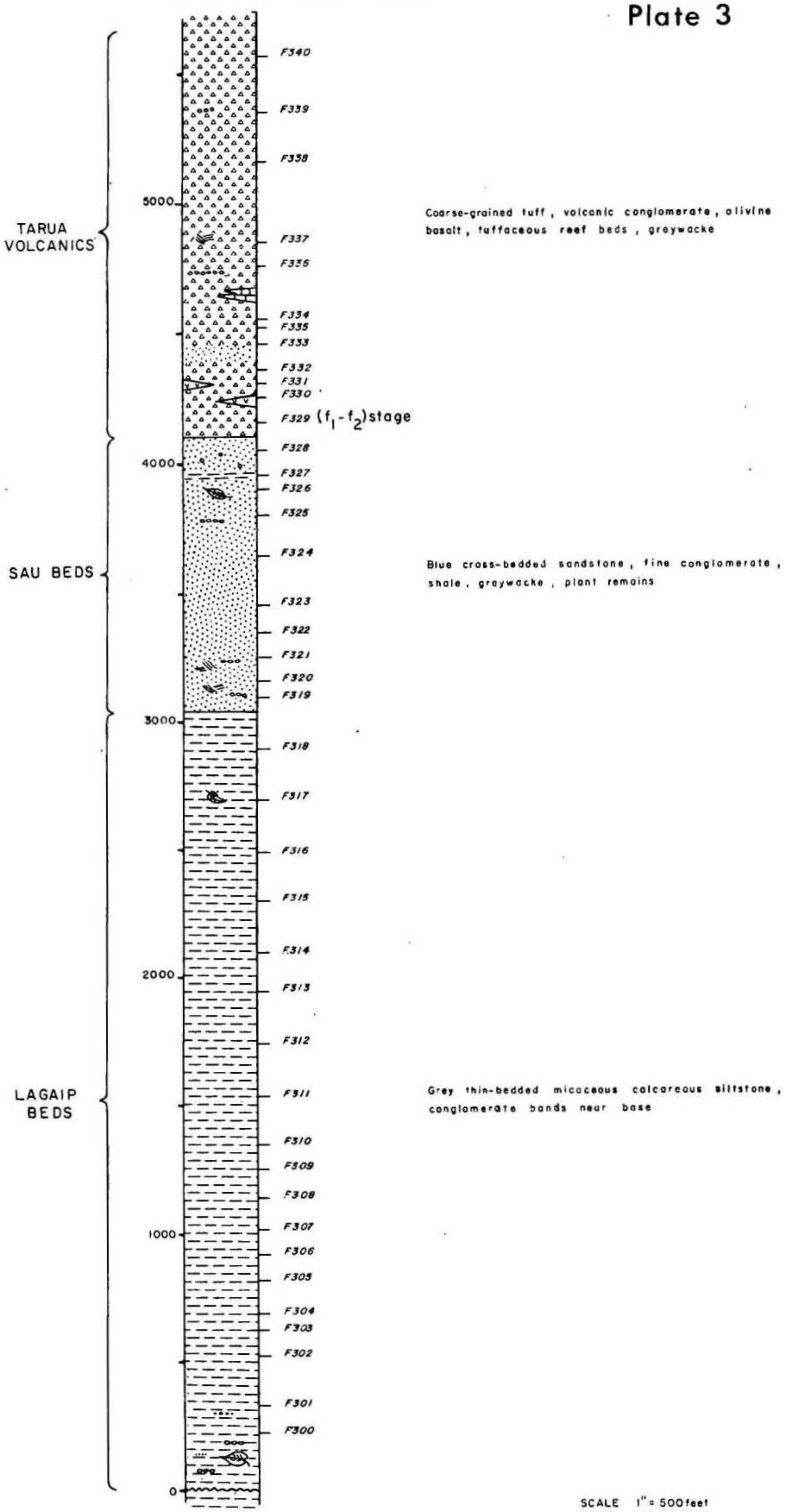

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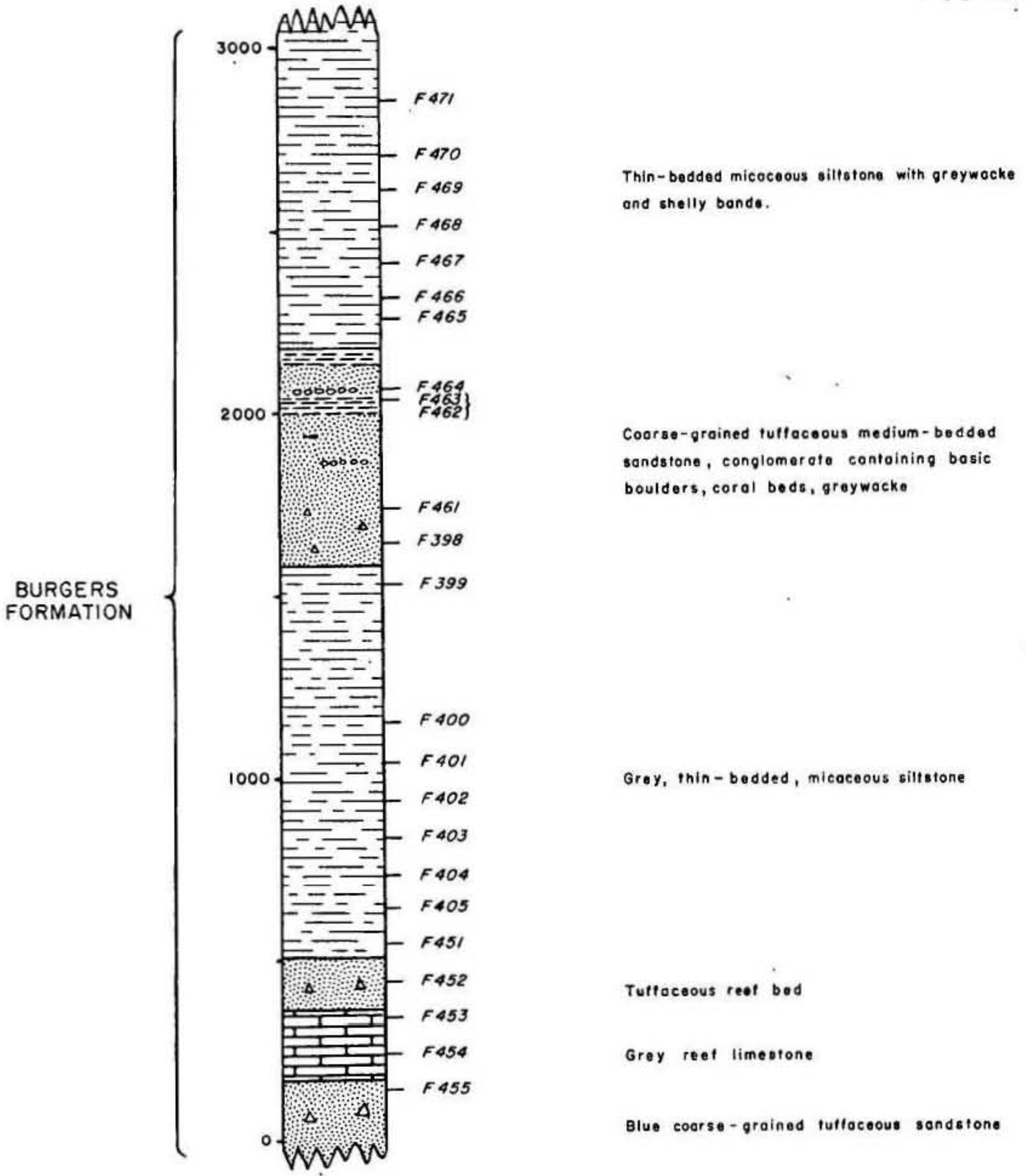
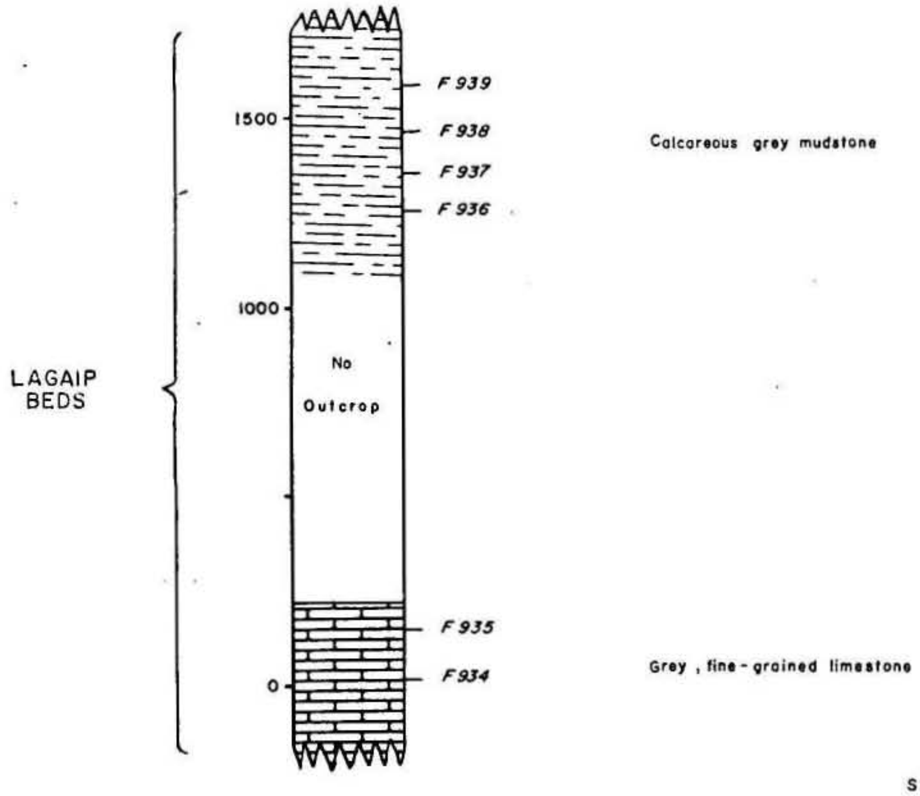
Plate 4

SECTION 2. BURGERS MOUNTAINS



SECTION 3. LAIAGAM

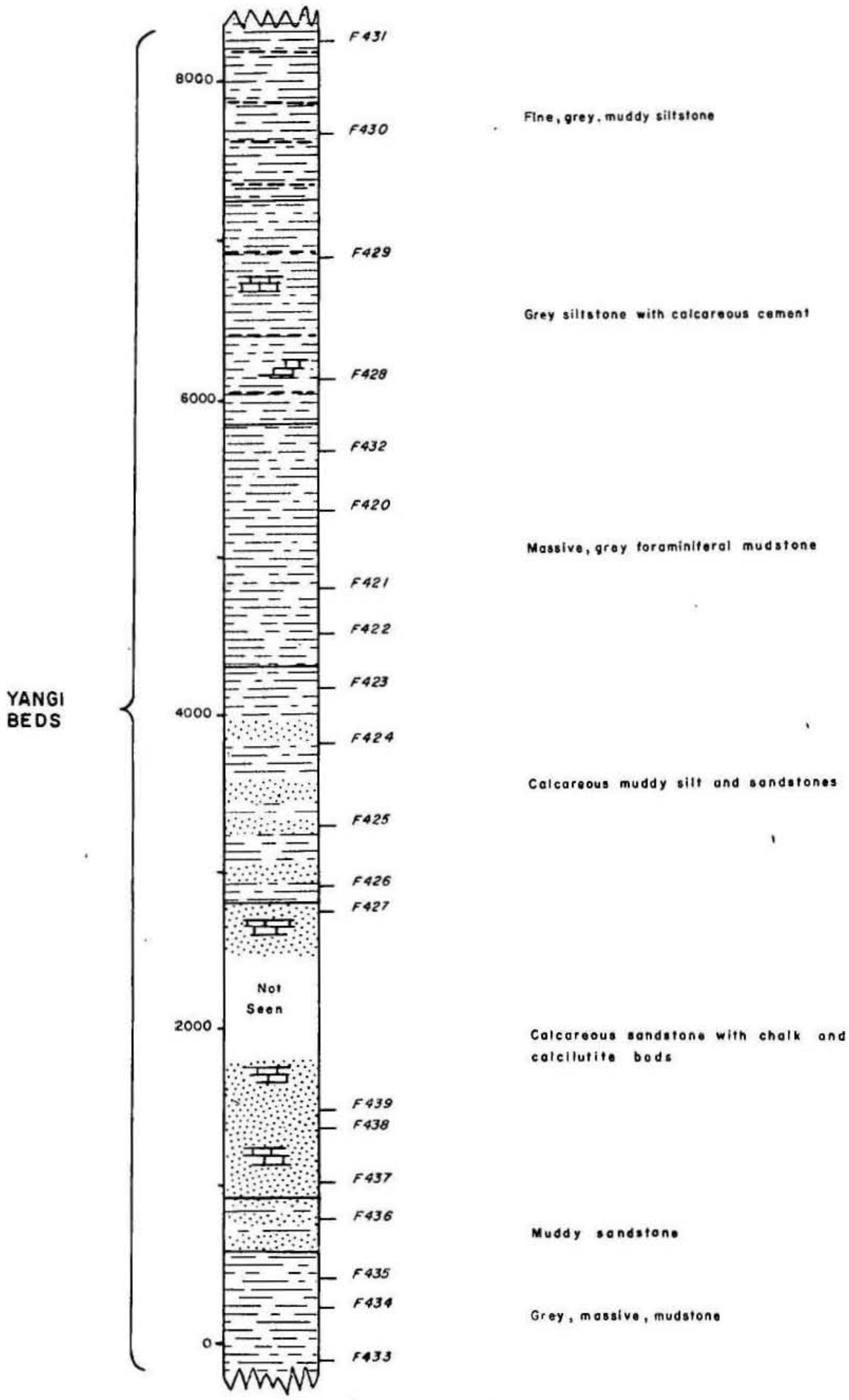


SCALE 1" = 500'

Bureau of Mineral Resources, Geology and Geophysic. February 1964 To accompany Record No 1964/137 B 54/A8/13

Plate 5

SECTION 4 : KINDAN

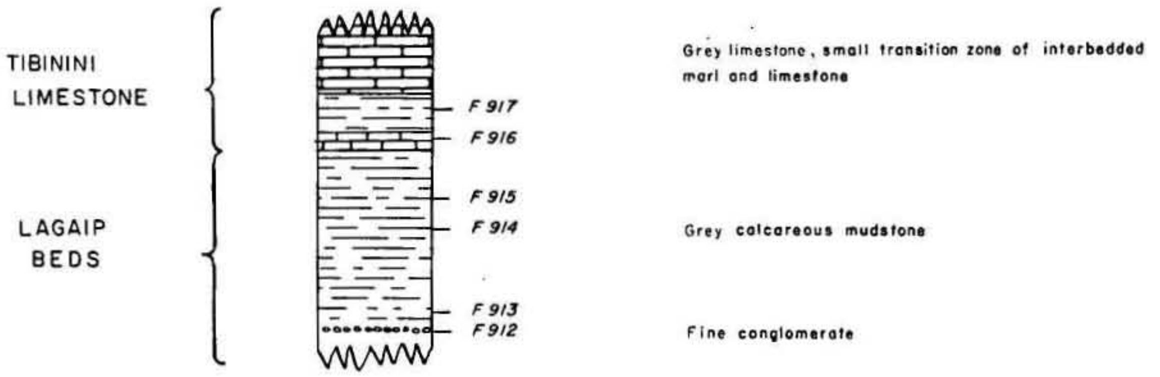


SCALE 1" = 1000 ft

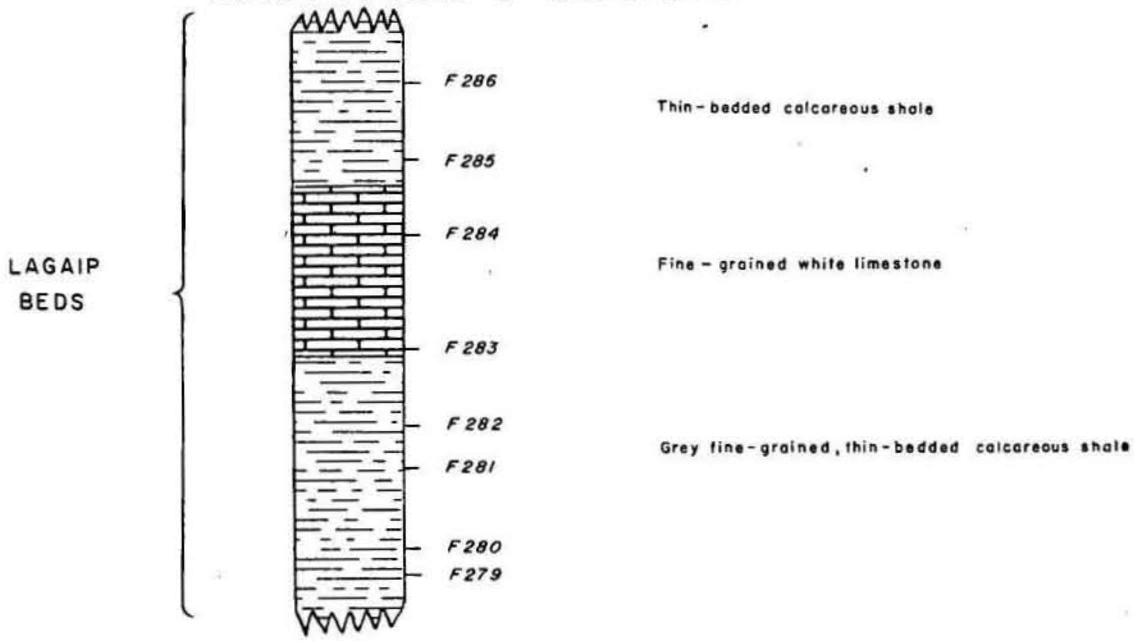
Bureau of Mineral Resources, Geology and Geophysics. February 1964 To accompany Record No 1964/137 B54/A8/12

Plate 6

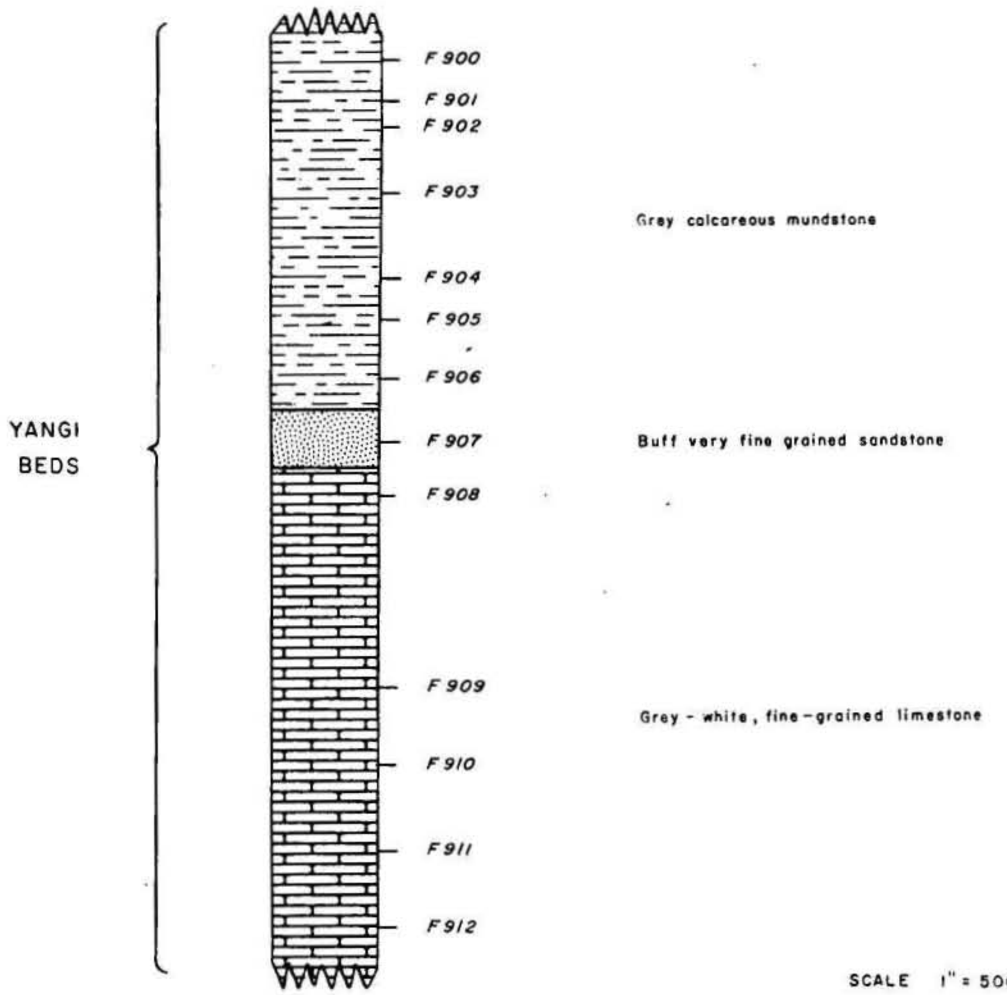
SECTION 5 : TIBININI



SECTION 6 : SOUTH OF CRATER LAKE



SECTION 7 : ANDEBARE RIVER



SCALE 1" = 500 feet

Bureau of Mineral Resources, Geology and Geophysics. February 1964 To accompany Record No 1964/137 B54/A8/14