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THE GEOLOGY OF THE KAINANTU GOLDFIELDS

by

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SUMMARY

The geology of an area covering most of the known gold occurrences in the Kainantu district was mapped in detail.

Probable Palaeozoic metamorphic rocks, the Bena Bena Formation, intruded by probable Lower Jurassic Bismarck Granodiorite and Mount Victor Granodiorite, constitute the basement on which Miocene e-stage Nasananka Conglomerate and Omaura Greywacke were laid down. Miocene f-stage Lamari Conglomerate, comprising basal volcanic rocks and overlying conglomerate, rest disconformably on the Omaura Greywacke. Andesitic Aifunka Volcanics of probable Pliocene age, Pleistocene lake sediments, and recent alluvial deposits complete the stratigraphical record of the Goldfields.

Extensive intrusion of dolerite and gabbro (the Akuna Dolerite), accompanied the Miocene f-stage vulcanism, and intrusion of the andesitic Elendora Porphyry accompanied the Pliocene volcanics.

The basement rocks and the Miocene e-stage sediments were broadly folded along east-west trending axes before the deposition of the Lamari Conglomerate in Miocene f-stage time. Later folding and concomitant faulting took place along east-north-east trending axes to form the Arona Syncline.

Alluvial gold has been shed by the Nasananka Conglomerate, but by far the greater proportion of the alluvial gold originated in the Elendora Porphyry. Most of the economic gold deposits derive from Porphyry gold deposited in the lake sediments and reworked by recent streams. Lode gold is known at several localities, but only two, Barola Reefs Mine and Mount Victor Prospect, are possible economic prospects. Minor deposits of lead-zinc, copper, cinnabar, beryl, and rutile are known, but are not economic. A large pyrite deposit at Mount Victor is a potential source of sulphur.

INTRODUCTION

Location

The area described covers the Kainantu one-mile area, and parts of Gonomi, Tamiloa Range, Lamari River, Mount Karsina, and Onga one mile areas. It is bounded by longitudes 145° 38' and 146° 05' East, and latitudes 6° 12' and 6° 32' South.

Access

Kainantu, which is the main centre in the area, is on the road linking the Western Highlands with Lae, a seaport on the Huon Gulf. The road is passable to conventional vehicles in the dry season, but care must be exercised at the Leron Ford in the Markham Valley. During the wet season, flooded rivers make the journey up the Markham Valley a somewhat hazardous one. Roads which radiate from Kainantu link all centres of European population.

Supplies for the region are mostly freighted by D.C.3 aircraft to Kainantu, which has an all-weather airstrip. Small airstrips suitable for light aircraft are maintained at Aiyura, Arona, Karanka, and Tarabou.

Field Method

The object of the survey was to map in detail the geology of an area covering the gold occurrences in the Kainantu district, here called the Kainantu Goldfields, and to assess the economic potential of the area. This work further served to extend the mapping of the Eastern Central Highlands done by McMillan and Malone.

Fresh rock exposures are for the most part confined to stream courses, although some rocks such as the Elendora Porphyry and the Sonofi Limestone, form extensive outcrops. Soils are shallow, and road cuttings commonly reveal weathered remnants of underlying rocks but outcrops along walking tracks are scarce.

Field observations were plotted directly on vertical aerial photographs of the Kainantu and Finintegu series which cover the entire area mapped. The initial base map was prepared from an uncontrolled mosaic of aerial photographs, but the part covering the Kainantu one-mile area was discarded when the provisional one mile sheet, released by the Division of National Mapping, Canberra, came to hand.

Photogeological interpretation is possible on a broad scale with the aid of some ground information. Post-Miocene faults can be clearly seen, and limestone ridges stand out in grass covered country, but some erosional and vegetation patterns investigated appear to be unrelated to the geology.

Climate and Vegetation

This area lies within the "tierra templada" zone of Köppen's climatic classification (Köppen 1931). The region is not subject to definite seasons, and rain falls during every month of the year. Less rain falls from May to September. The average annual rainfall is 80 inches at Kainantu and 87 inches at Aiyura.

The average maximum and minimum temperatures are constant, the annual average maximum temperature being 74.8°, and the annual average minimum, 56.3°F. Maximum average temperatures never exceed 76.9°F. for any monthly period, nor do they fall below 71.8°F. Minimum average temperatures range from 59.0°F. to 54.4°F.

Most days are warm, and nights are pleasantly cool, but above 6000 feet nights can be cold. Winds are generally light, and have no set pattern; overcast weather can persist for days on end, making the uplands very cold and bleak.

Two main types of vegetation exist; 1) Rainforest, 2) Grassland. The rain forest is characterised by dense undergrowth, and is difficult to penetrate in areas where paths are not well defined. The larger valleys and basins have been deforested by continual burning of the vegetation, and are now mainly grasslands. In the large eastward trending valley to the south of Okapa there is a large stand of Hoop Pine (Araucaria cunninghami).

Population and Industry

About 70,000 natives and 300 Europeans live in the area; only in the south in areas of dense forest, are villages sparse.

There are five centres of European population; Kainantu, Aiyura, Okapa, Omaura, and Arona. Kainantu is the sub-district centre, Aiyura a Government agricultural research station, Okapa a patrol post and medical research centre, Omaura a Seventh Day Adventist Mission, and Arona was, until recently, a Government experimental stock station. The Summer Institute of Linguistics has its headquarters near Aiyura. Many European coffee plantations are centered on Kainantu, which has a European population of about forty-five. Town amenities consist of a European general store, several trade stores, a 5 k.v.a. power supply, a native hospital, hotel, golf course, tennis courts, and country club.

Lutheran, Catholic, Seventh Day Adventist, and Four Square Missions, as well as the Summer Institute of Linguistics, have field workers settled throughout the district.

The map area has about ten coffee plantations run by Europeans and many natives now grow coffee as a cash crop. With the decline of the goldfields, gold mining is carried out almost exclusively by small groups of natives working small alluvial deposits. Other minor industries are cattle raising, vegetable growing, and a tea plantation at Karanka.

Previous Investigations

The first geological investigation in the Central Highlands was made by N.H. Fisher, Government Geologist for the Territory of New Guinea, who carried out a reconnaissance of the area in December, 1940, and January, 1941. His maps and notes were lost when the Japanese invaded New Guinea.

G.A.V. Stanley and K.M. Llewellyn, of the Australasian Petroleum Company, made a reconnaissance of the Central Highlands in 1949. They traversed the north-western and southern parts of the area mapped by the present writers, and photo-interpreted the geology of the south-western area.

In 1945 N.J. MacKay, of the Resident Geological Staff, investigated those parts of the area which are drained by the Ramu River.

N.J. McMillan and E.J. Malone's report on "The Geology of the Eastern Central Highlands of New Guinea" takes in the northern part of the area investigated in this report.

Investigations of mineralized areas have been made by J.G. Best, H.L. Davies, and D.B. Dow of the Resident Geological Staff, New Guinea Mines Division.

TOPOGRAPHY

The Kainantu region is a moderately dissected highland averaging about 5500 feet above sea level, but ranging as high as 9000 feet at Mount Elendora.

A narrow south-east trending dissected plateau dominates the map area to the south; it forms the watershed between rivers draining north to the Markam-Ramu Graben, and those draining south to the Papuan coast. The average elevation of the plateau is about 8000 feet - 2500 feet above the surrounding country. The plateau is eleven miles wide on its north-western end, but

Figure 1: Arona Valley looking north, with Yonki Dome on left. The Ramu River flows northwards through the saddle in the middle background, then drops nearly 3,000 feet through a gorge to the Markham-Ramu Graben. The flat-floored Arona Valley consists of Pleistocene Kainantu Lake Beds.

Figure 2: Headwaters of the Lamari River, looking downstream. The river cuts through Miocene Lamari Conglomerate in the gorge seen in the middle distance. Mount Piora (about 12,000 ft) is on the skyline.

narrows to about three miles to the south-east, where Nompia Creek cuts across it in a deep gorge. East of Nompia Creek, it is about eight miles wide, and the Lamari River flows across it in another deep gorge. The streams draining the plateau are mature over most of their courses, but near its edge they are deeply incised, and flow along youthful valleys.

The Kainantu Valley has an average elevation of about 5,200 feet, and is a basin of low relief occupied by flat-lying lake sediments. The basin is drained by the Ramu River, and the dissected lake deposits now have a rolling downs topography. The Arona Valley averages about 4200 feet above sea level, and is similar to the Kainantu Valley. It also is drained by the Ramu River which, on the northern margin of the map area, drops steeply to the Lower Ramu River through a very deep, steep-sided gorge.

South of Kainantu is an area of low relief. Most of the streams in this area flow parallel to the Arona and Kainantu valleys and follow flat meandering courses. Swampy areas are common in the valleys, the largest being the Norei Korei Swamp. The interfluves in this area are of low relief and broadly rounded.

STRATIGRAPHY

The oldest rocks exposed in the area are probable Palaeozoic metamorphics belonging to the Bena Bena Formation. Lower Miocene marine sediments, named here Nasananka Conglomerate, Omaura Greywacke, and Lamari Conglomerate were deposited unconformably on the metamorphics. Local eruptions formed the Pliocene Aifunka Volcanics. Pleistocene lake sediments, called the Kainantu Beds, and recent alluvium complete the stratigraphic column in the map area.

Bena Bena Formation

The name Bena Bena Formation was proposed by MacMillan and Malone in 1960, the type locality being in the Bena Bena River Valley, 24 miles north-west of Kainantu. The formation extends into the north-western corner of the map area where it unconformably underlies the Lower Miocene e-stage Nasananka Conglomerate.

In the map area the formation is mainly green actinolite schist and quartz muscovite schist in which the bedding has generally been obliterated. Light-coloured hornblende feldspar gneiss is common, and, in places near Kainantu, a sheared gneissic rock consisting of white feldspar and quartz was seen.

The rocks are riddled with small veins of glassy quartz; these are rarely more than six inches wide and several feet long. The veins contain scattered clots of muscovite; they have sharp contacts with the country rock, and are roughly concordant with schistosity. Also common are veins of fine-grained quartz-muscovite-feldspar pegmatite which rarely exceed several feet in length.

The Bena Bena Formation is pre-Miocene, and it can possibly be correlated with the pre-Permian Omung Metamorphics, which crop out 50 miles to the west-north-west (Rickwood, 1955), though recent work, (Dow and Dekker 1963) suggests that they could be Mesozoic.

Nasananka Conglomerate. (New Name)

The Nasananka Conglomerate consists of conglomerate, arkose, and minor greywacke; it crops out as an arcuate belt in the north-western corner of the map area, and as an east-west trending belt south of Omaura. The name is derived from Nasananka Creek, a tributary of the Ramu River about seven miles south-west of Kainantu, where the formation is well exposed.

To the north-west, where the conglomerate unconformably overlies Palaeozoic Bena Bena Formation it consists mainly of metamorphic components, but to the east, the component pebbles are mainly granodiorite derived from the underlying Mt. Victor Granodiorite.

In the north-western corner the main rock type is dark indurated pebble to boulder conglomerate; it consists of sub-rounded to sub-angular pebbles and boulders of schist, gneiss, argillite, silicified greywacke, quartz, and igneous rocks, in a coarse-grained greywacke matrix. The matrix is commonly carbonaceous, and contains wood fragments in places. The beds of conglomerate range in thickness from a few inches to several hundred feet; they are generally massive, though current-bedding has been noted in a few places.

Greywacke and siltstone are common in the formation, but subordinate to the conglomerate. The greywacke is dark blue to dark grey, fine-grained to coarse-grained, and is generally medium - to thick-bedded. The coarser beds grade both laterally and vertically into conglomerate. The siltstone is dark-coloured and micaceous.

The formation shows marked variations in thickness; it is 500 feet to 1000 feet thick in the north-west, and thickens to over 8000 feet near Nasananka Creek. In the Ornapinka Creek area it is again 500 feet to 1000 feet thick, but on the eastern side of the map area it is only 50 to 200 feet thick.

The formation was laid down in shallow water close to the shoreline. The great thickness of conglomerate near Nasananka Creek shows that this area was probably near the mouth of a large river.

The Omaura Formation which conformably overlies the Nasananka Conglomerate is Miocene e-stage and the conglomerate is regarded as only slightly older.

Conglomerate which crops out on the southern margin of the map area has been tentatively correlated with the Nasananka Conglomerate. The base of the conglomerate was not seen, and it is overlain by a thick sequence of greywacke and siltstone, lithologically similar to the Omaura Greywacke.

The components of this conglomerate range in size from pebbles to boulders up to four feet across, and are set in a coarse-grained greywacke matrix. The pebbles and boulders are generally well-rounded, though sub-angular boulders were commonly seen. They consist of the following components roughly in decreasing order of abundance: granitic rocks, quartz, gneiss, hornfels, chert, indurated greywacke, mica schist, and andesite porphyry. The conglomerate is massive and highly indurated.

Thin interbeds of coarse-grained greywacke, arkosic sandstone, and arkose constitute about 10% of the formation. These rocks are generally less indurated, are massively bedded, and commonly contain carbonaceous fragments.

Omaura Greywacke (New Name)

Omaura Greywacke is the name proposed for a sequence consisting predominantly of greywacke and siltstone. The name is derived from Omaura Mission, which is 10 miles south-east of Kainantu on the northern margin of an east-west trending belt of these rocks. The formation conformably overlies the Nasananka Conglomerate and is unconformably overlain by the Miocene f-stage Lamari Conglomerate.

Omaura Greywacke crops out extensively in the western half of the map area, and in the type locality it occurs as an easterly-trending belt between Mt. Ubank Prospect and Karanka.

The formation is predominantly fine-grained to medium-grained greywacke, commonly calcareous, with interbedded siltstone and minor beds of limestone, arkose and pebble conglomerate. Detailed stream sections were mapped, but only one, in the south near Asempa Village was measured by chain and compass. The others were plotted in detail on the aerial photographs, and approximate thicknesses calculated from the photographs.

The following section was mapped along the Wanton River, and a small tributary to the north, between Omaura Mission and Karanka.

TOP

850 feet. Almost all calcareous greywacke. Fine-grained to medium-grained, green to dark blue, generally micaceous and invariably calcareous. Contains thin interbeds of dark coloured micaceous siltstone which are generally phyllitic and have an incipient slaty cleavage; also invariably calcareous. Scattered crystals of pyrite, probably originating in dolerite and gebbro dykes of the Akuna Dolerite which intrudes this part of the section. The siltstone interbeds are generally less resistant than the greywacke, and the bedding is easily seen in outcrop; the rocks are thin bedded or laminated.

650 feet. Fine-grained calcareous greywacke and interbedded calcareous siltstone with sparsely distributed beds of fine-grained calcarenite up to 20 feet thick. The greywacke is dark blue to greenish-grey, fine-grained, and generally calcareous. The siltstone constitutes about 60 percent of the sequence; it is dark blue to brown, calcareous, indurated, and slightly recrystallised. It grades to phyllite in some places. The calcarenite is medium-grained, light grey, and is usually slumped and brecciated. Outcrop in this section is generally massive, though thin-bedding can be distinguished in good exposures.

150 feet. Coarse-grained calcareous greywacke consisting of fragments of chert, calcite, and quartz, in a calcareous, argillaceous matrix. Medium-bedded.

150 feet. Mainly medium-grained to coarse-grained arkose consisting of subangular to rounded fragments of feldspar, quartz, and chert with detrital muscovite. Some obscure fossil fragments. Grades downwards into feldspathic greywacke. Massive and thick-bedded.

350 feet.	Green feldspathic greywacke, medium-grained; grades downwards into fine-grained dark calcareous greywacke and siltstone. Medium-bedded.
200 feet.	Dense, fine-grained, grey-brown sheared limestone. Many small irregular calcite veins. Bedding massive.
550 feet.	Fine-grained dark, calcareous greywacke and calcareous siltstone. Finer beds slightly phyllitic. Some indurated, green to dark grey, micaceous greywacke. Generally medium-bedded.
400 feet.	Medium-grained feldspathic greywacke, green to light grey, and consisting of sub-angular fragments of feldspar quartz and muscovite. Large andesite porphyry dyke belonging to Elendora Porphyry. Sediments medium-bedded.
150 feet.	Coarse-grained massive calcarenite.

TOTAL: 3450 feet

Nasananka Conglomerate

The total thickness calculated is about 3500 feet, but the top of the formation was not seen.

In thin section, the greywacke is seen to be poorly sorted; it consists predominantly of angular to subrounded fragments of quartz, quartzite, feldspar, and rock fragments such as basalt, greywacke, and dark, fine-grained rocks. These fragments are chaotically distributed in an argillaceous matrix which constitutes over 30 percent of the rock. Near the Akuna Dolerite the rocks are metamorphosed to the albite-epidote-amphibolite facies. The matrix has been recrystallised, and consist of fine-grained tremolite, penninite, finely crystalline quartz, plagioclase, calcite, and some epidote.

The sequence given above is typical of the Omaura Greywacke between Mt. Ubank Prospect and the eastern margin of the map area. Graded bedding, intraformational conglomerate, scour and fill of the underlying beds, and flow casts are very common in this area and they indicate deposition in a geosynclinal environment.

Omaura Greywacke is again well exposed between Aiyura and Kainantu in the Taiora and lower Akwiranu Creeks. The rocks in this area are finer-grained, and comprise mainly siltstone and thin interbeds of fine-grained greywacke.

The siltstone is dark, fine-grained, commonly calcareous and grades to shale. The finer beds in particular are highly indurated and silicified, and grade into cherty siltstone; in some places an incipient slaty cleavage is developed at an angle to the bedding. The formation is generally massive and irregularly jointed; bedding is confined to the greywacke which is thinly interbedded with dark blue and grey siltstone. Slump structures are common.

The greywacke is fine-grained and occurs as thin beds between one inch and three inches thick. It is light grey or green, commonly calcareous, and almost invariably highly indurated, and constitutes about 20 percent of the sequence. Both graded bedding and cross bedding are common. Scattered crystals, veinlets, and joint linings of pyrite found throughout the section in the Aiyura-Kainantu area were probably introduced by the Akuna Dolerite.

Sediments in the southern part of the map area which are lithologically very similar to the Omaura Greywacke have been tentatively referred to this formation. The following section was measured near Asempa Village:

TOP

100 feet	Hard, fine-grained, recrystallised, light grey limestone.
330 feet.	Light grey fine-grained calcareous greywacke, jointed, veined with calcite; grades upwards into slightly coarser fraction which is darker grey in colour.
30 feet.	Interbedded, coarse-grained marble limestone and light grey, calcite-veined, fine-grained, calcareous greywacke.
500 feet.	Discontinuous outcrop of fine-grained, dark to light grey calcareous greywacke; much of this section is jointed, and some rocks display small-scale folding.
20 feet.	Fine-grained, thin-bedded, calcareous greywacke with interbeds of recrystallized limestone up to 1 foot thick.
200 feet.	Massive, light grey, fine-grained, calcareous greywacke.
130 feet.	Medium-grained, light grey greywacke which contains rounded lithic components up to 3" in diameter, and which is interbedded with recrystallized limestone beds up to 3 feet thick.
1200 feet.	Very uniform, massive, jointed, fine-grained, dark to light grey, calcareous greywacke - outcrop is discontinuous.
100 feet.	Massive, cavernous limestone beds, completely recrystallised: the upper beds have been brecciated and recemented.
830 feet.	Outcrop is discontinuous within this section of fine-grained, thin-bedded, calcareous greywacke, which is of even grain size and light to dark grey.
300 feet.	Fine-grained, light grey, thin bedded, and folded calcareous greywacke with widely-spaced interbeds of fine-grained limestone 2" to 3" thick. The rocks coarsen towards the base into a 20 feet band of medium-grained, calcareous greywacke.
350 feet.	Discontinuous outcrop of fine-grained light grey, thin-bedded, calcareous greywacke.
420 feet.	Medium and fine-grained, calcareous greywacke, some of which is jointed. Outcrops are discontinuous, and colour ranges from light to dark grey.
100 feet.	Massive, prominently jointed, light grey, calcareous, medium- to fine-grained greywacke.
220 feet.	Medium- to coarse-grained, massive, lithic greywacke with greywacke conglomerate bands from 1-2 feet thick. The medium-grained greywacke grades into fine-grained greywacke. Lithic components are dark, fine-grained siltstone, green chlorite schist, rare fine-grained intermediate igneous rocks and mica schist, set in a greywacke matrix.

280 feet.	Dark grey, fine-grained greywacke interbedded with medium-grained, lighter-coloured greywacke bands up to 2 inches thick which do not weather selectively - outcrops are massive.
250 feet.	Interbedded, fine-grained, dark grey greywacke, lighter grey medium-grained greywacke, and greywacke conglomerate. The alternating interbeds of fine- and medium-grained greywacke are 1" to 4" thick, and conglomerate beds are up to 6" thick.
850 feet.	Fine-grained, light grey greywacke with thin interbeds of medium-grained greywacke. Slumping before consolidation of the sediments has given rise to small-scale folding.
380 feet.	Interbedded medium-grained to coarse-grained lithic greywacke, greywacke conglomerate, arkose, and felspathic sandstone. The conglomerate may be well-sorted or poorly-sorted; well rounded quartz pebbles are predominant in some places.

6600 feet	BOTTOM

This section is divisible into two parts, an upper calcareous part, and a lower non-calcareous part. The lower part consists of coarse- to medium-grained lithic greywacke, and greywacke conglomerate, and fine-grained greywacke. The upper part is mostly fine-grained calcareous greywacke which varies only slightly, the coarser fractions being darker than the common light grey. This upper sequence contains within it two massive crystalline limestone lenses in which no fossils have been found. No petrographic work has been done on any of the rocks from this section.

The total thickness measured is 6600 feet, but the top of the formation was not seen.

Foraminifera giving the age of the Omaura Greywacke as Miocene e-stage have been collected from the following localities:

(1) In a small tributary of the Upper Ramu River near Sonofi Village, where calcarenite lenses yielded the following foraminifera described by D.J. Belford (BMR file report).

<u>Austrotrillina howchini</u>
<u>Spiroclypeus margaritatus</u>
<u>Borelis pygmea</u>
<u>Lepidocyclina (Trybliolepidina) sp</u>.
<u>Lepidocyclina (Eulepidina) sp</u>.
<u>Elphidium sp</u>.
<u>Planorbulinella sp</u>.
<u>Cycloclypeus sp</u>.
<u>Indeterminate smaller foraminifera</u>
<u>(Miliolidae etc)</u>.

(2) In the Ramu Gorge, $1\frac{1}{2}$ miles east of Kainantu where recrystallised limestone was found to contain the following foraminifera, described by I. Crespin (BMR Minute).

<u>Spiroclypeus tidoenganensis</u> (Van der Vlerk)
<u>Spiroclypeus margaritatus</u> (Schlumberger)
<u>Spiroclypeus orbitoideus</u> (Douville)

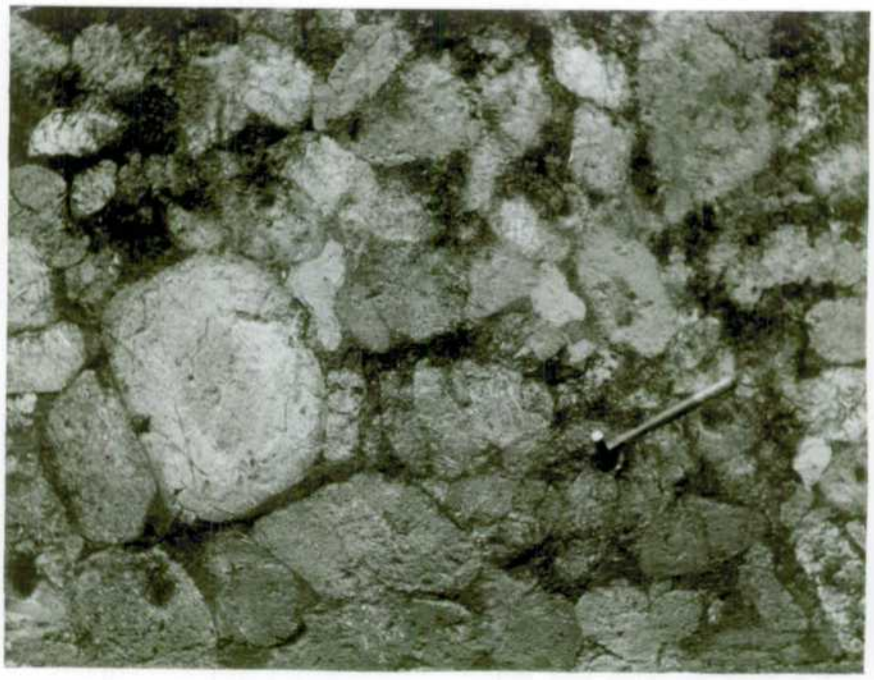


Figure 3: "Pillow lava" in weathered cutting on Okapa Road, Most of the boulders show constrictions caused by plastic flow under pressure whilst still hot from submarine volcanic action

Figure 4: Lamari Conglomerate with appearance of volcanic breccia.

Lepidocyclina (Nephrolepidina) angulosa
(Provale)
Lepidocyclina (Nephrolepidina) sumatrensis
(Brady)

(3) In a creek about 4 miles east of Aiyura Agricultural Station, where N.H. Fisher, in 1940, collected specimens of limestone which contained a fauna very similar to that found in the specimens from the Ramu Gorge (2) above.

Lamari Conglomerate (New Name)

Lamari Conglomerate is the name proposed for volcanic conglomerate which unconformably overlies Miocene e-stage Omaura Greywacke. The name is taken from the Lamari River which has cut a deep gorge through the formation, thus exposing the best section in the map area (Figure 2). The conglomerate forms a south-easterly trending belt between Tirikavi Village and the south-eastern corner of the map area.

The formation consists of volcanic conglomerate, tuffaceous sandstone, calcarenite, and basic volcanics.

In the north-western end of the map area, the most common rock is volcanic conglomerate. The larger fragments are rounded to sub-angular pebbles and cobbles of basalt, gabbro, andesite, and silicified siltstone. The matrix is unsorted crystal and lithic tuff made up of the following unabraded fragments in order of decreasing abundance: basalt and andesite, siltstone, plagioclase, augite, and quartz. The matrix is generally considerably altered to chlorite, epidote, and kaolin, and the sedimentary rock fragments are commonly epidotised near their margins.

Road cuttings in the north-western part of the Lamari Conglomerate expose a deeply-weathered rock which is probably a type of pillow lava (Figures 3 and 4). The fresh rock has not been seen: the weathered rock consists of multicoloured rounded to angular "boulders" in a weathered clay matrix. The "boulders" generally make sharp contacts with the matrix, and in many places show constrictions formed while the boulders were in a semi-plastic state (Figure 3). There is no apparent sorting, and where angular components predominate the rock has the appearance of volcanic breccia (Figure 4). The "boulders" have probably been formed during submarine eruptions, and are believed to have been pillows of lava which have rolled downwards from the eruptive centres, and have come to rest on the sea floor. Some of the pillows have been hot enough to be deformed on coming to rest.

Towards the south-east the formation grades laterally into volcanic conglomerate with interbeds of calcarenite. In the Lamari River the volcanic conglomerate consists of well-rounded cobbles and boulders (up to four feet across) of basalt and dolerite set in an indurated tuffaceous greywacke matrix. Andesite, quartz, and greywacke pebbles and cobbles constitute a small proportion of the rock. Lenses of calcarenite up to several miles long and several hundred feet thick are found within the conglomerate. This calcarenite is medium-grained, and consists of angular to rounded shell fragments in a fine-grained matrix of recrystallised calcite; corals and other macrofossils are abundant in places, but are generally poorly preserved because of recrystallisation.

The lower half of the formation throughout the area consists mainly of volcanic rocks. Basalt and basaltic agglomerate are predominant, and are interbedded with minor volcanic conglomerate and red, cherty siltstone. The lavas, as determined in hand-specimen, are porphyritic augite basalt containing rare phenocrysts of olivine and hornblende. The flows are up to three feet thick, and contain many vesicles which are commonly filled with agate or chalcedony.

At least 2000 feet of the Lamari Conglomerate are exposed in the Lamari Gorge, but only about 500 feet are exposed in the north-western part of the map area. The formation rests unconformably on Omaura Greywacke, as shown by the fact that it overlaps progressively older beds near Asempa and Sonofi Villages. Four miles south of Bontaa Village, agglomerate of the Lamari Conglomerate fills a small valley eroded in Omaura Greywacke.

Foraminiferal limestone collected from the Lamari Gorge was examined by D.J. Belford (BMR file) who reported on the foraminifera as follows: "The sample is a coarse-grained limestone containing larger foraminifera, bryozoa, algae, and echinoid spines. Foraminifera identified are:

Lepidocyclina (Nephrolepidina) ferreroi. Provale.
L. (N.) verbeeki. Newton and Holland.
L. (N.) sp. cf. sumatrensis. Brady.
Miogypsina polymorpha. Rutten.
M. sp. cf. Kotoi. Hanzawa.
Miogypsinoides dehaartii. Van der Vlerk.

This sample is placed in the lower part of the Miocene f1-2 stage."

The Lamari Conglomerate is thus a correlative of the Asaro Conglomerate mapped by McMillan and Malone twenty miles to the north-west. It represents the final phase of sedimentation in the Miocene geosyncline in the map area. The large amounts of basaltic and andesitic detritus were proably supplied partly by terrestrial and partly by submarine volcanoes. The formation was laid down in shallow water, as shown by the predominance of conglomerate and by the lenses of reef limestone. This shallowing of the basin of deposition was due partly to increased tectonic activity which accompanied the vulcanism, but also to the increased amount of detritus which rapidly filled the basin.

Aifunka Volcanics

The following is extracted from McMillan and Malone's report (1960, p. 35):

"The Aifunka Volcanics are a succession of basic to intermediate volcanic rocks which unconformably overlie the Miocene sediments in the vicinity of Aifunka, south-west Kainantu. They consist of fine-grained and porphyritic andesite lavas, with quartz porphyry andesite lavas, with quartz porphyry and porphyritic augite basalt as flows or sills and dykes. Approximately 100 feet of thin-bedded tuff with a few thin flows constitute the top of the succession. Beds of agglomerate are present in the sequence, and are particularly numerous near the base.

Mt. Munefinka, west of Kainantu, is a long narrow mass of rock rising to a height of 7700 feet. It is a dyke of coarsely porphyritic pyroxene-biotite andesite. The andesite

Figure 5: Arona Valley looking north-east. Flat-lying lake sediments form the floor of the valley. The Finisterre Range can be seen faintly in the distance (rising to 13,000 feet at the peak near the right margin) with the cloud filled Markham-Ramu graben intervening.

Figure 6: Kaniantu Beds south-west of Kainantu, taken from near Aifunka Hill looking south-east.

contains phenocrysts of feldspar, up to 5 millimetres long, and smaller phenocrysts of biotite and pyroxene in a fine-grained, light grey matrix. In composition it is very similar to the Aifunka Volcanics, and is probably an intrusive phase of the magma which produced them.

The volcanics are apparently younger than the orogeny which folded the Miocene and older sediments. They are overlain by Quaternary lake deposits. In the absence of any fossil evidence they are regarded as Pliocene in age."

The Aifunka Volcanics are undoubtedly the extrusive equivalent of the Elendora Porphyry (see later). Mt. Munefinka was mapped in the present survey as Elendora Porphyry.

Kainantu Beds

The name Kainantu Beds was first used by N.J. MacKay (1953) to describe lake sediments near Kainantu and in the Arona Valley (see Figure 1). The rocks are well-bedded cobble and pebble conglomerate, gravel, and sand and clay. The conglomerate consists predominantly of well-rounded to subangular quartz pebbles and cobbles set in gravel or a clay matrix. Other components are quartzite, dolerite, and andesite. The formation has a maximum thickness of about 100 feet.

The beds were laid down in two lakes which dammed up much of the watershed of the present upper Ramu river. The uppermost lake was centred on Kainantu, and had arms extending up the present Aiamontina, Ornapinka, and Taiora Rivers. Gold shed into the western half of this lake has supplied most of the metal won from recent river gravels in the Kainantu area. The lake was drained by the Ramu River downcutting the barrier east of Kainantu.

The second lake occupied the present Arona Valley (see Figure 1); the sediments of this lake are thinner and generally finer-grained. The lake was drained relatively recently by the Ramu River which has down-cut from the Markham - Ramu Graben.

The beds are regarded as Pleistocene in age.

Alluvium

There are a number of swampy basins filled with recent alluvium at the following localities: Aiyura, Norei Korei Swamp, Tapo Swamp, and the headwaters of the Lamari and Nompia Rivers. The deposits are white and yellow clay and silt carbonaceous clay and silt, and peat, and were laid down in depressions probably caused by recent warping of the land surface.

Many of the present-day rivers are flanked by low, recent gravel terraces, particularly where they cut through Kainantu Beds.

INTRUSIVE ROCKS

Granodiorite called the Mount Victor Granodiorite unconformably underlies Lower Miocene sediments: it may be Cretaceous or Palaeozoic in age. Miocene basic intrusives are called here Akuna Dolerite, and Pliocene intrusives of intermediate composition have been named Elendora Porphyry.

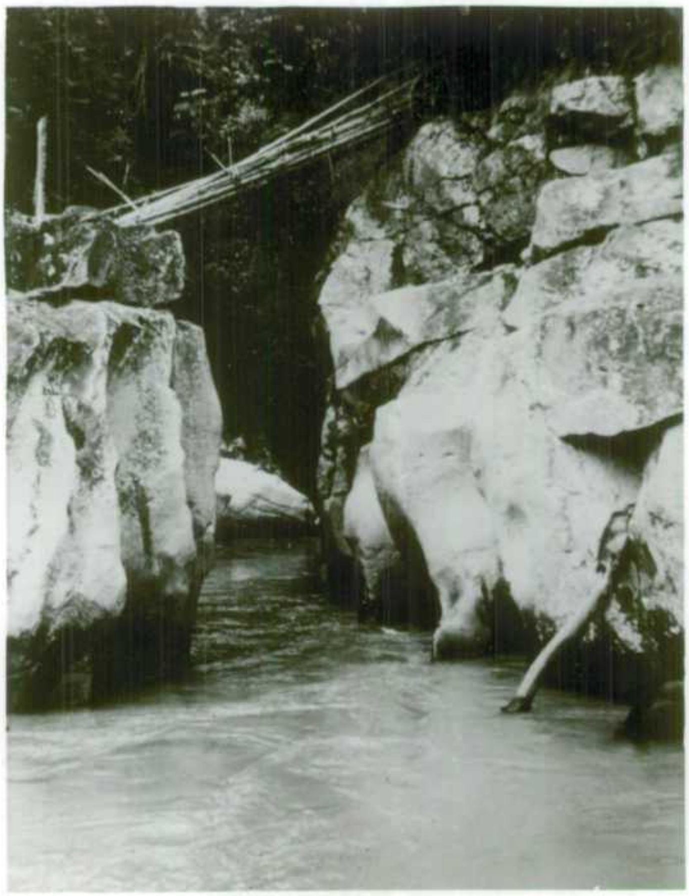


Figure 7: Ramu Gorge, upstream end, two miles east of Kainantu. Strongly jointed gabbro. (Akuna Dolerite).

Figure 8: Ramu Gorge, 2½ miles east of Kainantu. Boulders of silicified limestone and skarn rocks intruded by dolerite and gabbro. (Akuna Dolerite).

Mount Victor Granodiorite (New Name)

Mount Victor Granodiorite is the name proposed for pre-Miocene granodiorite which crops out on the eastern edge of the map area. The name is derived from Mount Victor Gold Prospect, which is on the western edge of the granodiorite.

The granodiorite is uniform in both texture and composition. It is coarse-grained, and has a granitic texture; in some places is slightly porphyritic. In thin section the rock is seen to consist of oligoclase, potash feldspar (microcline-perthite and some orthoclase), quartz, biotite, and minor hornblende. Accessory minerals are sphene, apatite, and iron oxides. The plagioclase is predominant, and all the samples taken belong to the granodiorite clan. The quartz content ranges from 7% to 25%, the rock in the former case being classed as tonalite or quartz diorite.

The rocks are generally altered to some degree, especially near Mount Victor Prospect; the feldspar has altered to sericite, and the biotite to chlorite (usually penninite).

The Mt. Victor Granodiorite is unconformably overlain by Miocene e-stage Nasananka Conglomerate, and is exposed in the core of an east-west trending anticline which plunges to the east near the edge of the map area. It is pre-Miocene, and could be a correlative of either the Late Cretaceous or Early Tertiary Morobe Granodiorite exposed 50 miles to the south-east, or else the probable Lower Jurassic Bismarck Granodiorite (Dow and Dekker 1963), which is exposed 35 miles to the north-west.

A large sill-like body of gneissic granite found near the head of the Karmantina River probably belongs to the Bismarck Granodiorite. The gneissic structure is explained by the greater susceptibility of the sill to deforming forces.

Akuna Dolerite (New Name)

Akuna Dolerite is the name proposed for basic intrusive rocks which crop out in the eastern half of the map area. The name is derived from Akuna, a village 6½ miles south-east of Kainantu.

The dolerite mass is arcuate in plan, and extends from Nompia Creek northwards to near Kainantu, thence eastwards towards Karanka; it is about 21 miles long by four miles wide. A lobe extends northwards past Yonki Dome to the northern margin of the map area. A small north-trending intrusion, six miles long by about one mile wide, which crops out to the south-south-west of Kainantu, also belongs to the Akuna Dolerite. In addition, the Omaura Greywacke in the northern half of the map area is intruded by myriads of basic dykes which can probably be correlated with the Akuna Dolerite.

The Akuna Dolerite is generally of basic composition, but contains minor ultrabasic and possibly intermediate members. It ranges in grain size from fine-grained dolerite to coarse-grained gabbro.

The dolerite is generally porphyritic, and consists of phenocrysts of augite and plagioclase set in a groundmass of plagioclase, augite, iron oxide, and commonly biotite. Some specimens contain a little olivine. Plagioclase is in the bytownite-labradorite range, and is generally slightly saussuritised. The augite is usually fresh but in some specimens has been altered to chlorite, actinolite, or tremolite.

With increasing grainsize the dolerite grades into gabbro, which is generally olivine-bearing. The northern side of Yonki Dome appears to consist almost entirely of hornblende gabbro. McMillan and Malone (1960) noted that this gabbro has been metasomatised on the north to monzonite, possibly by a more acidic intrusion.

Small intrusions of serpentinite occur within the main body near Omaura Mission, and other small ultramafic bodies intrude the Omaura Greywacke near Tirikavi Village. These are regarded as differentiates of the Akuna Dolerite which have probably been emplaced at a later date than the main intrusion. Hornblende andesite porphyry exposed near Kassam Camp could be an acid differentiate of the Akuna Dolerite, but probably belongs to the Elendora Porphyry.

The Akuna Dolerite intrudes Miocene e-stage Omaura Greywacke; it is overlain by Pliocene Aifunka Volcanics, and is apparently intruded by the Pliocene Elendora Porphyry. Its relationship with the Miocene f-stage Lamari Conglomerate is less clear: in the vicinity of Bontaa Village, dykes of gabbro of the Akuna Dolerite intrude basal Lamari Conglomerate. It seems likely that the Akuna Dolerite is the intrusive counterpart of these volcanics and is therefore probably basal Miocene f-stage.

<u>Elendora Porphyry</u> (New Name)

Elendora Porphyry is the name proposed for intrusive rocks of intermediate composition which crop out in the eastern half of the map area. The name is derived from Mount Elendora, a prominent peak on the eastern edge of the map area, which is mostly composed of these rocks.

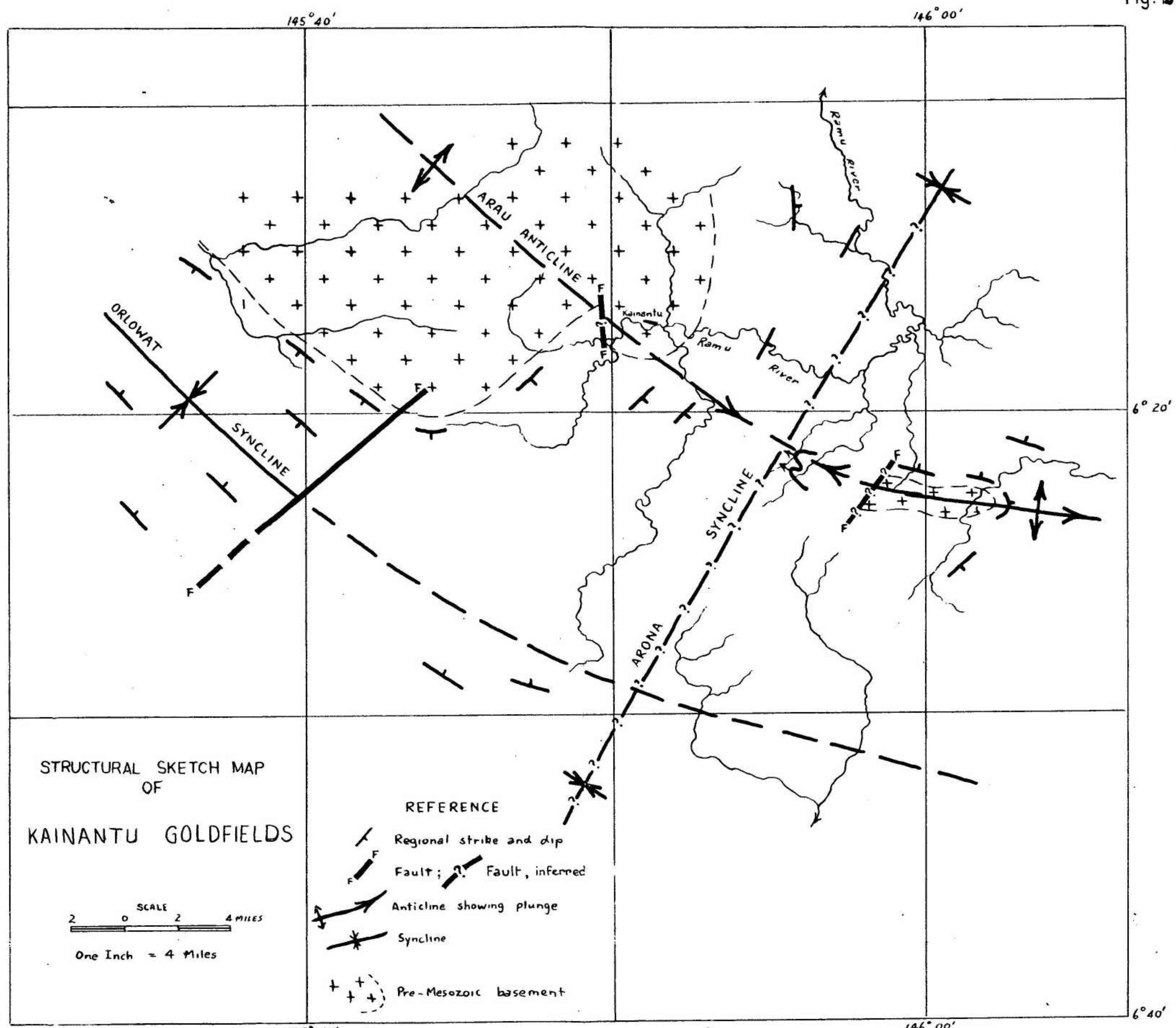
Two intrusions which are joined by a narrow neck are referred to the Elendora Porphyry. The smaller is located south-west of Omaura Mission; it is fairly irregular in shape and is about 4 miles long and averages about ½ mile wide. It is composed predominantly of propylitised andesite porphyry. Only the eastern part of the larger intrusion was mapped where it forms the watershed between the Lamari and Wanton Rivers. This intrusion is composed mainly of hornblende andesite porphyry which grades into microgranodiorite to the east. Small andesite porphyry intrusions in the area, one north of Omisuan, and the others near Obura, are referred to the Elendora Porphyry.

Samples from widely spaced localities in the smaller intrusion show that it is remarkably uniform in composition. It is hornblende andesite porphyry consisting of phenocrysts of andesine, hornblende, and minor pyroxene in a very fine-grained, granular groundmass. The groundmass is composed of feldspar together with some quartz, hornblende, and epidote. Accessory minerals are iron oxide, apatite, and zircon.

In most places the rock has been hydrothermally altered, particularly in the vicinity of Mt. Victor Prospect. The alteration has taken the form of propylitisation. Thus the feldspar has been altered to an intimate mixture of calcite, chlorite, and sericite with some albite, the ferromagnesian minerals to chlorite, epidote, calcite, leucoxene, and talc.

Figure 9: Mt. Elendora is the prominent peak in the centre background. Shows Arona Valley in middle distance.

Fig. 10



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Pyrite has been introduced, and occurs as scattered crystals, irregularly-shaped masses, and thin veins. Quartz occurs in some of the altered rocks as sparse euhedral crystals, and has probably been introduced by the hydrothermal solutions or formed during the process of propylitisation.

The western side of the larger intrusion is predominantly andesite porphyry, but it grades eastwards into hornblende microgranodiorite.

The porphyry is almost identical with that described above, and consists of phenocrysts of andesine and brown hornblende in a fine-grained groundmass of plagioclase and some quartz. Iron oxide and apatite are accessory.

The microgranodiorite is medium-grained and porphyritic, and consists of phenocrysts of andesine and green hornblende in a matrix of quartz, calcite, and iron oxide. Pyrite is common as scattered crystals and as joint linings. There is little sign of the propylitisation common in the porphyry and the rock is generally very fresh.

Pyrite mineralization is invariably associated with the Elendora Porphyry, and gold can almost always be found in streams draining the porphyry (see "Economic Geology").

The Elendora Porphyry is very similar in composition to the Aifunka Volcanics described above, and it is almost certainly co-magmatic. It intrudes Miocene f-stage **Lamari** Conglomerate, and is probably of Pliocene age.

STRUCTURE

The structure of the pre-Tertiary basement in the map area is unknown. A mild orogeny in the late Tertiary time folded and faulted the Tertiary rocks and has continued to the present day.

Folding: Miocene e-stage sediments and the underlying basement have been folded as a unit along axes which trend south-east on the western side of the map area. This trend is a continuation of that noted by McMillan and Malone which extends from Mt. Wilhelm to the map area. The trend of the fold axes gradually changes across the map area, and near Karanka the axes are nearly east-west.

Two major foldsare recognised viz., the Orlowat Syncline, and the Arau Anticline (see Figure 10).

The Orlowat Syncline was named by Stanley (1950) from the name Orlowat River which appears on the Kainantu One Mile Military Map. The river is on the western edge of the map area, and is locally called the Faiantina River. The syncline is symmetrical, and its limbs dip between 30° and 60°. Minor irregular folds and reversals of dip occur on the limbs of syncline. These features have probably been caused by subaqueous slumping during deposition, and by drag folding of the less competent beds on the limbs of the syncline. The syncline is well exposed to the west, but its south-eastern extension is covered by Miocene f-stage beds.

The anticline is called here the Arau Anticline after Arau Village near Karanka on the eastern margin of the map area. Erosion of Miocene rocks involved in this anticline has resulted in the exposure of pre-Tertiary rocks as inliers within the Miocene rocks in two areas - one north-west of Kainantu, and the other south of Omaura Mission. The limits of the larger inlier are well established except on its northern margin beyond the map area.

The Arau Anticline trends south-east from the north-western corner of the map area. Near Kainantu it plunges steeply to the south-east causing north-east trending Miocene rocks to wrap around the inlier. In the vicinity of Aiyura the plunge of the anticline reverses direction and causes the emergence of the granodiorite inlier south of Omaura Mission. Near Karanka, the plunge of the anticline is again to the east.

These reversals of plunge are probably caused by a narrow syncline which trends north-north-east, nearly at right angles to the Arau Anticline. This structure has been called the Arona Syncline after the Arona Valley which follows the syncline for most of its length. The Arona Syncline post-dates the Arau Anticline, and late movement along it probably formed the Pleistocene lake in which the Kainantu Beds of the Arona Valley were laid down. It is possible that Norei Korei Swamp and Nompia Swamp were formed by recent movement along this structure. The effect of the folding on the Lamari Conglomerate is not known because of lack of outcrop along the syncline, and intrusion of the Akuna Dolerite.

Faulting: Faulting is subordinate to folding in the map area.

A fault on the south limb of the Orlowat Syncline trends roughly parallel to the syncline. Downthrow to the south has caused repetition of the Nasananka Conglomerate. The westerly extension of the fault shown on the map is based on the discovery of a wide shear-zone in a stream traverse two miles to the west of Asempa Village.

A north-east trending fault truncates the outcrop of the Lamari Conglomerate on the western side of the map area, and displaces the Miocene e-stage limestone bed near Sonofi Village. Displacement on the fault is roughly 1800 feet, and downthrow is to the east.

An inferred fault 2½ miles north-west of Kainantu apparently truncates Nasananka Conglomerate. A vague linear feature (seen on the aerial photographs) trending just west of north could be the trace of the fault. Downthrow is to the west by an unknown amount.

Mount Victor Prospect is on a straight contact between Mount Victor Granodiorite and Elendora Porphyry. The contact is parallel to the axis of the Arona Syncline, and the senior writer has postulated that it is controlled by a deep-seated fault (Dow 1961).

GEOLOGICAL HISTORY

Little is known of the pre-Miocene geological history of the Kainantu Goldfields. Probable Mesozoic sediments were metamorphosed, intruded by granodiorite, and eroded before the deposition of Miocene sediments.

Basal Nasananka Conglomerate was deposited in Lower Miocene time, close to the shoreline of a transgressing geosynclinal sea. The sea eventually covered the whole of the map area, and the Omaura Greywacke was deposited over the conglomerate. The geosyncline was short-lived, but at least 7000 feet of sediments were laid down during Lower Miocene time.

A Miocene e-stage orogeny ended the geosynclinal sedimentation and broadly folded the sediments along north-west trending axes. This was followed closely by the intrusion of the Akuna Dolerite into the Omaura Greywacke and by wide-spread basaltic volcanic eruptions which formed the basal members of the Lamari Conglomerate.

The Lamari Conglomerate probably filled a trough formed by late folding along the Orlowat Syncline, and the writers believe that the conglomerate was never much more extensive than the present outcrop. Alternatively, the Lamari Conglomerate may have been downfolded after deposition; if this is so, only a small remnant has been preserved.

The Elendora Porphyry intruded the Lamari Conglomerate, probably in the Pliocene, and the Aifunka Volcanics were extruded at the same time. The main gold mineralization was introduced by these intermediate igneous rocks.

Sediments accumulated in lakes formed in Pleistocene time probably by folding and faulting along north-north-east trending axes. The lakes have since been drained by down-cutting of the Ramu River, but the swamps of Norei Korei and Nompia have probably resulted from recent downwarpings of the land surface along these older trends.

ECONOMIC GEOLOGY

Mining in the Kainantu Goldfields has been confined almost exclusively to gold. The only production of other metal was a small shipment of hand-picked copper ore from Yonki Creek. Most of the gold has been produced from alluvial mining, but some lode gold has been mined from Barola Reefs Mine at Aifunka Hill. However, the total production from the field is not impressive (see Tables 1 and 2).

TABLE 1

GOLD RETURNS - UPPER RAMU AREA

YEAR	GOLD Fine Ozs.	SILVER Fine Ozs.	PLATINUM Fine Ozs.	TOTAL VALUE
1948/49	1,309	71	-	£A14,105
1949/50	1,335	54	-	18,352
1950/51	1,206	82	-	18,710
1951/52	995	71	-	15,492
1952/53	1,299	102	-	20,244
1953/54	1,073	71	-	16,713
1954/55	1,141	73	-	17,856
1955/56	1,501	117	.063	23,506
1956/57	1,864	117	.042	29,166
1957/58	1,538	86	-	24,070
1958/59	1,564	112	1.242	24,454
1959/60	1,132	76	.859	17,843

Note: The returns before 1958/59 include returns from Goroka, but these are only a small proportion of the total returns.

Figure 11: Swamp between Barola Creek (foreground, flowing from right to left) and Nasananka Creek (background, flowing from right to left). Alluvial workings partly overgrown can be seen in Barola Creek, lower left. Several percussion drill holes were put down across the swamp in the middle of the photograph to the right of the village.

Figure 12: Alluvial flats, Karmantina River. Finintegu airstrip (overgrown) can be seen on right hand side of the tributary.

TABLE 2

GOLD RETURNS FROM BAROLA REEFS MINE

YEAR	GOLD Fine Ozs.	SILVER Fine Ozs.
1953/54	53.744	0.74
1954/55	54.872	3.96
1955/56	147.281	8.59
1956/57	60.303	5.72
1957/58	15.269	2.29
1958/59	13.851	0.53
1959/60	25.647	6.64
1960/61	0.568	0.18
TOTAL	371.535	28.65

The following mineral occurrences have warranted testing: a showing of galena, exposed in Efontera Creek about $2\frac{1}{2}$ miles north-west of Kainantu, which was diamond drilled by the New Guinea Administration in 1958 (Davies 1959); Mount Victor and Mount Ubank Gold Prospects which were tested between 1958 and 1960 (Dow 1961); and gold and copper mineralisation at Aifunka Hill.

Alluvial Gold

Up to 1957 most of the alluvial gold had been won by individual European miners or by small parties of Europeans, but since that year, gold production has been entirely in the hands of numerous groups of natives working on a small scale.

The alluvial gold is attributable to three main sources viz: (1) Aifunka Volcanics and Elendora Porphyry, (2) Kainantu Beds, and (3) Nasananka Conglomerate.

(1) Aifunka Volcanics and Elendora Porphyry.

Primary gold shed from the Aifunka Volcanics and the Elendora Porphyry constitutes a considerable proportion of the gold won from the Kainantu Goldfields. In addition, most of the gold derived from the Kainantu Beds came from these rocks.

Almost without exception, the streams draining the Aifunka Volcanics and the Elendora Porphyry contain some gold, and most have been worked, either by Europeans or natives, but there appears to be little prospect of further important discoveries of alluvial gold from this source in the map area. The small streams draining the Elendora Porphyry between Mount Victor Prospect and the Wanton River have not been prospected, and may contain alluvial gold payable to native miners. Elendora Porphyry continues beyond the map area south-east of Mount Elendora into the headwaters of the Wanton River, and though the porphyry on the edge of the map area sheds little gold, these headwaters are uninhabited and unexplored, and warrant further prospecting, particularly as they appear from the air to have fairly flat gradients.

Alluvial Gold has been won from Yonki Creek, both from the creek bed and from high-level terraces on both sides of the creek. The source of the gold is not known with certainty, but appears to be derived from more acidic phases of the Akuna Dolerite. Upper Yonki Creek may have undiscovered high-level terrace remnants, but prospects are not bright. Bilimoia Creek to the north of the map area has been worked by native miners for moderate returns, but the amount of wash available is small.

(2) Kainantu Beds

Gold has been won from the Kainantu Beds at the following localities: Barola Creek, near the junction of Anarinka and Funantina Creeks, from elevated remnants along Ornapinka Creek, and at Efontera Creek.

The gold won from Barola Creek (Figure 11) comes from quartz pebble conglomerate which was deposited in an arm of the Pleistocene lake in which the Kainantu Beds were laid down. It appears that this arm represents the flooded channel of the ancestral Ramu River which followed a course now marked by the Barola and Ornapinka Creeks. The gold in the conglomerate was derived from two sources, viz., the Nasananka Conglomerate and the Aifunka Volcanics. The quartz pebble conglomerate between Nasananka Creek and Barola Creek was tested by a percussion drill by the New Guinea Mines Division in 1960 (Dow 1963), but the gold values proved were not economic (Figure 11).

The same bed of quartz conglomerate was worked pre-war by Mr. E. Ubank just north of the junction of Anarinka and Funantina Creeks, and has since been worked by natives. There appears to be a progressive increase in gold values in this conglomerate between Nasananka Creek and Ornapinka Creek, and the conglomerate should be tested by drilling near Ornapinka Creek.

Kainantu beds occur as elevated terrace remnants on the north bank of Ornapinka Creek in the vicinity of Rypinka Mission, and these have been worked for gold by Mr. N. Stagg at Yanebo Claim. Boulder conglomerate of the Kainantu Beds was also worked in Efontera Creek, but neither area offers much hope of further economic gold deposits.

Most beds and recent terraces of streams draining the Kainantu Beds near the primary auriferous areas have been worked for gold. The gold has been concentrated from the lake beds by stream action. There appears to be many years' work left for native gold miners, but the deposits no longer have any significance for European miners.

(3) Nasananka Conglomerate

The gold mined from the beds and recent terraces of Barola and Nasananka Creeks has been concentrated from quartz conglomerate of the Kainantu Beds. Unlike the gold in the Kainantu Beds of other areas, which appears to be derived directly from the Aifunka Volcanics, most of this gold has been concentrated from the Nasananka Conglomerate, only the quartz and the gold being durable enough to survive weathering and deposition in the lake beds.

Conglomerate on the southern margin of the map area referred to the Nasananka Conglomerate was found to be shedding gold. The streams examined were too steep to allow concentration of the gold, but there is a chance of economic concentrations to the south of the map area where there appears to be a large area of the conglomerate exposed. Examination of the aerial photographs of the Lamari River and Mount Karsina one mile areas, when they become available, should show the possibilities of this area.

Gold found in the Karmantina River upstream from Finintegu is shedding from both the schist of the Bena Bena Formation and the sill of gneissic granite. The gold appears to come from small ferruginous joint linings and quartz stringers in these rocks.

Dish prospects from recent terraces upstream from Finintegu (Figure 12), show gold values estimated by the writer as about sixpence per cubic yard. The large alluvial flats in the area may contain payable gold, though the prospects are not good. However, while the Mines Division has a percussion drill in the Kainantu Goldfields it would be a simple matter to put down a few scout holds to test these flats. The area recommended is at the head of the flats about one mile east-north-east of Finintegu.

The large number of native miners at present working in the goldfields, each contributing a small parcel of gold from widely spaced localities, offers a good opportunity to document the fineness of gold in various places in the goldfields. The occurrences reliably located to date have been plotted on the geological map (Plate 1).

Most of the gold from localities near Aifunka Hill is derived from the Kainantu Beds. The gold from this source has remarkably consistent fineness, ranging between 870 and 930 fine. Lode gold from the Barola Reefs mine at Aifunka Hill (see later) also ranges between the same limits, indicating that most of the gold in the Kainantu Beds is derived from the Aifunka Volcanics.

Gold with anomalous fineness is found at the following localities:

(1) Anarinka Creek: Gold from Anarinka Creek, a tributary of Ornapinka Creek, ranges in fineness from 811 to 834, and is probably derived from the body of Elendora Porphyry which crops out above the alluvial workings. Just above Funantina Creek the gold fineness rises to between 860 and 880, indicating a source of higher fineness gold in this locality. It is below this point that Mr. E. Ubank found his unique "Hooky Gold" before World War II. The gold consists of twisted wire up to two inches long; it was won from the creek bed, but still has delicate twisted points on many pieces, and obviously had not travelled far in the stream. There is every possibility that intensive prospecting will reveal the source of this gold.

(2) Ramu River: Gold won from alluvial deposits in the Ramu River, 1½ miles downstream from the Nasananka Creek junction normally ranges in fineness from 767 to 785; though one parcel ranged up to 806. The gold is of lower fineness than usual for this area, and probably is derived from lodes within the Aifunka Volcanics in this locality. The volcanics and Elendora Porphyry in this locality are both highly propylitised, and there is abundant pyrite mineralisation. The area warrants prospecting for lode gold.

(3) Efontera Creek: Gold from alluvial deposits about half way down Efontera Creek has the lowest fineness in the area, i.e., it ranges between 672 and 872 fine, though the bulk of it is less than 740 fine. The rocks in this area are schist of the Bena Bena Formation intruded by Elendora Porphyry. The whole area has undergone intense hydrothermal alteration and mineralisation, probably caused by the porphyry. The following metalliferous mineralisation is known: there is a large body of highly pyritised porphyry upstream from the alluvial workings, cinnabar is commonly found with the alluvial gold, and there is a deposit of galena half a mile down-stream which was drilled by the Administration Mines Division in 1958 (Davies 1958). The area offers an opportunity to test the method of geochemical prospecting for copper and lead under New Guinea conditions.

Lode Gold

The following is intended as a brief summary of information on gold lodes found to date; for more detailed treatment of Barola Reefs, Mount Victor Prospect, and Mount Ubank Prospect, the reader should refer to Best (1958) and Dow (1959 and 1961).

Gold lodes have been found at the following localities: Aifunka Hill, Mt. Ubank, Mt. Victor, on Mr. L. Brady's property at Aionora, and at the head of Yonki Creek. In addition, gold shedding into the head of Imbuanki River from Mount Elendora has been traced to its source.

(1) BAROLA REEFS MINE

Gold lodes occur within the Aifunka Volcanics at Aifunka Hill, five miles west of Kainantu.

History

Gold was discovered at Aifunka Hill by E.W. Rowlands in 1933 in Rowlands Creek, which drains the western side of the hill. The tributary was very rich, and Rowlands is reputed to have won 800 ounces of gold from about 200 yards of creek bed. Rowlands prospected the head of the creek, and found several small auriferous garnetite bodies, but their gold content was low, and the lease was forfeited in 1937.

In 1951, Messrs. W.J. Bloomfield and G.P. Buchanan pegged the area, and in 1953 installed a small treatment plant which consisted of a five-head battery and two small cyanide tanks. Gold returns from the mine are given in Table 2.

A diamond drilling program was undertaken by the Mines Division of the Papua and New Guinea Administration between September, 1957 and February, 1958. Core recovery in the gold lodes was very poor and, though the garnetite bodies were proved to be fairly extensive, their tenor is not known; however, they are regarded by Best (1958) as being uneconomic.

Lode Geology

The gold occurs in garnetite bodies within the Aifunka Volcanics, which, in the mine area, consist of intermediate volcanic rocks. The rocks are predominantly fine-grained lava and tuff, intruded by porphyrytic andesite dykes. In the vicinity of the garnetite bodies the volcanics are strongly epidotised and propylitised.

The garnetite bodies are composed almost entirely of andradite garnet and range in thickness from several inches to fifteen feet or more; they strike roughly north and dip westwards at low angles. They are generally coarse-grained (crystals 2 mm. in diameter) near the footwall, and grade to fine-grained on the hangingwall; the better gold values are in the coarse-grained garnetite. Magnetite bands have been seen in the garnetite, and are apparently an indicator of higher gold values. Accessory gangue minerals are epidote, magnetite, specularite, pyrite, quartz, chlorite, calcite, and manganese oxides. The gold occurs free, and ranges in fineness from 870 to 930.

The garnetite lodes weather to a friable gossan of iron oxides containing quartz fragments, and stained with manganese oxides. Native copper is commonly associated with the gossan, and apparently originates in the highly pyritised volcanics underlying the garnetite. The Mines Division has percussion drilled the area to test this copper mineralisation, but results to date (February 1962), indicate that the grade is well below economic.

(2) MOUNT VICTOR GOLD PROSPECT

Mount Victor Prospect is about ten miles south-east of Kainantu.

History

The prospect was discovered by Mr. N. Stagg of Kainantu in March, 1957. It was tested under option by Australian Gold Development N.L. and King Island Scheelite Ltd., but the tenor of the lode was too low.

Lode Geology

Mount Victor Prospect consists of a ferruginous quartz lode on a contact between Mount Victor Granodiorite (footwall), and Elendora Porphyry (hangingwall).

The lode is lens-shaped, up to 50 feet thick and strikes nearly northeast and dips to the north-west at 10° to 12°. It is completely oxidised, and consists of friable sugary quartz which is colour banded and generally iron-stained. The lode includes large irregular masses of limonite up to 15 feet across containing some magnetite and haematite; these masses have resulted from oxidation of large pyrite segregations, some of which can still be seen unoxidised in the impervious porphyry hangingwall.

Secondary enrichment has played a large part in concentrating the gold, which occurs free and ranges in fineness from 800 to 830 fine. The oxidised lode contains about 60,000 tons of ore of estimated to contain 6 dwts of gold per ton.

The lode grades southwards into unoxidised, highly propylitised andesite porphyry which contains over 50 percent pyrite. The pyrite contains gold, and the tenor of the pyritised porphyry is about 0.5 dwt per ton.

A small erosion remnant of the main lode called Clarke Ridge Prospect, occurs 800 feet to the north-east. It is very similar to the Mount Victor Lode, but the tonnage proved is much smaller.

The porphyry-granodiorite contact is very straight, and though it is not a fault contact, it is believed by the senior writer to have been controlled by a fault parallel to the axis of the Arona Syncline, and coeval with the formation of the Syncline. Downthrow is to the north-west.

(3) MOUNT UBANK PROSPECT

Mount Ubank Prospect is situated about ten miles south-east of Kainantu. It was discovered in 1958 by Mr. N. Stagg while prospecting for Australian Gold Development N.L. A small amount of development was done on the prospect by this company and by King Island Scheelite Ltd., but the lodes were found to be uneconomic.

The lodes at Mount Ubank Prospect occur close to intrusive contacts between Elendora Porphyry and chert and silicified siltstone of the Omaura Greywacke.

The lodes are small and are rarely more than two feet wide or 30 feet long. They range in composition from friable iron-stained quartz containing small masses of limonite, to ferruginous, weathered porphyry. Accessory minerals are zircon, andradite, garnet and manganese oxide.

The gold occurs free, and the only assay taken for fineness gave a result of 830. Values in the lode are extemely erratic, and their present distribution is probably due to secondary enrichment. The prospect is not regarded as an economic proposition.

Auriferous granetite lodes have been found at the head of Yonki Creek and on Mr. L. Brady's property Aionora, but the small amount of development work done on these indicates that they are very low grade.

Fine-grained gold shedding into the headwaters of Wanton River from the north-western slopes of Mount Elendora has been traced to its source by Mr. N. Stagg, of Kainantu. Soils overlying the Elendora Porphyry in this area contain very uniform residual concentrations of fine gold. The porphyry in this area has many manganiferous stringers and joint linings which are generally auriferous, and as the porphyry is weathered away the gold is left in the soil as a residual concentrate. The deposit has no commercial value.

Other Mineralisation

The following showings of mineralisation of possible economic interest have been recorded in the Kainantu Goldfields: lead and zinc sulphides in Efontera Creek, secondary copper minerals at Yonki Creek, native copper at Aifunka Hill, and pyrite at Mount Victor Gold Prospect.

(1) Efontera Lead-Zinc Prospect

The prospect is situated near the Tapo Road, 2½ miles north-west of Kainantu. The mineralisation was first seen by Mr. E. Ubank, and in February, 1958, the Mines Division of the Papua and New Guinea Administration diamond drilled the prospect for New Guinea Goldfields Ltd (Davies, 1958).

The rocks of the prospect are schist and gneiss of the Bena Bena Formation intruded by granite and fine-grained pegmatite dykes. The mineralisation occurs as patches of marmatite, galena, and pyrite, in a vertical zone of grey pug which is apparently a large shear zone. Weathering is very deep in the mineralised zone, and the unoxidised zone was not reached by the drilling. Though not conclusive, assay results from costeans and the drilling were very low in both lead and zinc, and the prospect did not warrant further development.

(2) Yonki Copper

A small lode containing the secondary copper minerals malachite and covellite occurs near the head of Yonki Creek. W. Bloomfield in 1955, sent to Australia about 8 tons of hand-picked ore which averaged about 8 percent copper (W. Bloomfield, pers. comm.). During the present survey small veins of quartz containing pyrite and chalcopyrite were found in skarn rocks about two miles down Yonki Creek from the above occurrence. The skarn rocks have been formed by contact metamorphism of limestone and calcareous siltstone by dykes of Akuna Dolerite, and it is believed that the copper mineralisation originated in these intrusive rocks.

Pyrite mineralization is intense in the Akuna Dolerite of this area, especially near the head of Yonki Creek, and some geochemical testing is warranted.

(3) Mount Victor Pyrite

The gold lode at Mount Victor Prospect grades southwards into highly pyritised andesite porphyry. Visual estimates from percussion drill samples indicate a thickness of at least 100 feet, averaging over 50 percent pyrite. A large tonnage of pyrite is indicated; though it has no commercial significance at present, with industrial development of New Guinea it could possibly be exploited for sulphur.

Alluvial cinnabar has been found in tributaries of Efontera Creek but its source has not been traced. Beryl has also been found in stream gravels of Efontera Creek, and is probably derived from small pegmatite veins common in the area; the occurrence has no commercial significance. Rutile occurs in the stream gravels of Barola Creek; however, the volume of gravel is small, the rutile content is low, and the deposit is not a commercial proposition.

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PLATE I.
THE GEOLOGY OF
THE KAINANTU GOLDFIELDS
T.N.G.
Scale
4 miles
GEOLOGICAL BOUNDARIES
Established boundary - position accurate
" " - " approximate
Inferred, probable of indefinite boundary
STRIKE and DIP of STRATA
Inclined
Vertical
Strike and dip of foliation
Established syncline - position approximate
Syncline concealed
Plunge of minor fold
FAULTS
Position accurate
Position approximate
Inferred
Relative vertical movement
Macrofossil locality
Microfossil locality
Type section
Geological section
Specimen locality
Minor mineral occurrence
Unworked deposit
Mine
·790-850 Gold fineness
Major peak
·9260 Spot height
Road
Walking track
REFERENCE
QUATERNARY
Undifferentiated
Qa
Clay, silt, sand, gravel, and boulder beds
Pleistocene
Kainantu Beds
Qpk
Clay, silt, sand, gravel, and conglomerate
TERTIARY
Pliocene ?
Aifunka Volcanics
Tpa
Andesite tuff and agglomerate
Lower Miocene
f1-2-stage
Lamari Conglomerate
Tml
Conglomerate, tuffaceous sandstone, basic volcanic rocks
limestone
e - stage
Omaura Greywacke
Tmo
Greywacke and siltstone with limestone, arkose, and pebble conglomerate
limestone
Nasananka Conglomerate
Tmn
Conglomerate, arkose, and minor greywacke
PALAEOZOIC ?
Bena Bena Formation
Pzb
Schist, gneiss, quartzite
IGNEOUS ROCKS
TERTIARY
Pliocene ?
Elendora Porphyry
Tpp
Andesite porphyry, microgranodiorite
Miocene
f1-2-stage
Akuna Dolerite
Tma
Dolerite, gabbro, and minor serpentinite
PALAEOZOIC ?
Bismarck Granodiorite
Pzk
Granodiorite, gneissic granodiorite
Mt Victor Granodiorite
Pzv
Granodiorite, quartz diorite
LOCALITY MAP
NEW GUINEA
PAPUA
PORT MORESBY
145°40'
145°50'
146°00'
6°20'
6°30'
Henganofi
Tapo Swamp
KAINANTU
Ramu River
Aiyura
Aionora
Aifunka Hill
Rypinka Mission
Yonki Dome
Arona
Tirikavi
Sonofi
Bontaa
Akuna
Omaura
Karanka
Arau
Omisuan
Norei Korei Swamp
Mt Ubank
Clarke Ridge
Mt Victor
Tarabou
Okapa
Asempa
Mt Elendora
(5,000 ft)
Obura
Syncline
Bureau of Mineral Resources, Geology and Geophysics
G-0192
To accompany Record 1963/61
B55/10/9

KAINANTU GOLDFIELDS
GEOLOGICAL SECTIONS

PLATE 2.

Horizontal & Vertical Scale

1 0 1 2 3 4 miles

For Reference see Plate I.