COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Report No. 57

MISIMA ISLAND—GEOLOGY AND GOLD MINERALIZATION

BY

F. de KEYSER

Issued under the Authority of Senator the Hon. W. H. Spooner,
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Minister: SENATOR THE HON. W. H. SPOONER, M.M.

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CORRIGENDA

p. 3, last line but one:	for 'page 7' read 'Fig 4'.
p. 8, para 2, line 10:	for 'page 14' read 'page 16'.
p. 15, para 3, line 5:	for 'presents' read 'represents'.
p. 31, para 3, line 3:	for 'Fig.15' read 'Fig.14'.

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SUMMARY

Misima is a small island in the Louisiade Archipelago, 150 miles east-south-east of the south-eastern tip of Papua. The island was visited in 1959 for a period of four months by a Bureau field party in order to establish the regional geological setting of the gold mineralization. Misima is composed mainly of folded and faulted metamorphic rocks of unknown age, covered in the north-east by some 1,300 feet of Tertiary beds, and surrounded in the south and east by a rim of raised Quaternary coral reefs.

The metamorphic rocks can be divided into a higher-grade metamorphic series to the west and a lower-grade metamorphic series to the east. The nature of the boundary between the two series is still doubtful, because of lack of outcrop in critical areas, but the metamorphic unconformity is clear. Amphibolites (Lalama Amphibolite) and overlying gneisses and schists (Oiatau Gneiss) in the almandine-amphibolite facies of regional metamorphism constitute the higher-grade metamorphics. The amphibolites were probably originally volcanic flows and tuffs; the gneiss and schist were probably derived from normal clayey and silty sediments. Parts of the higher-grade metamorphic series are migmatized.

The lower-grade metamorphics consist of a volcanic formation (Ara Greenschist) overlain by a succession of intergrading dark graphitic and micaceous phyllites and schists, quartzose schists, and banded schists (Umuna Schist). A marble and limestone horizon (St Patrick Limestone) separates the Umuna Schist from the Ara Greenschist. The lower-grade metamorphics belong to the greenschist facies of regional metamorphism.

Tertiary deposits include rocks of three different penecontemporaneous types: a volcanic facies in the east (Kobel Volcanics), a conglomeratic facies in the west (Liak Conglomerate), and an intermediate clastic facies (Gulewa Formation). Quaternary sediments are represented by coral reefs which were raised above sea level in several stages, to a maximum elevation of about 1,400 ft. Alluvium is rarely present because of the rugged, rejuvenated topography. Pre-Tertiary igneous rocks include hornblendite (probably pre-metamorphic) and trondhjemite (syn-kinematic) in the west, and dacitic and andesitic porphyries in the east. Post-metamorphic basic and acid dykes cut across the higher-grade metamorphics.

Native gold is the only ore mineral mined; it is accompanied by small quantities of the base-metal sulphides pyrite, galena, sphalerite, and chalcopyrite. Gold, first found in 1888, is restricted in its occurrence to the eastern part of the island. Total production from both alluvial and lode sources has been of the order of 240,000 ounces of fine gold. Lode gold was successfully mined just before World War II, but production was practically restricted to the Umuna lode, although other lodes are known. The reserves in the oxidized portion of the Umuna lode are not large enough to warrant re-opening of the mine, but an orebody of sufficient volume and grade may be present in the primary zone, which has never been explored. Mineralization is epithermal and connected with intrusive porphyry. The only production in 1959 came from the Double Chance, a postwar discovery which is an open cut on a series of thin leaders spaced close enough to allow profitable mining as a one-man enterprise.

Further lodes may be concealed beneath overburden on eastern Misima, but it is unlikely that they could be located by surface exploration and panning alone. More favourable results are to be expected from geophysical surveys and follow-up drilling. The most favourable areas to explore for gold are areas where porphyry crops out abundantly and near the greenschist boundary.

INTRODUCTION

Misima is a mountainous island in the Louisiade Archipelago, 150 miles from Samarai at the south-east tip of Papua. It is 25 miles long, east to west, and 6 miles wide at its broadest, and covers about 90 square miles. The average annual rainfall at Bwagaoia is 123 inches (Min. Nat. Dev. 1951), but inland it is much higher; the rainfall is fairly evenly spread out over the year. During the south-east monsoon, when heavy seas are common, the only refuge for ships is in Bwagaoia harbour, which can accommodate ships of up to 1,000 tons.

The native population, estimated at roughly 4,000, lives in a number of villages scattered along the coast. Because the island is mountainous, native gardens are small and few, and the supply of fruit and vegetables is limited. The small European population lives mainly in Bwagaoia, the Government Station. Contact with the outside world is maintained by radio communication and by an irregular shipping service.

Field work. A Bureau of Mineral Resources geological field party, consisting of two geologists (F. de Keyser and D.S. Trail), a survey hand, and fifteen carriers, mapped the island from May to October 1959, with the object of establishing the regional geological setting of the gold mineralization.

The field work consisted mainly of compass and clinometer traverses along the numerous creeks where good outcrop is readily found. By contrast, the slopes and ridges have a thick mantle of decomposed rocks and dense vegetation which obscure the outcrop and slow down the rate of progress. The rugged and trackless south-western part of the island was visited by chartered ship. Vertical air photographs at a scale of approximately 1:40,000, taken by the U.S. Air Force in 1947, and a base map compiled from the photographs, were used by the party. Structural and lithological photo-interpretation was virtually impossible.

Barometric height readings indicate that the altitudes of spot-elevations given on Admiralty Chart No. 1477 are generally exaggerated by one to two hundred feet.

Previous investigations. Apart from scattered observations made by occasional visitors, most of our knowledge of the geology of Misima is due to E.R. Stanley, who made the only systematic study of the island, including a comprehensive report on the gold deposits, and the compilation of a geological map (Stanley, 1915). Later reports on gold on Misima include those of King, Moodie, & Thomas (1949), Palmer (1957, 1959), and Davies (1959). Davies also summarized the mining history of the island.

PHYSIOGRAPHY

The long and narrow western portion of Misima is very steep and mountainous, and has a single sharp divide 2,000 to 3,000 feet high. The highest point is Mount Oiatau (3,400 feet). Where the island broadens to the east the mountains become less precipitous, and the eastern hills are not more than a few hundred feet high. This difference is probably mainly due to differential uplift, as evidenced by the great variation in altitude of the elevated Quaternary reef limestones, but is accentuated by the lithological differences between the higher-grade metamorphics of western Misima and the lower-grade phyllites and schists of the eastern part.

Topography and drainage are youthful: the creeks have cut deep, narrow, v-shaped valleys, and abound in waterfalls and rapids; alluvial deposits do not exist on western Misima and are only small in the eastern portion; and convex mountain slopes are common in the western part. The island is drained by numerous creeks with a considerable run-off. On eastern Misima the main watershed runs from Mount Sisa to near Bwagaoia, and most of the main creeks originate on the slopes of Mount Sisa.

The Quarternary uplift which raised Misima hundreds of feet above sea-level took place in several stages. This is most clearly illustrated in the raised coral reefs along the eastern and southern coasts (Fig. 1). The greatest number of terrace remnants is found at Ebora, in the west, where at least five, and possibly seven, benches may be counted. Stanley (1915) estimated the maximum height of the limestone to be 700 or 800 feet, but 1,000 feet is probably more correct. Still higher elevations are noted west of Eiaus, where the Admiralty Chart shows altitudes of 1,300 to 1,400 feet on a ridge covered by these reefs. This illustrates the magnitude of the post-Tertiary uplifts. East of Eiaus the altitude of raised reefs decreases rapidly, and at Bwagaoia Point the reef is only 20 feet high; but north of Bwagaoia, remnants of an old erosion platform 200 to 300 feet above sea level point to a somewhat higher uplift in this region also.

STRATIGRAPHY
(Table 1)

PALAEOZOIC OR MESOZOIC (?)

Metamorphic rocks form most of the island, but their age is unknown; they may be equivalent to the Owen Stanley Metamorphics on the mainland of Papua, which are probably of Palaeozoic or Mesozoic age. The metamorphics on Misima are divided into two distinct groups of different metamorphic grade. Higher-grade amphibolites and gneiss, forming the narrow and elongated western portion of the island, are placed in the almandine-amphibolite facies; lower-grade phyllites and schists, forming the eastern part of Misima, are placed in the greenschist facies. Their interrelation is not known.

The Higher-grade Metamorphics

The higher-grade metamorphic rocks, in the field, were grouped into two formations, for which the names Lalama Amphibolite and Oiatau Gneiss are introduced. The Oiatau Gneiss is the younger formation.

Lalama Amphibolite

The name Lalama is derived from the village of Lalama on the north coast of western Misima, where the formation is well exposed. Outcrops occur along the north coast and lower mountain slopes between Ewena and Liak; along the south coast and southern slopes from about 3 miles west of Bwagabwaga to near Awaibi; and on the west coast north of Ebora. Between Awaibi and Liak these rocks are generally strongly injected by a gneissic quartz diorite, and from Liak to west of Lalama exposures show strong migmatization and injection by intrusive gneiss (see page 7). The thickness of the formation is unknown as the base is not exposed, but it is at least 1,000 feet.

The main lithological types in the Lalama Amphibolite are: massive, coarse-grained to medium-grained plagioclase amphibolite; finer-grained foliated amphibolite; layered amphibolite or quartz-plagioclase-hornblende gneiss; and hornblende-biotite gneiss with varying amounts of hornblende and biotite. All these rocks are garnetiferous in places. The common rock-forming minerals in the formation are : plagioclase (generally oligoclase-andesine), green hornblende, quartz, brown biotite, garnet, and epidote; accessories include sphene, apatite, magnetite, and pyrite; chlorite is generally present as a secondary mineral.

A coarse massive plagioclase amphibolite constitutes practically the whole of the Lalama Amphibolite cropping out west of Bwagabwaga. It also occurs extensively in the creeks along the north coast, but is here associated with other rock types of the formation. Schistosity and foliation are typically absent or very coarse and weak. Plagioclase and hornblende are the dominant constituents, generally in crystals a few millimetres across; sphene, apatite, pyrite, magnetite, and possibly some quartz, are the common accessory minerals. The massive amphibolite commonly contains remnants of finer-grained foliated amphibolite. The latter has good schistosity and foliation, and possibly a lower feldspar content than the coarse massive type described above. Small quantities of biotite and quartz occur in some exposures. Typical outcrops were seen near Ebora, and transitions into the layered amphibolite or quartz-feldspar-hornblende gneiss are common.

Layered amphibolites or gneisses are well exposed along the coast just west of Lalama and are characterized by a regular alternation of light and dark layers, which range from two to ten millimetres in thickness and are generally constant within one outcrop (Figs. 2 and 3). The light layers consist of quartz and plagioclase, the dark layers predominantly of hornblende and epidote. Quartz-rich hornblende-biotite gneiss forms subordinate intercalations within the amphibolites. The ratio of hornblende to biotite varies greatly, often to the exclusion of hornblende, and in places the amphibolites and hornblende-biotite gneisses appear to grade into each other, as on the southern mountain slopes north of Bwagabwaga.

Oiatau Gneiss

The Oiatau Gneiss is named after Mount Oiatau, and occupies the higher part of the mountainous watershed of western Misima, descending to sea level west of Ewena and along most of the south coast between Ebora and Bwagabwaga. It rises eastwards and finally disappears above the erosion surface north of Bwagabwaga, but may crop out again in the area between Awaibi and Liak. The preserved part of the Oiatau Gneiss is probably about 2,500 feet thick.

Little is known of the Oiatau Gneiss, for it occupies the most rugged part of Misima, where tracks do not exist and access is very difficult. The gneisses and schists are composed of quartz, plagioclase (ranging from oligoclase to andesine), and varying amounts of muscovite, biotite, garnet (up to 6 mm. across), and epidote. Hornblende is present in some beds, and in one thin section staurolite and kyanite were recognised. Apatite, sphene, and iron oxide are the common accessory minerals. Some of the gneisses are highly quartzose and granular; others are rich in muscovite and garnet. Gneissic textures are well expressed, but where an abundance of micas imparts a strong schistosity the rock is better called a schist. Foliated amphibolite occurs within the Oiatau Gneiss as a few subordinate intercalations and lenses, particularly near the base of the formation.

TABLE 1.—SUMMARY OF STRATIGRAPHY.

Age.	Formation.	Map Symbol.	Thickness.	Description.	Distribution.		Remarks.
QUATERNARY ..	Alluvium ..	Qa	..	Gravel deposits, sago swamps, thick soil cover	Locally on eastern Misima		Rare
	Raised coral reefs ..	Q1	..	Organic reefs (corals, algae, bryozoa), with locally impure bedded limestone, sandy limestone, and gravel patches	Benches along the southern and eastern coasts		Raised to a maximum height of 1,400 feet above sea level
TERTIARY (MIOCENE)	Liak Conglomerate	Tml	700′ +	Coarse pebble conglomerate, with pebbles of metamorphic basement	Area of 3 square miles south-east of Liak	Three pene-contemporaneous facies.	
	Gulewa Formation	Tmg	1,300′ to 1,500′	Conglomerate, sandstone, greywacke, siltstone, mudstone, pebbly sandstone, intra-formational breccia, tuffaceous and calcareous beds, and a limestone member (100 feet thick)	Between Guntuka and Liak to a depth of about 2 miles inland		
	Kobel Volcanics ..	Tmk	1,000′	Agglomerate, volcanic conglomerate, flows, tuffs, ash beds. Composition andesitic and trachytic; some basalt	Several isolated areas of outcrop: south of Guntuka-Kalotawa, on either side of lower Ara Creek, and between Kulumalia and Lapipai		
ANGULAR UNCONFORMITY							
Intrusion of dacitic and andesitic porphyries.							
PALAEOZOIC OR MESOZOIC ?	Umuna Schist ..	M/Pzu	?	Dark graphitic and micaceous schists and phyllites, banded schist, quartzose schist. Intergrading.	Main rock type on eastern Misima	Lower-grade metamorphics.	Overlying St. Patrick Limestone
	St Patrick Limestone	M/Pzs	0–100′	White and dark marble and impure limestone, in places with silica bands (recrystallized chert ?) and lenses and bands of sandy limestone	Sporadic. Main outcrop in Ara Creek		Overlying Ara Creek Greenschist
	Ara Greenschist ..	M/Pza	At least 300 to 500′	Massive green rocks composed of albite, chlorite, epidote, and actinolite. Volcanic origin	Main outcrop along Ara Creek and region east of Umuna		Schistosity not pronounced. Possibly underlain by schists of Umuna type
?-?-?-POSSIBLE UNCONFORMITY-?-?-?							
Intrusion of Trodhjemite, followed by basic and acid dykes.							
	Oiatau Gneiss ..	M/Pzo	At least 2,500′	Various gneisses and schists composed of quartz, plagioclase, muscovite, biotite, hornblende, garnet, some staurolite and kyanite	Main part of the mountain range of western Misima	Higher-grade metamorphics.	Overlying the Lalama Amphibolite
	Lalama Amphibolite	M/Pzl	?	Massive plagioclase amphibolite, schistose and foliated amphibolite, and layered amphibolite or quartz-plagioclase-hornblende-epidote gneiss. Locally migmatitic. Predominantly igneous and tuffaceous origin. Mise en place of hornblendite	Mainly along north coast between Liak and Ewena, and around Bwagabwaga		

To face page 5.

The Oiatau Gneiss clearly overlies the Lalama Amphibolite, and between Ewena and Lalama the boundary between the two formations is sharp and unambiguous. South of Mount Oiatau, however, the distinction is not so obvious; massive plagioclase amphibolite is followed, to the north, by foliated and bedded finer-grained amphibolite which gradually passes into biotite-hornblende-quartz-plagioclase gneiss and garnet-muscovite-quartz-plagioclase gneiss still containing some thin layers of amphibolite. The upper limit of the coarse plagioclase amphibolite is well defined in this area and is therefore chosen as the boundary between the two formations, although the actual boundary may lie in the transitional zone to the north-west.

The Lower-grade Metamorphics

Lower-grade metamorphic phyllites and schists occupy most of eastern Misima, and are the host rocks of the gold mineralization. Broadly, the stratigraphical succession may be given as follows:

(e) - (upper?) dark schist, phyllite, mica schist, layered schist, quartz schist;
(d) - dark calcareous schist;
(c) - marble;
(b) - greenschist;
(?a) - (lower?) dark schist, phyllite, mica schist.

The name Umuna Schist is introduced for (e); (c) and (d) are included in the St Patrick Limestone; and (b) forms the Ara Greenschist. The existence of (a) was not proved, only inferred; since units (a) and (e) are indistinguishable in the field, they are both placed in the Umuna Schist on the geological map. A complete sequence is not necessarily found everywhere; the marble and dark calcareous schist appear to be missing in many places; the greenschist, on the other hand, may occur in more than one unit, or may alternate with dark schists at its upper boundary.

Ara Greenschist

Ara Creek is the type locality for the Ara Greenschist, which is very well exposed there. The greenschist underlies extensive areas, mainly in a belt from the north coast, between Siagara and Rokia Point, southwards along Ara Creek to Mount Sisa and further to the upper reaches of the creeks west of Kaubwaga. A second, narrower belt runs from north of Eiaus over the Quartz Mountain area to Ingubinaina Creek. Greenschists in both belts probably belong to the same formation. Smaller outcrops are either structural repetitions or are thin intercalations of minor importance within the Umuna Schist. The Ara Greenschist is estimated to have a minimum thickness of 300 to 500 feet.

The greenschists are typically fine-grained, massive, and structureless. In outcrop they partly correspond to the 'basic schists' of Davies (1958). Schistosity is generally weak or absent and no traces of stratification were found. The greenschists range from light greyish-green to dark green and nearly black when fresh and weather to yellow-brown. One variety of greenschist is a spotted schist in which the white spots are micro-aggregates of albite Where schistosity is present, elongated spots and lenticles are aligned with it. Magnetite is in places recognisable as small octahedra in hand specimen, and pyrite is also common.

Thin sections reveal a mineralogical composition of albite, chlorite, epidote, actinolite, magnetite, and pyrite, with locally some sphene, muscovite, and calcite. Quartz is rarely present. The albite is generally untwinned, and in some beds encloses all the other minerals. Most thin sections reveal schistose structures to a greater or lesser extent.

The Ara Greenschist is overlain by the St Patrick Limestone, and may be underlain by dark schists and phyllites. Where marble of the St Patrick Limestone is not present, greenschist and overlying dark graphitic schist and layered schist seem to grade into one another and to alternate.

St Patrick Limestone

The formation is named after St Patrick Creek, an alternative name for Ara Creek, in which the marble is very well exposed in a gorge and here attains its probable maximum thickness of about 100 feet. Other outcrops occur intermittently in a belt between the Quartz Mountain district and the region north of Eiaus, in Ingubinaina Creek, on the Mararoa track, and halfway between Mararoa and Siagara. The formation is absent, or at least not exposed, in many places along the greenschist/Umuna Schist boundary, and is in some localities only indicated by the presence of a few pebbles and boulders.

The St Patrick Limestone is generally a white to grey, massive, fine to medium-grained marble, uniformly sugary in outcrop. In some exposures the rock is nearly black. Overlying the massive marble is a zone of marble layered with sugary quartz parallel to the bedding. These layers are 1"-3" thick, are irregularly spaced with an average interval of one foot, and are frequently interrupted, swelling and pinching, sometimes branching; they are thought to be recrystallized chert layers. In places the marble contains inch-thick beds, lenses and tongues of sand. Specks of galena, pyrite, and sphalerite are visible in some outcrops.

The light-coloured marble of the St Patrick Limestone is in several areas overlain by a zone of dark impure limestone or calcareous schist which in places contains thin dark marble layers, and which gradually merges into the non-calcareous dark phyllites and schists of the Umuna Schist. Pyrite is a common accessory mineral throughout the formation.

Umuna Schist

A thick series of intergrading graphitic phyllite and schist, sericite schist, mica schist, layered schist, and micaceous quartz schist overlies the St Patrick Limestone and is grouped together under the name of Umuna Schist, after the mining centre of Umuna, where these rock types abound. They form the bulk of the lower-grade metamorphics of eastern Misima. The thickness of the formation cannot be estimated as the rocks are folded, bedding is commonly not recognisable, and the upper boundary is not seen. It is possible that schists and phyllites, lithologically indistinguishable from the Umuna Schist proper, underlie the Ara Greenschist.

The dominant black to dark grey colouring of the Umuna Schist is caused by a black opaque dust which is either carbonaceous material, as assumed here, or finely disseminated iron minerals. 'Purer' mica schists are more silvery. The black graphitic schists decompose to a dark grey or, in places, brick red soil, whereas the more micaceous members give a lighter grey soil. Most of the schists are very fine-grained, but the grain size tends to increase with decreasing 'graphite' content. The main mineral constituents were found by microscope examination to be quartz, albite, muscovite or sericite, and chlorite; minor

Figure 1.—Part of the south coast, looking west. Rugged topography and benches of raised coral reef (a to f). Village in foreground is Patnai. (Photo: D. S. Trail.)

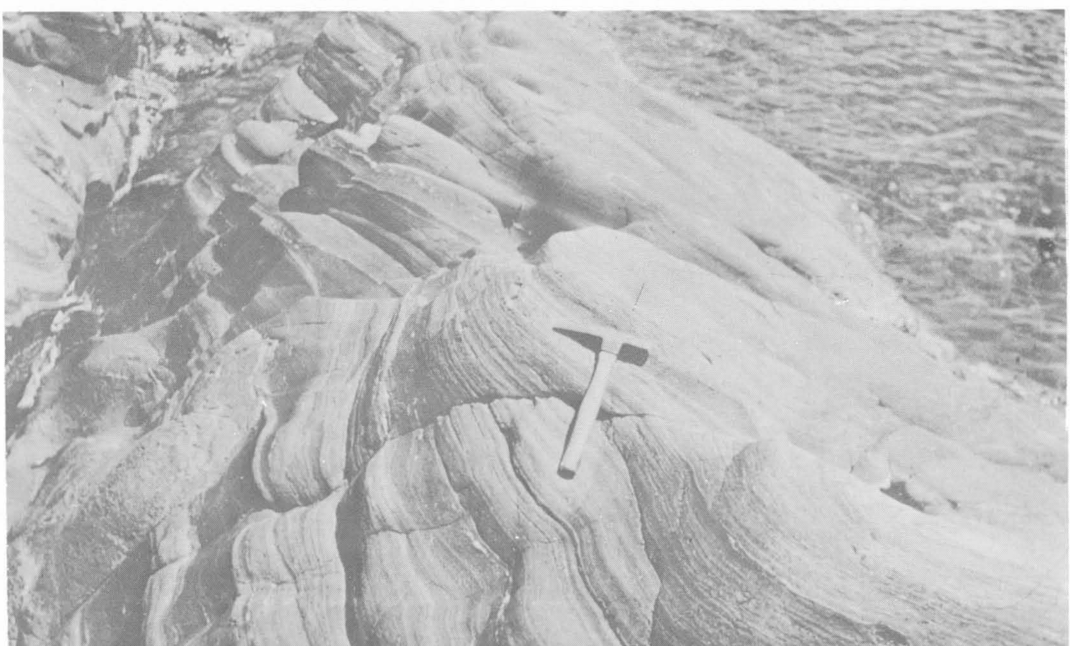


Figure 2.—Banded amphibolite or quartz-plagioclase-hornblende-epidote gneiss, dipping 25-30 north. Outcrop 200 feet west of Lalama, north coast. (Photo: F. de Keyser.)

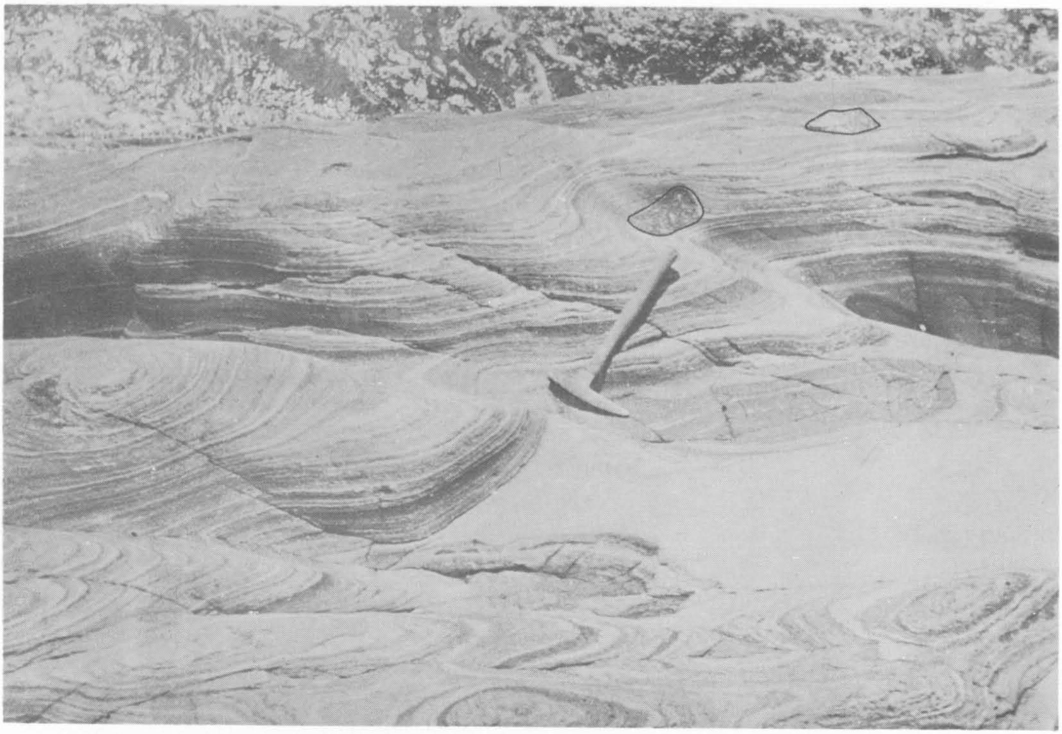


Figure 3.—Banded amphibolite or quartz-plagioclase-hornblende-epidote gneiss, with two inclusions of coarse-grained hornblendite. Outcrop 200 feet west of Lalama, north coast. (Photo: F. de Keyser.)

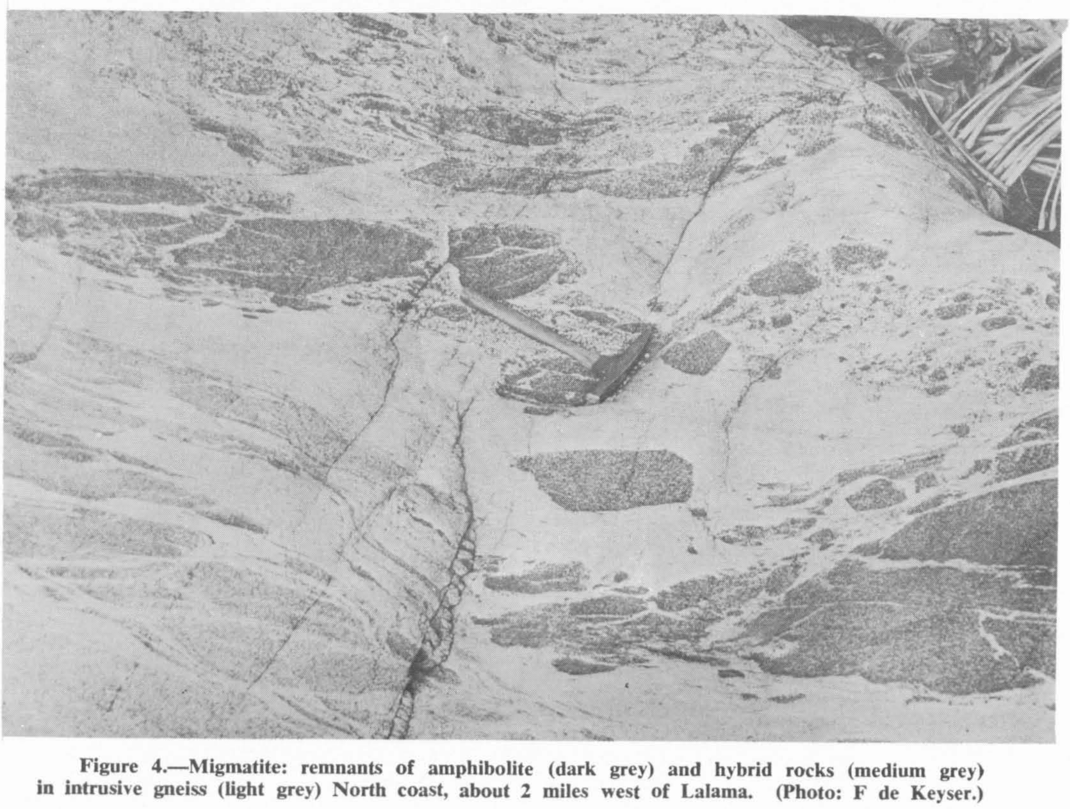


Figure 4.—Migmatite: remnants of amphibolite (dark grey) and hybrid rocks (medium grey) in intrusive gneiss (light grey) North coast, about 2 miles west of Lalama. (Photo: F de Keyser.)

quantities of calcite and epidote are present in some rock types. Apatite and pyrite are common accessory minerals, and are widely disseminated.

Schistosity and lineation are pronounced, and in many places the rocks are strongly crumpled and crenulated, particularly in central eastern Misima. They are generally very fissile and soft, but the layered schists are hard, poorly fissile rocks typically consisting of alternating light and dark layers which vary greatly in thickness but are commonly 5-10 mm thick. They may be tuffaceous: in one outcrop a lens or inclusion of a much altered volcanic rock was found. They are distributed mainly in north-eastern Misima. Light-coloured micaceous quartz schists are found in the Boiou area and in the south-east corner of Misima. They are thick-bedded to laminated, and are coarser-grained than the dark schists and phyllites. A thin section revealed a composition of quartz-albite-chlorite-epidote with some muscovite.

Boundary between Lower-grade and Higher-grade Metamorphics

The boundary between the lower-grade and the higher-grade metamorphics is largely concealed by the Liak Conglomerate and the raised Quaternary coral reefs west of Eiaus, and only part of it is exposed in the area north-west of Awaibi, where it can be seen in the Ulabwe and Awailu Creeks and in one of the branches of Weipou Creek. The lower-grade metamorphics are here represented by dark graphitic schists, micaceous schist, and altered basic igneous rock; the higher-grade metamorphics consist of amphibolites intruded by gneissic quartz-rich granodiorite. In Weipoou Creek there seems to be a thin transition zone less than 200 feet wide between the two metamorphic sequences: at the boundary an amphibolite, in which the hornblende still has actinolitic affinity and the plagioclase is probably an albite-oligoclase, has a grade of metamorphism intermediate between the altered basic igneous rock of the greenschist facies and the amphibolite of the almandine-amphibolite facies. In the other outcrops no such transition could be traced, and the boundary line is generally marked by the contrast in appearance between the dark, fine-grained, lower-grade phyllites and the underlying coarser-grained rocks with their gneissic texture and higher degree of metamorphism.

Unfortunately no actual contact was found. The attitudes of schistosity and foliation on either side, however, and their changing trends seem to correspond closely, and an angular unconformity could not be proved. Nor is it likely that the boundary is faulted, because it seems too sinuous for this.

The seemingly rather sharp difference and sudden change in metamorphic grade at the boundary is perhaps more illusory than real, and may be due to retardation of metamorphic reaction by the high graphite content of the lower-grade schists. If this is the case, it may well be that the lower-grade metamorphics bound the higher-grade metamorphics in a normal manner, and that the graphitic mica schists are the lateral equivalents of the Oiatau Gneiss, as both overlie the Lalama Amphibolite. Also, the Ara Greenschist may then possibly be the lower-grade equivalent of the Lalama Amphibolite. The contrast between the Oiatau Gneiss, which is notably poor in graphite although some was noted in thin sections, and the black graphitic Umuna Schist is disturbingly great, however, and there must have been a very sudden change in sedimentary environment to cause the difference.

Metamorphism, migmatization, and origin

In the higher-grade metamorphics various combinations of the following minerals are found: quartz, plagioclase (oligoclase-andesine), green hornblende, biotite, muscovite, garnet, epidote, staurolite, and cyanite. According to the definition of Fyfe, Turner & Verhoogen (1958), the higher-grade metamorphics of Misima occur in the almandine-amphibolite facies, mainly in the staurolite-quartz subfacies. This would be the staurolite-almandine subfacies of Turner & Verhoogen (1960). The co-existence of plagioclase, generally oligoclase-andesine, and epidote is typical of this subfacies, as is also the blue-green colour of the hornblende. Of the mineral combinations given by Fyfe et al., the following correspond to combinations found on Misima:

for pelitic rocks	-	quartz, plagioclase, muscovite, biotite, almandine, and epidote;
		quartz, plagioclase, kyanite, staurolite, muscovite, (biotite).
for basic rocks	-	hornblende, plagioclase, almandine, epidote, (quartz, biotite);
		hornblende, plagioclase, epidote, (quartz, biotite).

These assemblages indicate a medium-grade regional metamorphism.

The higher-grade metamorphics are, in some areas, intensively intruded and impregnated by syntectonic quartz dioritic magma, which has resulted in the forming of migmatite and hybrid rocks. Typical outcrops of these mixed rocks occur along the coast between Liak and Lalama; exposures generally consist of acid gneissic masses with numerous remnants of amphibolite (Fig. 4 and 5), the outlines of which are sharp in some places, blurred and absorbed in others. Hybridization and contamination of the intrusive material is evident from the colouring of the gneissic masses, which show patches of different shades of grey. A thin section of one of these gneisses reveals a composition of quartz, plagioclase, hornblende, biotite, and pink garnet, with accessory apatite and magnetite. The biotite is dark greenish-brown, like the biotite of the trondhjemite intrusive mass (see page 14), and unlike the reddish-brown biotite of the uncontaminated metamorphic Oiatau paragneiss. It is likely that metasomatism accompanied the development of these migmatites, but its nature and extent are unknown. The occurence of large feldspar porphyroblasts in some outcrops may be an indication of such metasomatism.

Stanley (1915) considered all the higher-grade metamorphics to be of igneous origin, undoubtedly because his traverses took him mainly through the migmatized area between Liak and Ewena. However, the Oiatau Gneiss is definitely a metamorphosed sequence of pelitic and perhaps psammitic sediments, and part of the Lalama Amphibolite has at least a sedimentary component. The massive plagioclase amphibolites are probably of igneous origin, as their feldspars exhibit a strong rhythmic zoning and have largely retained their original crystal form; biotite and quartz are lacking, and outcrops commonly contain inclusions of other types of amphibolite. The layered amphibolite or quartz-plagioclase-hornblende-epidote gneiss was possibly a tuff, an impression that is strengthened by the observation of coarse-grained hornblendite inclusions in the layered gneiss (Figure 5), which are regarded as possible volcanic bombs.

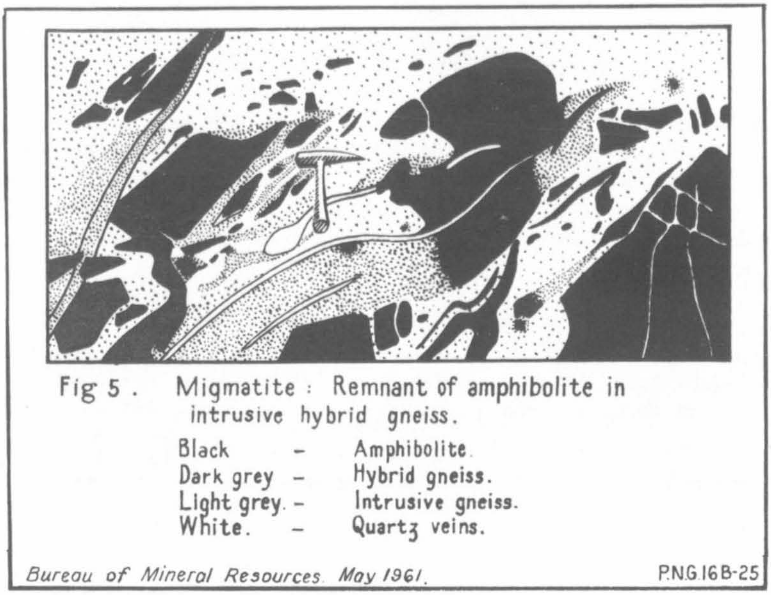


Figure 5: Migmatite; Remnants of Amphibolite in Intrusive Hybrid Gneiss.

The lower-grade metamorphic schists generally appear to fall into the quartz-albite-muscovite-chlorite subfacies of the greenschist facies of regional metamorphism. This implies metamorphism under conditions of low temperature and moderate pressure (equivalent to a depth of burial of roughly 10 km according to Fyfe et al., 1958). Mineral assemblages mentioned by Fyfe et al. and occuring on eastern Misima include the following:

for pelitic rocks	-	quartz, muscovite, chlorite, albite, (epidote);
for basic rocks	-	albite, epidote, chlorite, actinolite, sphene, (quartz); albite, epidote, chlorite, sphene, (quartz); albite, epidote, chlorite, calcite, sphene, (quartz, actinolite).

It is possible that the grade of metamorphism slightly increases towards the west, for graphite schists west of Eiaus are believed to contain biotite, although this could not be verified without the help of thin sections, and mica schists south of Gulewa contain occasional small pink garnets (spessartite?), indicative of the highest subfacies of the greenschist facies. Layered schist in the Kobel Creek area contains biotite-rich laminae.

Interesting relationships between metamorphism and deformation are shown in the thin section of a crenulated graphite schist sampled in the Ingubinaina Creek area. The schist is composed of very fine-grained muscovite, sericite, chlorite, and graphite (?) dust, arranged in very thin laminae, which have developed crenulation and false cleavage. The deformation is apparently younger than the regional metamorphism, since small muscovite flakes in the crenulated folds are bent. Occasional prisms 0.5 to 1 mm. long consisting of clusters of tiny granules of sphene (?) generally surrounded by a thin outer rim of indeterminate, colourless material (quartz or sericite?), cut across the bedding and crenulation without being disturbed, and were formed after the deformation. The prisms, which are very much coarser than the minerals constituting the rock, probably formed during a second thermal stage of metamorphism (intrusive porphyry crops out nearby). It is hard to see why biotite did not develop, however.

The graphite schists, phyllites, mica schists, and quartz schists of the lower-grade metamorphics are considered to have been originally fine-grained pelitic sediments and muds with a high organic content. An igneous origin must be assumed for the greenschists in view of their composition and appearance in the field. It seems that Stanley (1915), and perhaps others have mistaken many greenschist outcrops for basic dykes. However, since their stratigraphical position is constant and no intrusive contacts were noticed, they undoubtedly represent metamorphosed volcanic products such as lavas, ash beds, or tuffs.

TERTIARY (MIOCENE)

Tertiary rocks are distributed along the north coast from Liak to Rokia Point, and reach inland for 2 to 2 1/2 miles. A Tertiary remnant occurs between Kulumalia and Lapipai, descending from the 900 - foot contour to sea level. In all, some 10 square miles are covered by the Tertiary rocks, which have a total thickness of at least 1,300 to 1,500 feet.

The Tertiary rocks have been subdivided into three stratigraphic units, based mainly on facies differences. They are, in general outcrop distribution from east to west, the Kobel Volcanics, the Gulewa Formation, and the Liak Conglomerate.

Kobel Volcanics

The best outcrops are along Kobel Creek, where agglomerate or volcanic conglomerates form the walls of a deep gorge. The Kobel Volcanics occupy the eastern portion of the Tertiary outcrop, and comprise agglomerate, volcanic conglomerate, tuffs, ash beds, and flows, generally of trachytic and andesitic composition. A maximum thickness of about 1,000 feet is estimated.

In the Kobel Creek-Kalotawa area the principal rock-type is a coarse volcanic conglomerate, with subordinate beds of coarse tuffs. The conglomerate is dark grey, and contains boulders with a maximum diameter of about 5 feet, mostly rounded and grading down into a poorly sorted, coarse, angular, fragmental matrix. The boulders are of grey, porphyritic andesite (field term) and contain light-grey phenocrysts of feldspar, 2 to 4 mm long, and thin hornblende prisms 2 to 3 mm long. The rather high degree of rounding suggests deposition of agglomerate in an aqueous environment. Tuff beds are not common, but may reach a thickness of 20 feet; they are weathered, light-grey to white, medium to coarse-grained, and dominantly composed of sub-angular to sub-rounded feldspar crystals which are uniform in size in each individual horizon. A little quartz may be present. The coarse tuffs are massive, the fine-grained tuffs have well-developed lamination. They all contain occasional small pebbles of lava. The number of tuff beds increases from Kobel Creek to Kalotawa, and the volcanic rocks capping the hills behind Kalotawa are predominantly coarse crystal tuffs and flows with some beds of agglomerate, in which fragments rarely exceed 5" across.

Flows have also been reported from the Kalotawa-Guntuka shore section, and Gibb Maitland (1892) gave the following analysis of one of these lavas, which he called a trachyte:

Si	68.02%
Al	14.08%
Fe_2O_3	5.19%
Mn	trace
Ca	5.30%
K	1.26%
Na	5.17%
loss on ignition	1.37%
	100.68%

The volcanics capping the hills around the mouth of Ara Creek are weathered red, and include fine pebbly volcanic conglomerate, agglomerate, flows, and crystal tuffs (?). The Ara Creek agglomerate is a light green-red rock with sub-angular fragmental material. The pebbles were derived from vesicular lavas composed of small phenocrysts of feldspar, and probably some quartz, with little matrix. The flows and crystal tuffs in this area are light greenish-grey when fresh, but weather to red and chocolate-brown. They are medium-grained and contain feldspar and quartz phenocrysts; drusy quartz veins and quartz-filled cavities are common. A trachyte from Nigom shows, in thin section, phenocrysts of perthitic alkali feldspar, 1-3 mm across, set in a much altered micro-crystalline matrix in which alkali feldspar could be recognised, together with minor quartz. Small phenocrysts of a mafic mineral (hornblende ?) are completely altered.

The Tertiary remnants which occur on the 900-foot level near Kulumalia, and down to sea level near the Mission Station and Lapipai, consist of light-grey, soft, weathered, tuffaceous sediment or tuff, and, near the Mission Station, of greenish-grey fine-grained volcanic breccia. Rounded fragments of fine-grained trachyte with fluidal texture, embedded in a finely crystalline quartz (?) - feldspar matrix, were seen during microscope examination of the breccia. Grains of clino-pyroxene and brown hornblende occur in the matrix as well as in the fragments, which are several millimetres across. It is possible that the rock represents a vent breccia; this would also explain its occurence at sea level while less than a mile to the north the base of the tuffs is 900 feet above sea level.

Stanley (1915) placed the source of the Tertiary vulcanism 'somewhere in the deeps off the coast line between Siagara and Patlilu Point', but there is little proof of this supposition. On the contrary, some coarse cross-bedding in agglomerate or volcanic conglomerate near Gulewa indicates a provenance from a roughly south-eastern direction, and the occurence of the vent (?) breccia near the Mission Station also suggests a south-eastern source. The fact that no eruption centres could be recognised with certainty is perhaps due to the rapid erosion that followed the post-Tertiary uplifts.

To the west, near Gulewa, the volcanics interfinger with, and are succeeded by, the sediments of the Gulewa Formation.

Gulewa Formation

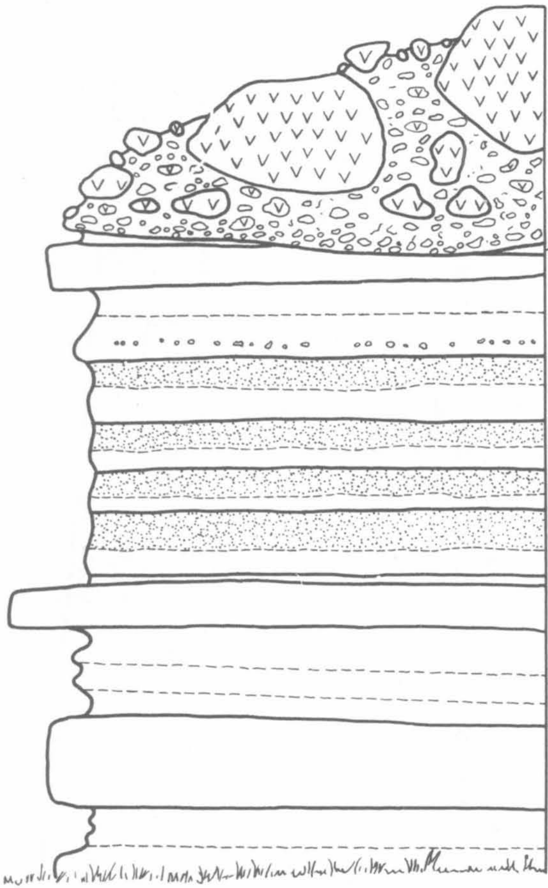
The Gulewa Formation consists of a limestone member and a great variety of clastic sediments, many of which seem to be tuffaceous. Its name is derived from Gulewa village, near which the clastic sediments are well exposed. The formation is about 1,300 feet thick and extends from Gulewa to near Liak, where it gives way to the Liak Conglomerate.

The limestone member crops out about 3/4 mile south of Gulewa. In this locality it is separated from the metamorphic basement by a thin zone of clastic sediments. The limestone is corallogene in its thickest parts, and is there practically undistinguishable from the Quaternary raised coral reefs. Outcrops in Imgamanina Creek show the limestone to be interbedded with other Tertiary sediments. It is not impossible, however, that some of the limestone outcrops mapped as Tertiary are of Quaternary age, as for instance the patch of limestone south-east of Gulewa.

Typically the limestone is white to cream, and has abundant fragments of pelecypods, corals, bryozoa, foraminifera, and other fossils. The corallogene types are hard, but the other organic limestones are commonly weathered to a soft and chalky substance. In Imgamanina Creek the first signs of the approach of a reef environment, going upstream, are fragments and pebbles of reef limestone enclosed in bedded calcareous Tertiary sediments. These fragments give way to tongues and beds of limestone which are intercalated with weathered tuffaceous (?) and calcareous siltstone and marl. Further upstream the limestone beds have congregated into quite massive, thick and reef-like deposits, represented in the creek by huge tumbled blocks and boulders. Maximum thickness of the limestone, south of Gulewa, is 70 to 10 feet. The limestone country is marked by numerous sink holes and by subterranean drainage, and is fairly difficult of access.

The lateral correlation of the limestone to the east is doubtful, as the Gulewa outcrop is terminated by a fault. An intermittent limestone horizon, which is probably the equivalent of the limestone horizon described, exists at the base of the volcanic conglomerate in the Kobel Creek area, and directly overlies the metamorphic schists. The limestone is generally impure, and in places contains calcareous sandstone beds, and lenses of calcareous conglomerate. The calcareous sandstone is dark grey, fine to medium-grained, with small silt lenses, and contains micaceous and carbonaceous material, fossil fragments and foraminifera. The conglomerate lenses consist mainly of quartz pebbles with a few flat mica schist pebbles in a calcareous matrix. West of Gulewa the limestone thins rapidly and becomes a calcarenite, mainly composed of foraminifera and small limestone fragments, with other fragments of quartzite, gneiss, feldspar, epidote, and hornblende, as observed in thin section. Near Liak, this calcarenite is overlain by the Liak Conglomerate.

The clastic sediments of the Gulewa Formation are very varied, and include such rock types as fine-grained and coarse-grained sandstones, siltstone, mudstone, coarse greywacke, pebbly beds, conglomerate and sedimentary breccia (Fig. 6). Intercalations of agglomerate and flows probably occur as interfingering members of the Kobel Volcanics. Some beds seem to be tuffaceous, others are calcareous. Many strata contain abundant clastic mica and carbonaceous material, shell fragments and micro-fossils. Glauconite occurs locally. The bulk of the sediments is above the limestone member, but a thin zone of Gulewa sediments separates this member from the metamorphic basement in most places. Beds may be massive or thinly laminated. Conglomerate and breccias are coarse, with pebbles up to one foot across, or are fine and gravelly. They range from well-sorted to poorly sorted, and pebbles are well-rounded or angular to sub-angular. In some conglomerates pebbles consist of metamorphic rocks, in others they are derived from penecontemporaneous deposits of siltstone and mudstone. The sandstones, which vary from fine to very coarse-grained, contain angular and sub-angular grains and are commonly poorly sorted. The greywackes are coarse to very coarse-grained, poorly sorted, and composed of angular rock fragments (including some volcanics), quartz, and feldspar, in an impure sandy matrix of quartz, feldspar, augite, hornblende, chlorite, epidote, biotite, muscovite, tests of foraminifera, calcite, and other minor constitutents. Mudstones and siltstones are generally rather massive, but between Gulewa and Kakamwa they are well-bedded, and are probably tuffaceous. A good exposure of an intercalated agglomerate horizon is found on the north coast about half a mile west of Gulewa. The boulders and fragments range from a few millimetres to about 3 feet across, and consist of scoria and lavas, among them a black basalt containing small phenocrysts of labradorite and augite, in sandy and tuffaceous matrix. The lower part of the agglomerate is finer-grained and better sorted, and shows some rough cross-bedding which indicates a provenance for the material in a roughly south-easterly direction.



Thickness	DESCRIPTION
± 15-20 ft.	Agglomerate: pebbles and boulders of scoria, andesite and basalt; diameters from gravel size to 1 yard approx; lower part moderately sorted; matrix sandy, tuffaceous.
1-2"	Fine grained tuff ?
2-3"	Grey tuffaceous(?) siltstone, bluish grey, siliceous.
3½"	Fine siliceous siltstone
4"	Fine sandstone; some mud pellets and volcanic pebbles; foraminifera.
5"	Cycles of cracked mudstone or fine siltstone (top parts) grading into fine sandstone (bottom parts); cycle boundaries sharp; foraminifera.
5"	
4"	
3"	
3"	Finely laminated fine sandstone; locally some fine cross-lamination.
1"	
4"	Tough, greyish-blue siliceous siltstone.
10"	Cycles of cracked mudstone or siltstone and fine sandstone; fine lamination and locally fine cross-lamination; weathering colours creamy, yellow, pale pinkish-white.
10"	Grey massive sandstone
?	Cycles of cracked mudstone or siltstone and fine sandstone.

FIGURE 6 TYPICAL SECTION OF WELL-BEDDED TERTIARY SEDIMENTS ALONG THE SHORE 500 YARDS WEST OF GULEWA.

Bureau of Mineral Resources, Geology & Geophysics. March, 1961. P.N.G 16 B-24

All these deposits are more or less grey when fresh, but become white, yellow, brown or greenish on weathering. Bedding structures are not common. Some worm-burrows (?) and fine mud cracks occur in the mudstone, but cross-bedding is rare. An example of load-cast structure was also found. Many beds are fossiliferous, containing pelecypods and other shells and foraminifera; and, according to Stanley (1915), there are carbonized plant remains in the mudstone.

Liak Conglomerate

The uniform and massive Liak Conglomerate is well exposed in Gowa Creek near Liak, and in the upper reaches of Ulabwe Creek, and covers an area of 3 square miles in the vicinity of Liak. Its thickness is estimated at about 700 feet. The composition and size of the mostly well-rounded pebbles and boulders vary somewhat according to locality. North of Awaibi, for instance, the boulders are mostly 2-3 inches across, with a maximum of more than a foot. They consist mainly of amphibolite, greenschist, porphyry, quartz, schists, and dolerite, with rare pebbles of Tertiary limestone. South of Liak, near the boundary with the metamorphics, the conglomerate is finer and more sandy, and the pebbles are generally coated with a film of limonite. In Gowa Greek the proportion of pebbles of Tertiary rock types is somewhat higher. In general, the content of metamorphic components increases from south to north. Intercalated in the conglomerate are some minor lenses and tongues of moderately to poorly sorted sandstone, which is locally fossiliferous.

According to Stanley (1915), the conglomerate overlies the Tertiary sediments of the Gulewa Formation with an angular unconformity. He based this opinion on differences in attitude between the Gulewa sediments and the Liak Conglomerate. However, our field work showed that attitudes are the same for the conglomerate and underlying calcarenite, and that both appear to follow the same structural undulations. It seems, therefore, more likely that the conglomerate overlaps and probably interfingers with the sediments of the Gulewa Formation, and that any unconformities present are only local.

The relationships of the Tertiary formations described above are tentatively shown in the diagrammatic section of Plate 1. Their age was given by Stanley as late Tertiary. Foraminifera sampled during our survey include the following genera and species determined by D. Belford : *Globorotalia cultrata* (d'Orbigny), *Globoquadrina altispira* (Cushman & Jarvis), *Globigerinoides quadrilobatus* (d'Orbigny) *trilobus* (Reuss), *Pulleniatina obliquiloculata* (Parker & Jones), *Sphaeroidinella dehiscens* (Parker & Jones), *Eponides umbonatus* (Reuss), *Plectofrondicularia interrupta* (Karrer), *Bolivinita quadrilatera* (Schwager), *Nodosaria arundinea* Schwager, *Bulimina aculeata* d'Orbigny, *Cassidulina* sp. cf. *C. subglobosa* Brady, *Siphogenerina* sp.

This association puts the Tertiary rocks on Misima in the upper Miocene. Stanley, who in 1915 had included the Kobel Volcanics in the Tertiary, stated in 1917 that they were 'Recent' but did not discuss his change of opinion. This later age seems illogical since Stanley himself had written in 1915 that the volcanics just east of Gulewa were interstratified with the sedimentary rocks of proven Tertiary age.

QUATERNARY

Deposits of Quaternary age consist mainly of raised coral reefs; a few small swamps and accumulations of gravel alluvium occur on eastern Misima.

Figure 7.—Rokia Point, consisting of raised Quaternary coral reef. Height roughly 300 feet above sea level. (Photo: D. S. Trail.)

Figure 8.—Dacitic dyke traversing migmatic gneiss. Shows emplacement accompanied by faulting (displacement of amphibolite band, presence of tension joints and "lineation" or flow banding). (Photo: F. de Keyser.)

The raised coral reefs are a striking feature of the island and form terraces and benches all along the southern and eastern coasts, rising locally to a maximum altitude of 1,400 feet (see page 2 and Fig. 1). Raised reefs with heights of 10 to 200 feet above sea level occur along the east coast between Rokia Point and Cape Henry (Fig. 7). Along the northern shore they are notably absent. The reefs normally have a corallogene facies and are mainly built up by foraminifera (Operculina, Cycloclypeus, and others), algae, bryozoa, and corals. Locally subordinate bedded impure limestone, calcareous sandstone, gravel patches, and in one place even a conglomerate, are also exposed. The limestone areas are characterized by their white cliffs, subterranean drainage, sinkholes, caves with stalactites, deep canyons, and the like.

On the map all raised reefs are shown as Quaternary. This age is definite for the lower levels, but the higher levels may well be Tertiary, perhaps the equivalent of Tertiary coral limestone south of Gulewa. In that case, uplift of the island during Tertiary times must have been a one-sided, tilting movement. The southern end must have risen rapidly whilst the northern zone remained comparatively stationary, causing sands and conglomerate derived from the southern zone to be deposited along the northern coastline.

Alluvial deposits are few, and are restricted to eastern Misima, where uplifts with resulting rejuvenation of the drainage system apparently were less vigorous. They consist of sago swamps and gravel deposits, and occur at the mouths of the larger creeks, such as Ingubinaina Creek, Cooktown Creek, and Ginesia Creek. The 'alluvium' shown on the geological map west of Bwagaoia probably partly presents fine sandy and silty lagoonal deposits raised slightly above sea level.

INTRUSIVE IGNEOUS ROCKS

Hornblendite, trondhjemite, post-metamorphic acid and basic dykes, and porphyries are the intrusive rocks met with on Misima. The Tertiary effusive rocks and the amphibolites of uncertain origin are not considered in this section.

Hornblendite occurs on the divide between Liak and Bwagabwaga, and in Bwagabwaga itself. The rock is a massive, coarsely crystalline aggregate of hornblende, with varying amounts of interstitial plagioclase and some scapolite and quartz. Pyroxene and epidote are occasionally seen in some sections. The hornblende is commonly about 1 1/2 cm. across, euhedral and short-prismatic. This habit is probably the reason why Stanley (1915) described the rock as a pure gabbro containing many large well-formed augite crystals. The mineral shows some schiller structure, and is light grass-green, in contrast with hornblende in the metamorphics, which is deep bluish-green. Scapolite is clear and free from inclusions, and plagioclase is albite-twinned and rather calcic. A magmatic origin seems very likely.

Age of emplacement of the hornblendite is in doubt. It is most probably pre-metamorphic, because inclusions of the rock were found in layered amphibolite or quartz-plagioclase-hornblende gneiss near Lalama (Fig. 3), and remnants occur in the migmatite between Liak and Ewena. The inclusions in the layered amphibolite were perhaps deposited as volcanic bombs in tuff or ash beds. On the other hand, no sign of metamorphic effects could be recognised in thin section. Possibly the hornblendite has withstood metamorphic stresses thanks to its coarseness and massiveness. Possibly also the inclusions in the layered gneiss are not related to the hornblendite but are coarsely recrystallized amphibolite; in other words the similarity could have been caused by convergence of two different processes.

Contact relationships were unfortunately not seen, but in a few places the hornblendite seems to grade into the coarse plagioclase amphibolite.

Trondhjemite, which is a leucocratic acid plutonic rock essentially composed of soda-rich plagioclase and quartz, occupies much of the area between Liak and Awaibi and forms the main mass of Mount Apatikaiogeian. It may also be the original intruding component in the migmatites. No outcrops were seen in the lower-grade metamorphics. In thin section the plagioclase appears to be oligoclase or albite-oligoclase; quartz, one of the main constituents, shows strain shadows; biotite is present as small dark green-brown shreds, often accompanied by epidote. Sphene, apatite, and zircon are present as accessory minerals.

Emplacement of the trondhjemite was probably largely syntectonic, as a gneissic structure is generally apparent. Injection of smaller veins was rather forcible. This is demonstrated in an outcrop about 1 1/2 miles east of Ebora (Fig. 9), where a trondhjemite dyke shows faint flow layering curved downwards strongly along the walls owing to friction, whilst the gneiss and amphibolite forming the wall rocks have been dragged in the direction of movement. A thin section of the dyke-rock reveals pronounced granulation or protoclastic structure. The trondhjemite must have been emplaced under conditions of high temperature and pressure, to account for the protoclastic structure and the smooth ruptureless plastic drag shown by the wallrock gneiss.

Post-metamorphic acid and basic dykes intrude the higher-grade metamorphics in several places, but were not found in the lower-grade metamorphics. The dykes occur mainly in the area between Ewena and Liak, locally in swarms, and generally strike either east-north-east or west-north-west. Thicknesses range from 6 inches to 5 feet.

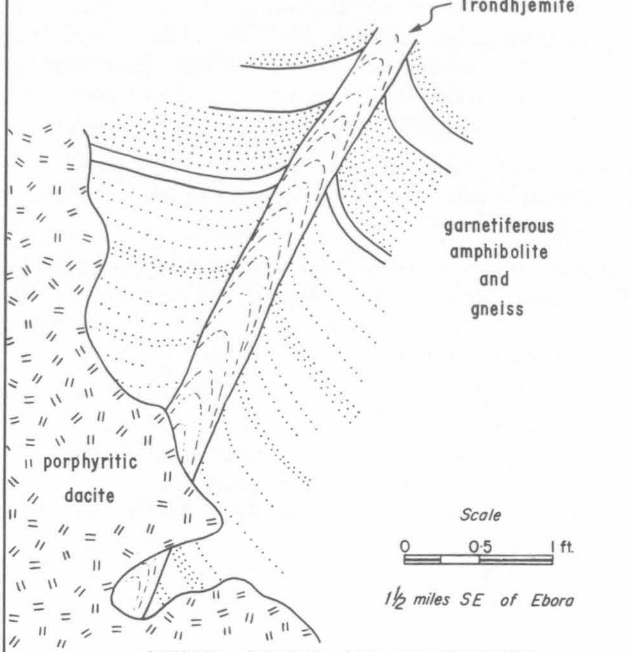
Two thin sections were made, one of an acid, one of a basic dyke. The acid rock (Fig. 8) is a mica dacite containing phenocrysts 0.5 to 1 mm across. They are mainly feldspar, together with some muscovite and quartz, and are embedded in a fine-grained matrix of quartz, feldspar, and green-brown biotite. The feldspars are twinned plagioclase (oligoclase or andesine-oligoclase) and potash feldspar. The crenulated margins of the phenocrysts suggest that the final stage of their growth has coincided with the crystallization of the matrix.

The basic dyke rock sectioned appears to be a hornblende-albite lamprophyre. Phenocrysts of a reddish-brown barkevikitic hornblende are embedded in a fine and even-grained panidiomorphic network of brown hornblende and a plagioclase which is probably albite. Clusters of epidote and chlorite are probably fillings of amygdales or are pseudomorphic after some unknown basic phenocryst, perhaps olivine. Quartz is a rare constituent in the matrix, and pyrite and chlorite are accessory.

Porphyries include a variety of generally porphyritic intermediate to acid intrusive rocks that crop out extensively in the lower-grade metamorphics in eastern Misima and are considered to be responsible for the gold mineralization. They occur as sills, dykes, and irregular bosses of various dimensions, and were probably intruded at the end of the paroxysmal phase of deformation, although they themselves are affected by continued faulting and shearing. They were emplaced in more than one stage, as some porphyries are seen to cut through others; felsitic varieties are generally younger than the porphyritic types. In places the country rock is hornfelsed near the intrusive contact.

The most common types are porphyries of dacitic or andesitic composition. They are light or dark grey when fresh, and contain many phenocrysts about 2 to 4 mm across in a microcrystalline matrix. The phenocrysts are mainly white euhedral feldspars, with some

FIG. 9



OUTCROP SHOWING AGE RELATIONSHIPS BETWEEN AMPHIBOLITE & GNEISS, TRONDHJEMITE, AND PORPHYRITIC DACITE

Bureau of Mineral Resources, Geology & Geophysics. March, 1961. P.NG.16B-23 quartz in the more acid rocks. Plagioclase (oligoclase or oligoclase-andesine) predominates over potassium feldspar. Mafic phenocrysts are euhedral biotite, or green hornblende, or both.

In some localities the porphyries grade into more plutonic, phanerocrystalline rocks. An extreme example is found in the intrusive mass north of Sikekeu; no matrix is present in this rock, which is a quartz diorite, made up of plagioclase, some potassium feldspar, biotite, and some quartz. Another variety is a very fine-grained, aphanitic, greenish, felsitic rock in which no phenocrysts are visible. It generally occurs in dyke form, and never forms large bodies. A thin section shows a trachytic composition with strong silicification in the form of impregnation and veining with quartz. Phenocrysts of potassium feldspar, though not visible in hand specimen, are present, embedded in a fine-grained quartz-feldspar matrix.

Many of the porphyry outcrops are much altered to a yellow, yellow-brown, pink, or white clayey substance, in which quartz phenocrysts, and in places white specks of kaolinized feldspar, are conspicuous. The mafic minerals are chloritized; biotite is commonly bleached to a white 'mica' which could be mistaken for muscovite in hand specimen. Other decomposition products are calcite, sericite, and epidote, generally in the form of saussurite.

A few outcrops of a hornblende dacite porphyry are present in the higher-grade metamorphics (Fig. 7), but it is not known whether or not they are related to the porphyries in the lower-grade metamorphics.

Other intrusives. Dolerite dykes and veins have been reported by several authors (Stanley, 1915; Davies, 1958) from the lower-grade metamorphics, but we did not see any. One possible example occurs at the Double Chance mine (Fig. 10), but extreme decomposition and weathering have obliterated the original mineralogical composition. It is highly probable that Stanley (1915) mistook certain greenschist exposures for basic dykes.

Outcrops of what are thought to be metamorphosed basic dykes occur in the higher-grade metamorphics. A thin section of one of these rocks shows pale green hornblende and epidote enclosed in irregular porphyroblasts of albite, the main constituent. Quartz and chlorite are sparse. The hornblende is still actinolitic and the rock probably belongs to the greenschist facies. This is in strong contrast to the almandine amphibolite facies of the surrounding gneiss, and it is therefore suggested that the dyke was intruded when conditions of metamorphism had become less severe.

STRUCTURE

As can be expected in areas of regional metamorphism, folding and faulting are conspicuous in the metamorphic basement; the Tertiary and Quaternary sediments are also tectonically disturbed, though to a much lesser degree.

It is difficult to present a precise structural picture of the metamorphic formations, because airphoto interpretation is virtually impossible, outcrops are scattered and not traceable over any distance, and no marker beds, with the exception of the St Patrick Limestone, were found. Moreover, bedding is commonly not recognisable, and measured dips and strikes therefore generally refer to the attitudes of schistosity and foliation, which may or may not coincide with the original bedding. The sections (Pl. 1) give an interpretation rather than a true picture and demonstrate only qualitatively the regional structure.

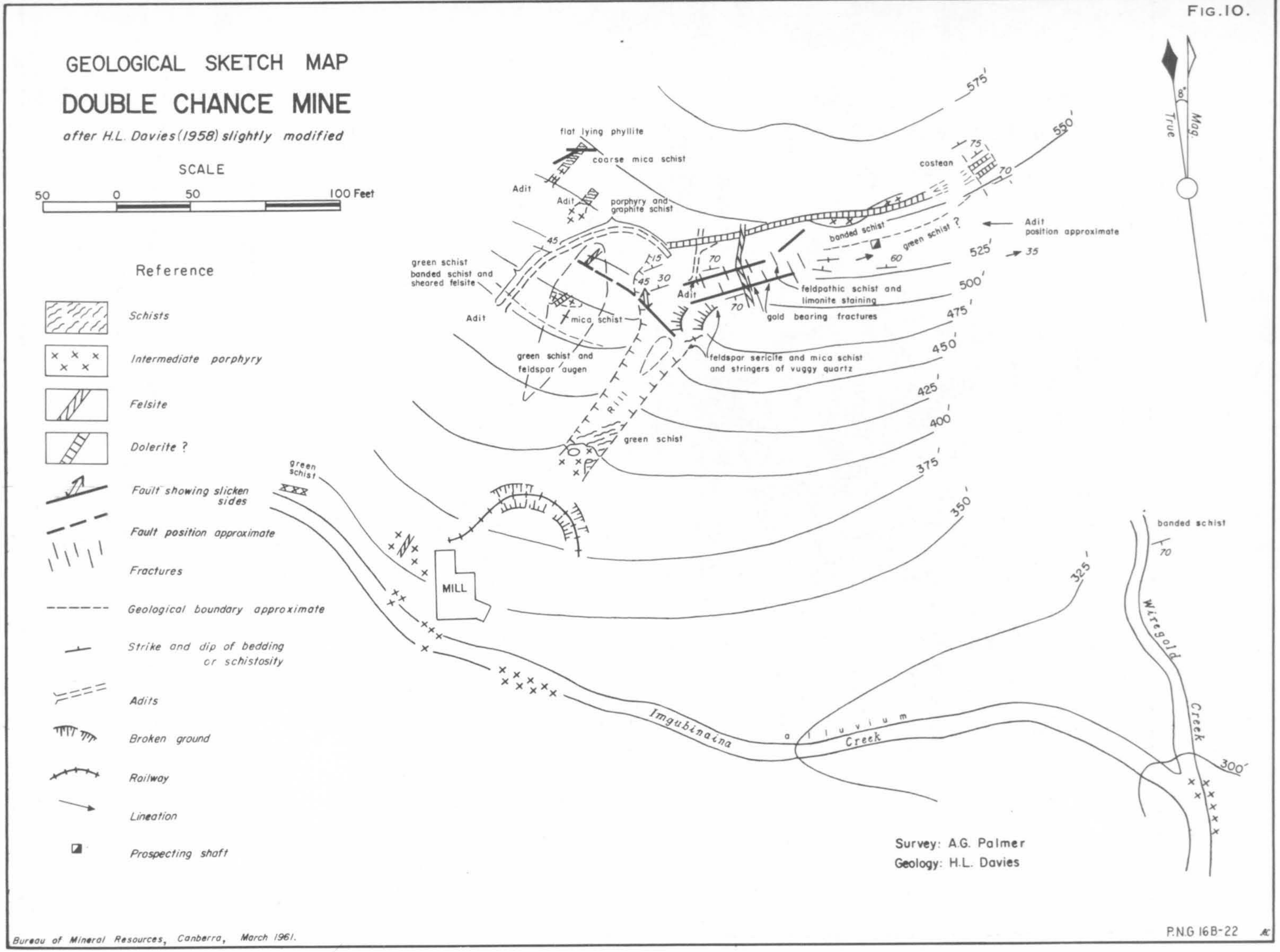


FIG. 10.
GEOLOGICAL SKETCH MAP
DOUBLE CHANCE MINE
after H.L. Davies (1958) slightly modified
SCALE
50 0 50 100 Feet
Reference
Schists
Intermediate porphyry
Felsite
Dolerite ?
Fault showing slicken sides
Fault position approximate
Fractures
Geological boundary approximate
Strike and dip of bedding or schistosity
Adits
Broken ground
Railway
Lineation
Prospecting shaft
True
Mag.
8°
flat lying phyllite
coarse mica schist
Adit
Adit
porphyry and graphite schist
green schist
banded schist and sheared felsite
Adit
mica schist
green schist and feldspar augen
green schist
green schist
MILL
costean
banded schist
green schist ?
Adit position approximate
feldpathic schist and limonite staining
gold bearing fractures
feldspar sericite and mica schist and stringers of vuggy quartz
Adit
575'
550'
525'
500'
475'
450'
425'
400'
375'
350'
325'
300'
banded schist
Imgubinaina
alluvium
Creek
Wiregold
Creek
Survey: A.G. Palmer
Geology: H.L. Davies
Bureau of Mineral Resources, Canberra, March 1961.
P.N.G 16B-22

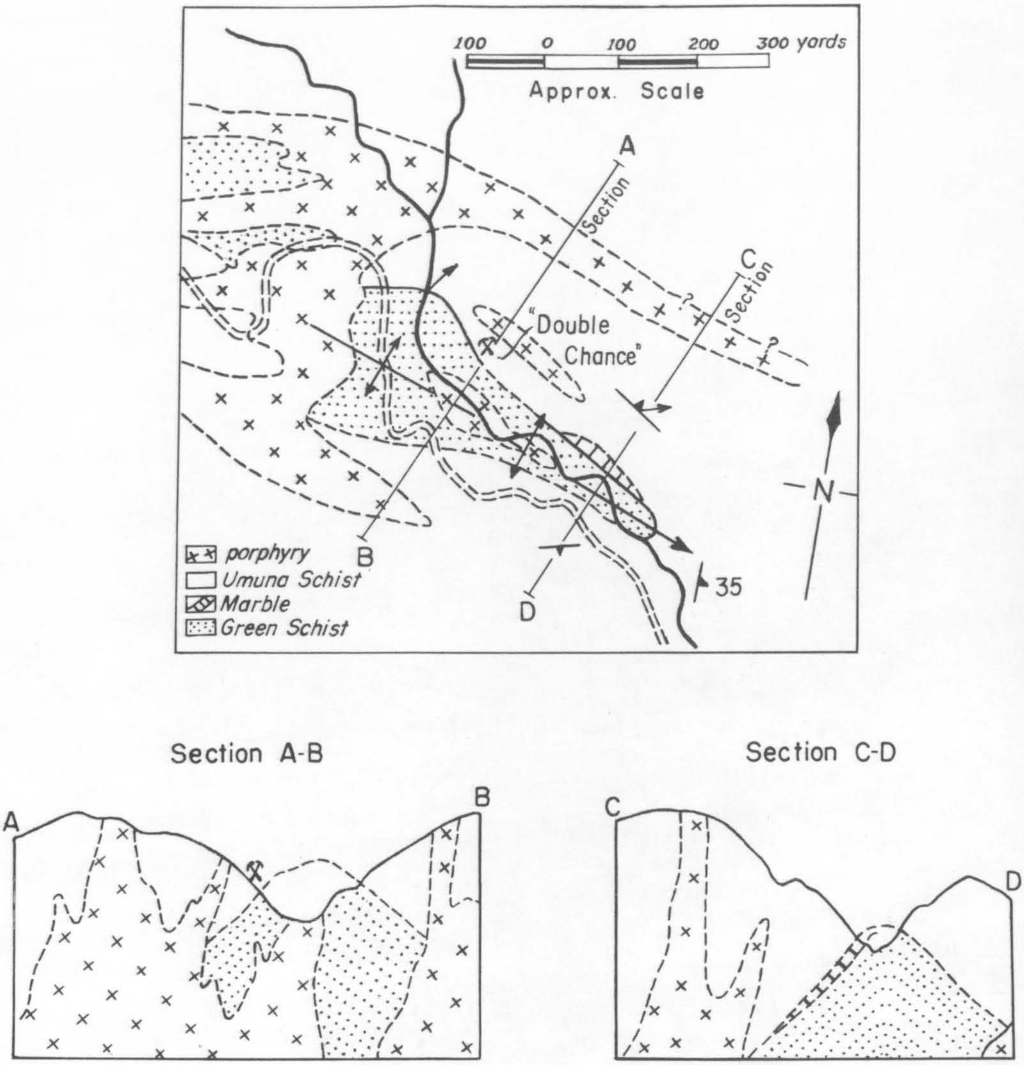


FIG. II. THE DOUBLE CHANCE ANTICLINE
(Geology simplified)
vertical scale = horizontal scale

Bureau of Mineral Resources, Canberra. March 1961. P.N.G. 16B-2

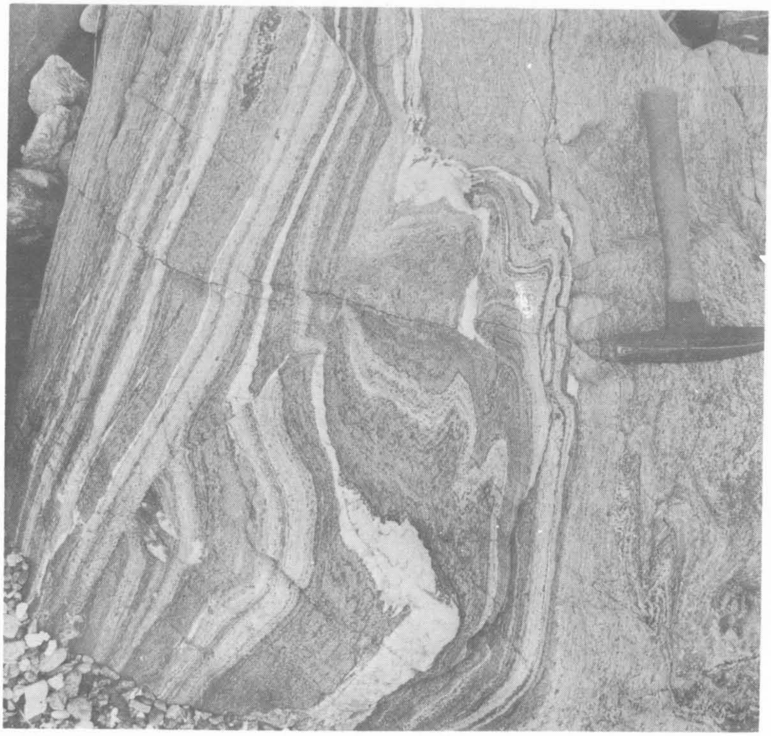


Figure 12.—Minor disturbances in amphibolite and gneiss. South coast, 1½ mile sout-east of Ebora. (Photo: D. S. Trail.)

Folding. The regional strike of fold axes on Misima is roughly east-west. Several orders of magnitude of folding are present in the metamorphic rocks; on a small scale, schists and phyllites are plicated and crumpled, locally to such an extent that the schist is rodded. This fine-scale crenulation is expressed on planes of fissility as a distinct lineation, which, where observed, is parallel to the axes of larger folds (b-lineation). It is assumed, and in some places demonstrated, that the plunge of lineation coincides with the plunge of larger structures which cannot be recognised in outcrop, and the measuring of lineation in the field may be of much value in trying to unravel the obscure major structures.

Larger-scale structures are represented by folds of several feet or yards in amplitude, and may be recognised in good exposures. They show steep plunges in some outcrops, but may be rather flat in other places. With increasing dimensions structures become more difficult to interpret. The Double Chance anticline (Fig. 11), for instance, could be recognised only by the presence of the boundary plane between Ara Greenschist and Umuna Schist, combined with information given by the lineation.

The overall structure of eastern Misima is probably undulating with predominantly shallow to moderate dips and plunges (Sections A-B and C-D, Pl. 1); the many steep dips of the planes of schistosity are attributed to secondary shear folding. Dips and strikes appear to be much more constant and regular in areas where outcrops of porphyry are small and scarce than in the densely intruded regions, where the porphyry bodies seem to have been, directly or indirectly, responsible for the confused structures. One such undisturbed area is the south-east corner of eastern Misima, where an east-plunging anticline is present. Cross-folds occur on eastern Misima in the region between Rokia Point and Cape Henry, where the formation boundaries indicate a general strike to the south-east, but where individual attitudes of schistosity and lineation are commonly at right angles to this direction.

Dips may be gentle in the higher-grade metamorphics, as along the north coast west of Lalama and in many places along the south coast, or they may be steep, as in the region west of Bwagabwaga. It is assumed that bedding and schistosity in the Oiatau Gneiss largely coincide: planes of schistosity and layers of different composition and grain size are generally parallel. Plastic folding suggests that deformation occurred under conditions of high pressure and temperature. An interpretation of the overall structure is given in sections EF and GH (Pl. 1).

Folding in the Tertiary sediments was much weaker. Dips reach 40° at the most, but are generally much less. The regional dip is towards the sea, away from the metamorphic basement.

Faulting. Faulting is common throughout the island and affects all rock units. Definite fault-planes in the metamorphics can rarely be traced in the field, but are recognised by brecciation and shearing, in many places combined with quartz veining; the Umuna lode is the best known example. Many exposures show small-scale faulting and thrusting (Fig. 12). Tertiary sediments are also affected by faulting; exposures show that small-scale faulting has frequently occurred as low-angle thrust movements.

Even the Quaternary coral reefs were subjected to tectonic stress, resulting in considerable post-Tertiary uplift. Vertical off-sets in raised coral benches have been noticed on the south coast, and Bwagaoia harbour was probably formed as a sunken wedge bounded by fault planes. West of Eiaus the raised coral reefs show low dips in opposite directions, perhaps owing to drag movements caused by block faulting.

Although geological and structural photo-interpretation was generally not possible, a pattern of lineaments was detected by close study of the air photographs (see insert on Pl. 1). This lineament pattern, which has some influence on the drainage system, undoubtedly includes joint systems as well as fault planes. Bwagaoia harbour, for instance, is bounded by a set of lineaments, and probably owes its artificial-looking, canal-like appearance to differential movements along these lines: a small wedge has subsided below sea level, a western block has slightly emerged, and an eastern block has remained stationary. The coral reef west of Bwagaoia has been raised about 20 feet, and its former lagoon is now just above sea level and is being filled by alluvium. The Umuna lode also seems to fit in the pattern, and the lineaments deserve close attention in the exploration for gold, as they may guide and concentrate activities along lines of structural weakness which are logical structural traps for the mineralization.

GEOLOGICAL HISTORY

The oldest rocks in the area now occupied by the higher-grade metamorphics were basic volcanics and plutonics, followed by clays and silts with occasional tuff beds and flows. These deposits were deeply buried and regionally metamorphosed; subsequently they were deformed, locally migmatized, and intruded by trondhjemite under deep-seated conditions. At a somewhat later stage, after the conditions for regional metamorphism had largely disappeared, lamprophyric and acidic dykes were injected.

In the eastern region, a period of basic vulcanism was succeeded, and perhaps also preceded, by a period of deposition of dark organic muds and silts, which commenced with the formation of limestone banks, possibly as coral reefs or other organic structures. These volcanic and sedimentary rocks subsided and were transformed by regional metamorphism into phyllites and schists, with accompanying faulting and folding. Porphyry masses and dykes were probably emplaced in the later stages of deformation after regional metamorphism and were accompanied by gold and sulphide mineralization.

Both suites of metamorphic rocks were then raised above sea level and eroded. In Tertiary times the outlines of the island became roughly defined, and fringing reefs formed in places. Continuing emergences seem to have been much stronger in the south than in the north, with the result that coral reefs (which continued to develop into Quaternary times) were raised, in stages, to a considerable height in the south, while Miocene shallow-water sediments and volcanics were deposited in the north. Andesitic and trachytic lavas and tuffs were laid down over the north-eastern part of Misima, whereas farther west coarse clastic sediments and conglomerates were deposited. Finally, the emergence which began on the south coast extended to the north and both Tertiary beds and Quaternary coral reefs of the entire island were raised above sea level.

Faulting accompanied all these stages of uplift and occurred in Recent times, as is demonstrated in the formation of Bwagaoia harbour.

ECONOMIC GEOLOGY

Apart from one trial parcel of base-metal sulphide ore, gold has been the only mineral mined on Misima, yielding silver as a by-product. Small quantities of lead, zinc, and copper sulphides occur, but are not of economic interest.

TABLE 2.—THE UMUNA LODE: MINING COMPANIES AND PRODUCTION FIGURES.

Period.	Mining Company.	Tons of ore.	Ounces of fine gold.	Average grade dwt/ton.
	CENTRAL SECTION AT UMUNA			
1949 ..	Cuthbert's Misima Goldmine Ltd. (attempt to re-open the mine)	2,117	351	3.3
1935–1942	Cuthbert's Misima Goldmine Ltd.	199,474	52,346	5.2
1928–1935	New Misima Goldmines Ltd.	75,167	20,900	5.5
1922–1928	Misima Goldmining Company, and various other syndicates	?	?13,000	?
1914–1922	Block 10 Misima Gold Mines, N.L.	101,637	40,700	8.0
?–1914	St. Aignan Mining Company	?	?	?
		378,395+	127,297+	6.0
	NORTHERN SECTION AT MT. SISA			
1933–1940	Gold Mines of Papua Ltd.	40,000	8,500	4.2
1947–1948	Mararoa Goldmines N.L.	?	150	?
1953–1955	Scottish Queen (Mr. H. Gladstone)	1,200	1,225	20
	SOUTHERN SECTION AT KULUMALIA			
1940–1942	Gordon's Misima Company	..	..	..
1935–1940	Misima Gold Reefs (N.G.) N.L.	..	..	..
	TOTAL	419,595+	137,172+	±6.0

To face page 23.

Misima came into existence as a mining field in 1888, when alluvial gold was found and worked in Ginesia Creek and subsequently in other creeks. It was one of the first times that gold was discovered in Papua. In 1904 R. Boyd, a prospector, traced lode-quartz boulders in Cooktown Creek upstream to their origin and so located the first lode, which he called the Massive, now the central section of the Umuna lode.

A succession of syndicates and companies attempted the mining of the lode (see Table 2) but only a few of them were financially successful. The mine was in a state of healthy production, the monthly output was continuously increasing, and record production figures were being obtained, when World War II forced it to close. After the war an attempt to re-open the mine failed, and the workings have since been abandoned. During the successful mining of this central section of the Umuna lode other companies were active on the southern section at Kulumalia, and the northern section at Mount Sisa, but production remained far below expectations, owing partly to operational difficulties.

The Quartz Mountain lodes are the best known of other smaller and less well-defined lodes on the island, but negligible amounts of gold have been produced from them. The only production of gold after the war came from a few scattered localities, where the metal was mined for short periods and yields of up to 2,000 ounces were obtained, as at Mararoa, the Scottish Queen, and the Double Chance. The Double Chance is the latest find, and was still being worked in 1959 by its discoverer, Mr H.Gladstone. Natives are still producing a few ounces of gold per year from creek alluvium.

Estimated total production of gold from the lodes and alluvial deposits of Misima Island is of the order of 236,000 to 239,000 ounces (Davies, 1959), of which at least 127,000 ounces were obtained from the central section of the Umuna lode.

Alluvial Workings

Until 1904, alluvial deposits were the only source of Misima's gold. The best known deposits were along the Ginesia, Ara, Ingubinaina, Inhabit, and Maika Creeks and the two top branches of Kobel Creek, but some gold was found in nearly all creeks on eastern Misima. The largest known, tested, deposit is on Tauhik Creek, south of Quartz Mountain. The alluvium was drilled and sampled in 1939, and the reserves were calculated at about 1 1/2 million cubic yards of wash carrying 10.5 grains per cubic yard. About 80 percent of this gold is very fine, and difficult to recover. Dredging was not considered practicable because individual deposits were small, scattered, and at considerable depth (Donaldson, 1939). Potential deposits may exist at the mouths of the gold-bearing Ingubinaina and Ginesia Creeks; these swampy flats have never been tested, although their areas are larger then the Tauhik area.

The total production of alluvial gold on Misima is given as 80,000 to 100,000 ounces, but much may not have been offically recorded.

The Lodes

Known lode mineralization occurs in the Umuna area, the Quartz Mountain area, and the Ingubinaina Creek area, and there is evidence that further lodes may be hidden under the decomposed rock mantle. Most of the workings are collapsed and inaccessible at present, with the exception of a few adits such as the No. 7 at Umuna and the Waterfall adit at Kulumalia.

The Umuna Line of Lodes

The Umuna line strikes north-north-west from Kulumalia via Umuna to Mount Sisa over a distance of about 1 1/2 miles, and perhaps continues for another 2 1/2 miles to the vicinity of Ara Creek. The known portion, between Kulumalia and Mount Sisa, is well-defined. Its continuation to the north-north-west is inferred only from a number of old leases situated near Ara Creek, some of which reportedly have shown good gold values in lode material similar to that of the known Umuna lode. The known portion of the Umuna lode follows a prominent ridge and is subdivided into three sections: a central section at Umuna, a northern section at Mount Sisa, and a southern section at Kulumalia. The lode is best defined in the central section; in the other two the lode seems to branch and weaken. The central section has also shown the highest values and has produced the bulk of the gold.

The Central or Umuna Section. The lode is not well known geologically because the mining companies did not employ qualified geologists and workings have now collapsed. According to Stanley (1915) the lode consists of '... two apparent walls which, in reality, represent two reversed faults, highly brecciated ...'. King et al. (1949) described the lode as '... a fault breccia with quartz, soft pug, and rocky gangue derived from the schist and porphyry ...'. At Umuna the fault dips steeply to the west. Boulders of sugary, vuggy, occasionally layered, white or yellow quartz mark the trend of the lode at the surface. Nevertheless the lode is not strictly a quartz reef, but a shear zone traversed by veins and stringers of quartz. Palmer (1959) believes that the main orebody, in which gold values are erratic and very unevenly distributed, is enveloped in a halo of very low-grade mineralization with a maximum width of 250 feet.

Only the oxidized zone of the lode has been worked because, owing to the softness of the rock, the easy-milling character of the ore, and the fact that no expensive winzing and raising was required, costs were very low. Access to the lode was obtained by adits driven into the hill side. Seven levels were developed, mainly by Block 10 Misima Gold Mines, N.L. (1914-1922), and by Cuthbert's Misima Gold Mine Ltd (1935-1942). These two companies also accounted for about 73% of the recorded total production of 127,000 ounces fine gold, which came from some 400,000 tons of ore with a recovery grade averaging 6 dwt per ton, and was extracted mainly from the No. 5 and No. 7 levels (Palmer, 1959).

Below the bottom level (No. 7 level) the primary sulphide zone gradually makes its appearance in the form of patches of semi-oxidized sulphides of lead, zinc, and some copper. The possible value of the sulphides has been realized by mine managers since 1937, but no exploitation at depth was undertaken, undoubtedly because the cheaply produced gold in the oxidized zone was by no means exhausted. After the war Cuthbert's Misima Gold Mine Ltd, during an effort to re-open the mine, attempted to test the primary zone by means of three diamond drill holes, but met with little success because of very poor core recovery and failure to reach targets when holes collapsed in the soft country rock.

Reserves in the oxidized zone have been estimated at approximately 270,000 tons by King et al. (1949) and at 400,000 tons by Palmer (1957). These estimates include the 'probable' and 'possible' reserves. Few, if any, assay and survey records exist; however, 33 samples from the No. 6 and 7 levels, though not considered representative, gave an average of 2.5 dwt of gold per ton (with 0.6 oz silver, 0.3% lead, and 0.4% zinc), and King therefore feared that much of the ore reserves may have a lower grade than the ore previously worked. Depth and tenor of the primary zone are virtually unknown factors, and it is impossible to give even a rough estimate of any possible reserves. On production figures, gold values do not decline with depth; but the bottom level is still mainly in the oxidized zone, where secondary enrichment of the gold may have taken place, and gold values may therefore decrease to some extent in the actual sulphide zone. The only figures on the tenor of the ore in the sulphide zone are to be found in two assays. One is a bulk assay of a 52-ton parcel of semi-oxidized ore which in 1952 was extracted from the bottom level by two prospectors and consigned overseas, and which showed the following values:

Au 18.5 dwt per ton, Ag 3.0 oz per ton, Pb 20.2%, Zn 36.1%.

The other assay was of a sample handpicked from a dump of high-grade sulphide ore near the portal of a drainage tunnel, and gave the following values:

Au 3.6 dwt per ton, Ag 3.0 oz per ton, Pb 23%, Zn 25.5%, Cu 0.56%.

<u>The Northern Section near Mount Sisa.</u> The lode at Mount Sisa is not so clearly expressed as at Umuna, and cross-lodes are probably present, as for instance at Mararoa. There is even some doubt whether the lode worked by Gold Mines of Papua Ltd was the main branch of the Umuna lode. After a five-year period of testing and development work, the production of 8,500 ounces of fine gold and 24,000 ounces of silver, obtained from about 40,000 tons of ore in 1938-1939, remained below expectation, notwithstanding the fact that the mine was modern and well equipped and assay results appeared to be satisfactory. A strong discrepancy between assay values and recovery grade has never been fully explained (tailing assays suggest that most of the gold was recovered), but mining warden's reports suggest that theft may have been one of the reasons. The mine was closed in 1940.

A smaller lode, developed west of the main lode, differed in that it had a high proportion of calcite.

The only other production in the northern sector came from Mararoa, where Mararoa Goldmines N.L. extracted some 150 oz of gold in 1947-48, and from the Scottish Queen, where H. Gladstone, its discoverer in 1953, drained a small lake to expose the lode and produced about 1,225 fine ounces from 1,200 tons of ore within 22 months. Good values occurred in this deposit, and the warden's reports mention monthly returns of, for example, 95 ounces from 60 tons of ore, and 40 ounces from another 60 tons of ore. Gladstone abandoned the mine when the gold values dropped below 5 dwt per ton (Palmer, 1957). The Scottish Queen is now completely overgrown, but Davies (1959) states that the gold occurred in a shallow-dipping layer of grey pug probably lying in a fault-zone. Palmer (1957) suggests that the orebody may have a pipe form, presumably at the intersection of two planes of weakness.

Good values were reported elsewhere in the northern section of the Umuna lode and its possible north-western extension. A very rich find was made by A. Alexander in 1941 on leases abandoned by Goldmines of Papua Ltd. One parcel was said to assay 44 ounces per ton, and a check sample confirmed 5 ounces per ton (Warden's Reports). Apparently the find was a small, rich pocket, and nothing more has been heard of it. Farther north near Ara Creek, more of less on the projected strike of the Umuna lode, some good gold values were obtained in 1939 from costeans and adits on leases held by Misima North Gold Mines. Donaldson reported 24 dwt over a width of 18 feet, and 12.9 dwt over a width of 23 feet, in two lodes 12 feet apart, and estimated that 75,000 tons with an average grade of 6 dwt per ton were present to a depth of 80 feet below the surface (King et al., 1949). However, no attempts were made to develop and produce this ore.

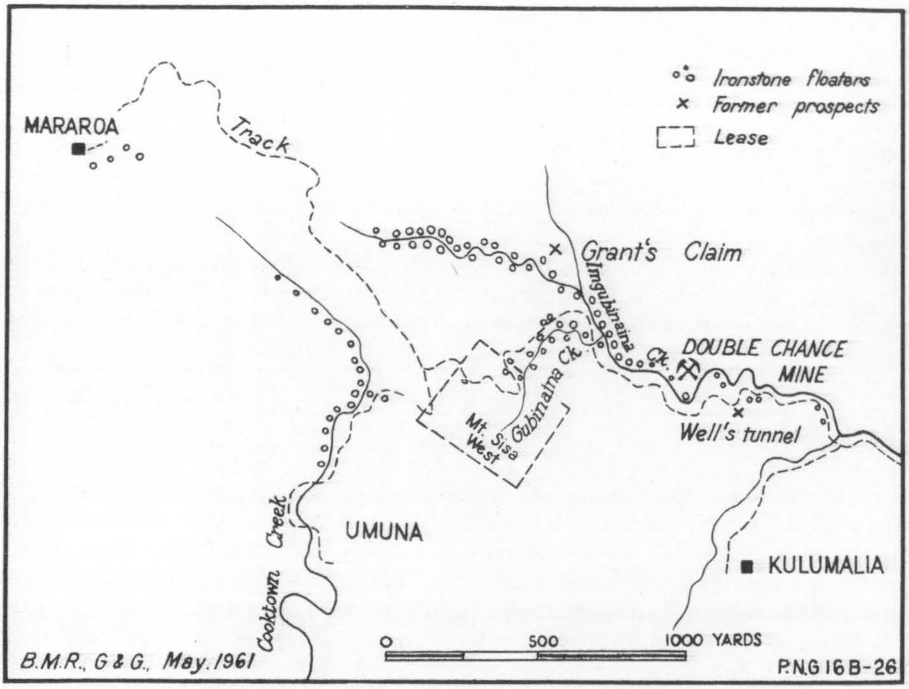


FIGURE 13 CONCENTRATION OF MAGNETIC IRONSTONE FLOATERS AND BOULDERS IN THE MARAROA—KULUMALIA AREA

The Southern or Kulumalia Section. Misima Gold Reefs (New Guinea) N.L., under the management of Major Stuart Love, and Gordon's Misima Company, which took over in 1940, were active in the Kulumalia area. Three main lodes and at least five other lodes were reported from the area (Palmer, 1957). The main lode is a branch of the Umuna lode.

No reliable estimate can be made from the available reports of the value of the lodes. In 1934 the average value was established at about 9 dwt per ton, and in 1936 the ore reserves were estimated to be some 52,000 tons with an average grade of 4.8 dwt per ton (Love, 1936). In 1938, however, these estimates were reduced to about 40,000 tons of 'payable ore', a discouraging conclusion after the years of extensive development work; nevertheless the company was ready to start production when war intervened in 1942. After the war, H. Gladstone milled about 150 tons of the better ore from the area (Davies, 1959), but when production did not confirm the reported assays, he abandoned the project.

The Quartz Mountain Area

The Quartz Mountain area is situated about 5 miles west of Bwagaoia and 1 1/2 miles south-west of Umuna. According to Donaldson (1939) the mineralization follows subordinate tectonic lines, but its pattern has been obscured by slip and creep of the ore down the steep hillsides. Six or more lodes have been found within an area of about three quarters of a square mile. They are similar to those at Umuna, and are characterized by drusy zoned quartz, and by much earthy manganiferous material in places. Some lodes are in leached, honeycombed and partly silicified limestone. Pyrite, galena, sphalerite, and some chalcopyrite are disseminated throughout the quartz matrix and occur locally in the limestone, but there has been little or no production, owing to the generally low values encountered. Quartz Mountain (Papua) Ltd, a New Zealand company, took over the leases in 1934, and started to build roads, bring in machinery, and to construct a mill, all before any values were ascertained or an estimate of reserves was made. Not surprisingly the only production (in 1937) was 55 ounces of gold from 1,000 tons of ore, which corresponds to a recovery grade of about 1.1 dwt per ton, against an assay value of about 6 dwt per ton. In 1938 C.H. Donaldson was employed as manager. He carried out a sampling and assaying programme, but was disappointed with the results, as he found that good ore values are very patchy and rapidly peter out with depth (Donaldson, 1939). Low values are present over a large area.

Only the 'Open Cut', the No. 4 or Waipuna lode and the Quartz Mountain Extended zone show any possibility of containing economic gold deposits. Values have been found to exceed 10 dwt per ton over short distances in these lodes. The 'Open Cut' is an area of quartz boulders set in clay; the boulders assay about 5.2 dwt per ton over a length of 300 feet; and the clay matrix averages about 1 dwt per ton. It is reported (Donaldson, 1939) that 19 feet of material assaying 12.6 dwt per ton were intersected in the No. 2 cross-cut, 300 feet south-west of the 'Open Cut'. A low cliff of vuggy quartz to the west of the cross-cut, representing a fault-zone 6 feet wide, was reported to contain a stretch of 40 feet averaging 15.6 dwt per ton. Check samples taken from this cliff in 1958 gave an average of 8.1 dwt per ton (Davies, 1959). After the Second World War, Quartz Investment Ltd attempted to start production from the Open Cut, but in 1951 a cyclone badly damaged the plant before the mill was in full production, and the project was abandoned for lack of capital.

The Ingubinaina Creek Area

Several small prospects and leases were located along Ingubinaina Creek or in its vicinity, among which were Grant's Claim, Well's Tunnel, and Mount Sisa West (Fig. 13).

The Double Chance was discovered by H. Gladstone in 1957 and was still being worked in 1959. Grant's Claim lode consists of quartzose ironstone containing pyrite, magnetite, and probably gold (Stanley, 1915). Boulders of ironstone are also concentrated in the upper reaches of Ingubinaina Creek and Cooktown Creek (Figure. 13); some are stained with green and bluish-green secondary copper minerals such as malachite and probably chrysocolla. It is possible that the ironstone lode is responsible for the magnetic anomalies in this area mentioned by Stanley (1915). Well's Tunnel was driven for roughly 70 feet through strongly quartz-veined dark phyllite and micaceous schist intruded by feldspar porphyry. The Mount Sisa West lease is situated along Gubinaina Creek, a small tributary of Ingubinaina Creek (Fig. 13). It has a few small, irregular, lode outcrops which consist mainly of fine, black, gritty quartz. Production figures for these old prospects and workings are not known but are probably very small.

The Double Chance was the only gold producer in 1959, and is fully described by Davies (1959). It is an open cut situated on a hill side above Ingubinaina Creek, on the northern limb of an east-plunging anticline (Fig. 11). The open cut trends parallel to the strike of the surrounding schists in an east-north-east direction, and is 12 to 15 feet wide and at least 120 feet long. It is located approximately at the boundary of underlying greenschist and overlying phyllite and micaceous schist; the walls are defined by vertical shears, and the entrance to the cut is marked by a fault striking 135^{o} magnetic (Fig. 10). Gold is irregularly concentrated, partly as wire-gold, in steep northwest-trending fractures or leaders which are filled with quartz or coated with iron and manganese oxides. High gold values occur between the two vertical shears; beyond these the grade is reported as uneconomic and the values in the intervals between the fractures are very low-grade. To the north-east the number and gold content of the fractures appear to decline rapidly. The material mined is a weathered feldspathic schist, possibly a sheared greenschist. Gladstone sank a prospecting shaft here in 1959, but the higher values were not picked up again, perhaps because of a possible pitch of the ore-shoot to the east.

Production in a twelve-month period (1957-1958) was about 230 fine ounces from some 2,400 tons of ore, corresponding to a recovery grade of almost 2 dwt per ton. It is not certain whether values improve with depth; Palmer reported a gradual increase from 2 to 7 dwt per ton, but according to Gladstone the values vary irregularly. In September 1959, Gladstone produced roughly 6 to 8 ounces per week by deepening the open cut and treating the ore in a small three-head stamp battery. The gold is recovered by amalgamation.

Mineralization

The mineralogy of the deposits is fairly simple: gold occurs only in its native form, generally very fine-grained with local development of wire-gold. The sulphides are mainly pyrite, galena, sphalerite, and some chalcopyrite. Secondary ore minerals observed or reported are: malachite and chrysocolla, pyromorphite, cerussite, and chromate of lead. Microscopic examination by Stilwell (1936) revealed some tetrahedrite, covellite, and chalcocite, the last two replacing galena and sphalerite. The gangue is, as a rule, composed of quartz together with altered and brecciated rock fragments; in the Mount Sisa sector calcite is present, and barytes occurs between Umuna and Mount Sisa. Manganese staining and iron compounds are common.

It is evident from the reports that the gold is very unevenly and erratically distributed throughout the orebodies, and that many rich patches are scattered within a wide zone of low-grade mineralization. Stanley (1915) noted that the best values at Umuna were found '... on the footwall side in the brecciated porphyry portions, in which much well-crystalline pyromorphite is found occurring in vugs with a little chromate of lead ...'. Love (1936) reported that the best and most consistent values at Kulumalia occur where the lode has been most heavily leached and altered.

Sulphides occur as scattered crystals and grains disseminated throughout the quartz lodes. In the Quartz Mountain area they are found at the surface as a sprinkling of pyrite, galena, sphalerite, and more rarely chalcopyrite, in the quartz veins and altered limestone. In the Umuna lode they are rarely visible at the surface, where they have been oxidized, but occur more in depth. The ore becomes richer with increasing depth, and locally in the bottom level galena and sphalerite may each constitute more than 20 percent of the ore though restricted to small bodies only. The parcel of 52 tons of sulphide ore taken from the bottom level in 1952 (see page 25) was obtained from a lens tapering from 2 - 3 feet in the middle to 2 - 3 inches at the ends. Loose boulders of base metal ore are known from the north-eastern slopes of Mount Sisa.

The presence of barytes, the very light honey colour of the sphalerite (pointing to low temperatures during crystallization), and the boulders of saccharoidal, drusy, and vuggy, banded quartz indicate that the lodes are epithermal.

No specific host rocks are known: gold occurs in brecciated porphyry as well as in sheared greenschist, graphitic phyllite, and micaceous schist. It may, however, be significant that all lode gold occurrences roughly follow the greenschist contact. The Double Chance is right on the contact (Fig. 11), and the other prospects in the Ingubinaina Creek area are also very near the contact. Greenschist outcrops are not far from the Quartz Mountain lodes. The Waterfall adit at Kulumalia passes through greenschist, and greenschist is known by drilling to underlie the Umuna workings at no great depth. Ara Creek and Ginesia Creek, where alluvial gold was abundant, both run through a greenschist region.

The lodes are all situated in a region where porphyry outcrops are large and abundant and probably represent the roof of a large intrusive consisting of numerous roof pendants, dykes and irregular masses of porphyry. This is a common environment for gold deposits.

Previous workers tend to believe that the feldspar porphyry has introduced the gold into the greenschist and sediments. However, the possibility that the greenschists are source beds at depth should not be excluded. Such an origin is proposed by Boyle (1959) for the Yellowknife gold deposit in Canada, where greenstone is overlain by sediments and is intruded by quartz-feldspar porphyry. Boyle determined that the gold and other elements in the lode could have been derived from the sheared greenstone and that they need not necessarily have been deposited from magmatic mineralizing solutions. The intrusive porphyries merely served to induce a steep thermal gradient from which the elements migrated upwards by diffusion, to be precipitated in zones of dilatation such as shear zones. No chemical analyses have been made of Misima greenschists, but the concentration of the gold on or above the greenschist boundary in areas of intense porphyry intrusion could suggest that a process similar to that described by Boyle may have been active on Misima.

No gold has ever been found in the higher-grade metamorphics of western Misima, although prospectors were active along the north coast, and it appears that the gold is restricted to the lower-grade metamorphics of eastern Misima.

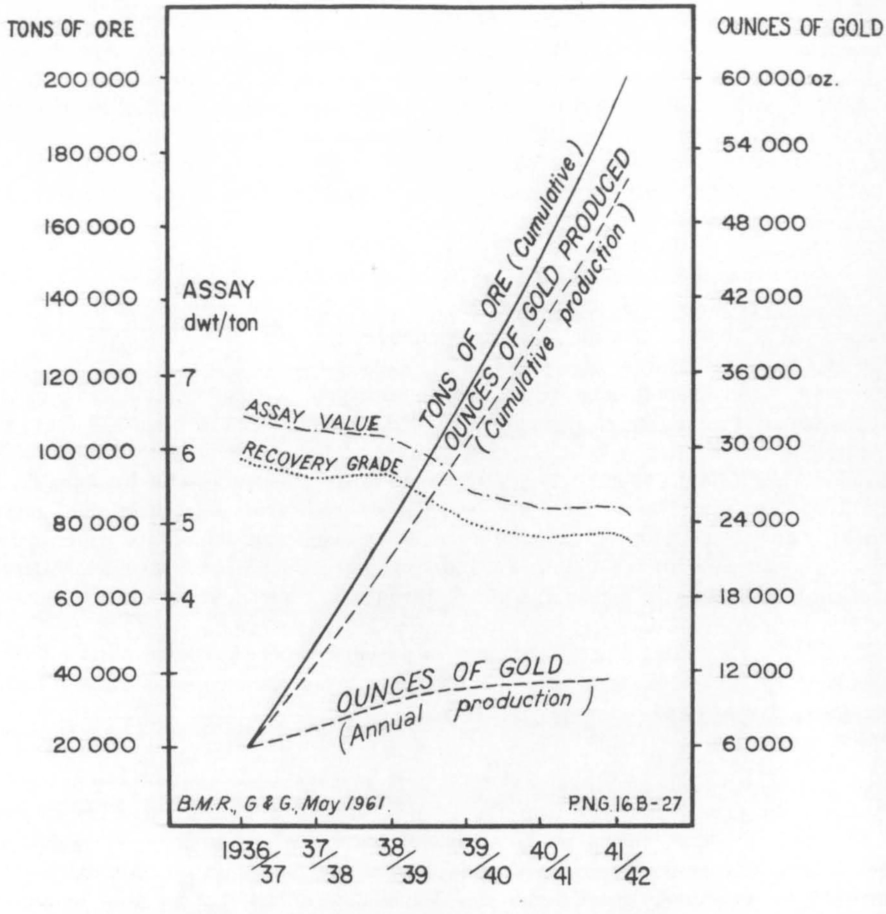
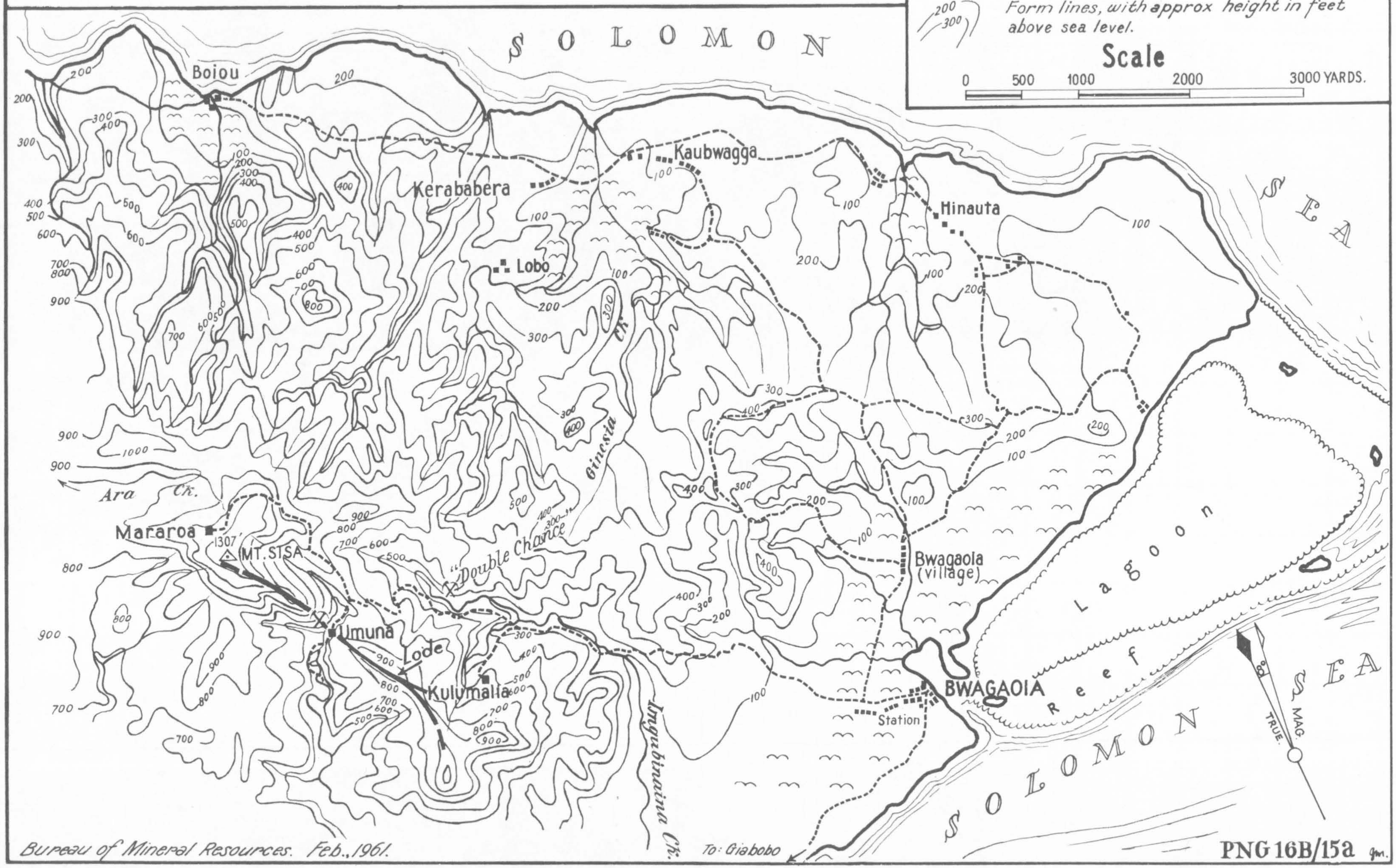


FIGURE 14 PRODUCTION AND AVERAGE ASSAY VALUES CUTHBERT'S MISIMA GOLD MINE LTD.

TOPOGRAPHY OF EASTERN MISIMA ISLAND



Bureau of Mineral Resources. Feb., 1961.

PNG 16B/15a

The question of secondary enrichment has received some attention, and all previous investigators agree that gold has probably been enriched. They generally have in mind secondary solution enrichment, but residual surface enrichment must also be considered probable, particularly in the Quartz Mountain area. The supposition of secondary solution enrichment is based on the observation that economic orebodies were rarely indicated by good values at the surface. Experiments have shown that gold is soluble in surface waters only in the presence of free chlorine, which can be produced by the interaction of sulphuric acid, sodium chloride, and manganese dioxide. On Misima, sulphuric acid is generated by the oxidation of pyrite, sodium chloride may have blown in from the sea, and manganese oxides are present. The chemical reactions are as follows:

$$MnO_2 + 2NaCl + 3H_2SO_4 \rightarrow MnSO_4 + 2NaHSO_4 + 2H_2O + 2\,Cl;$$

$$3Cl + Au \longrightarrow AuCl_3 \text{ (soluble).}$$

The gold and manganese solutions will trickle downwards until a reducing environment, such as would exist in the presence of carbonates, sulphides, or organic matter, is met where excess acid is removed. Gold and manganese will then be reprecipitated. The acidity may also be reduced by kaolinization of feldspars: this could serve as an explanation for the fact that the best gold values at Kulumalia were reported to occur where the lode is most thoroughly leached and altered.

In the Quartz Mountain area the rare good values appear to peter out rapidly at depth, and quartz boulders are commonly richer in gold on the outside than in their centres (Donaldson, 1939) indicating residual enrichment. McKinstry (1955) mentions that gold is generally enriched in an oxidized zone owing to the removal of other elements (residual enrichment), whereas secondary solution enrichment is usually a local process only and produces small rich seams and pockets rather than a well-defined zone of enrichment. In outcrops of the oxidized zone it is usually very difficult if not impossible to distinguish between residual or secondary solution enrichment and hypogenetic gold, since the metal everywhere occurs in its native form and other criteria are generally lacking.

Discussion

Gold production was terminated on Misima in 1942 solely owing to the intervention of war. Production curves in the previous years show a steadily increasing output, and it is evident that there was no question of exhaustion of the ore (Fig. 15).

At Umuna, Block 10 Misima Gold Mines N.L. (1914-1922) worked ore with an average grade of 8 dwt per ton, whereas Cuthbert's Misima Company, which produced just before the war, averaged a recovery of 5.2 dwt per ton, and the tenor was slowly but steadily decreasing (Fig. 14). According to Palmer (personal communication) this was caused by decreasing values in the lateral direction then followed by development work; values are believed to remain constant vertically. However, vertical development would be accompanied by an increase in mining and treatment costs brought about by more expensive development and the complexity of treatment of sulphide ore, and the cut-off grade for the primary zone would therefore be higher than for the oxidized zone.

That the grade of ore has always been dangerously near the cut-off level is illustrated by the fact that most companies worked at a loss. Even the Block 10 Misima group, notwithstanding its comparatively high recovery grade of 8 dwt per ton, had to spend too much capital on the construction of a tramway and other non-productive development work. New Misima Goldmines Ltd was the first company to make a profit, thanks mainly to a splendid team of men who all worked at moderate wages (Warden's Report). Cuthbert's Misima was successful, mainly because it took over a going concern in which all non-productive development work had already been carried out. King et al. (1949) point out that to start afresh would involve the expenditure of much capital, more than is warranted in view of the low grade and the limited reserves.

Nevertheless, Palmer (1959) takes the view that modern techniques and machinery would largely offset these difficulties, and that the increasing sulphide content in depth may make the base metals attractive as a by-product. Sufficiently large reserves in the primary zone and satisfactory tenor are required to counter-balance the high initial and mining costs.

The best site for test drilling of the primary zone would be near where Cooktown Creek crosses the lode. Highest consistent values have been found here, and the primary sulphide zone has the thinnest cover, probably no more than 150 feet. To give an idea of the costs involved when serious attempts at exploration and development are made, it may be cited that after the second World War Cuthbert's Misima spent about £120,000 during its efforts to re-open the mine. This amount included £12,000 on the three diamond drill holes which had an aggregate length of 1,883 feet, £11,000 on the reconditioning of the mill, and £36,000 on new buildings, equipment, and power plant (King et al., 1949).

Much depends on the question of secondary enrichment of gold. If large-scale enrichment occurred in the Umuna lode, then the primary zone has not much chance as a gold prospect, for a decrease in average grade can be expected. Although no indication of a decline in gold values has been found in the bottom level of the mine, it must be remembered that this level is still mainly in the oxidized zone. However, if base-metal sulphides increase sufficiently in depth to make them a worthwhile by-product, then the possibility of an economic prospect in depth at Umuna cannot be excluded. In the Quartz Mountain area residual enrichment seems to have predominated, and there is not much hope for a successful future for this region; nor can it be expected that the base metals will increase in depth, for they occur in their sulphide form at the surface with little evidence of leaching.

The possibility that other lodes are hidden on the island is good. Evidence is furnished by the concentration of large boulders of yellow, Umuna-type lode quartz in the upper reaches of many creeks, most of which have yielded alluvial gold. In most of these creeks it is improbable, geographically, that the boulders were derived from the Umuna lode. One lode may be present just east of Ingubinaina Creek and stretch from near Bwagaoia in a north-westerly direction approximately parallel to the Umuna lode. * Stanley mentions the winning of gold from a deposit of quartz boulders in Gera Gera Creek, about 1 mile above Bwagaoia, which could be in line with this lode. The Double Chance might be an off-shoot deposit of the lode, and the alignment of Grant's Claim, Double Chance, and various other smaller claims led Palmer also to the conclusion that a lode parallel to the Umuna might exist in this general area.

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* Since this report was written, Pacific Island Mines Ltd reported that costeaning approximately along this line, north-north-west of the Double Chance, has revealed manganese mineralization with gold values.

A zone of slipped pyritiferous rubble, boulders of quartz and ironstone, and copper staining can be traced in a north-north-easterly direction across the Umuna lode at Mararoa, and may be the surface indication of another lode. Large concentrations of lode-quartz boulders are found in Ara Creek, where they may have been derived from a north-western extension of the Umuna lode. Many other creeks carry gold, but where accumulations of lode-quartz are absent the gold is believed to have been derived from stockworks of thin leaders which do not attain lode proportions. This applies, for instance, to the small creeks west of the Quartz Mountain area.

The Umuna lode is deeply cut by Cooktown Creek, and this factor may have led to its early discovery. Other lodes may exist which have not been cut into by deep erosional features.

Enrichment has probably taken place on Misima and surface exploration by soil panning alone is not sufficient to locate concealed lodes, because values encountered at the surface commonly bear no relationship to those found in depth. Other, more expensive means of detection such as geophysical and drilling methods will have to be employed. A geophysical survey might be carried out to determine location, extent, depth, and inclination of the lode which is thought to be present east of Ingubinaina Creek. It would first be necessary to test the practicability and suitability of the various methods as difficulties might arise owing to dense vegetation, topographic relief, and the presence of graphitic schists which could interfere with the interpretations. It is suggested that test-surveys be first conducted over the Umuna lode. Exploratory surveys could then be run to investigate the hypothetical Ingubinaina lode, which is in a district not far from Bwagaoia, accessible by road, and which could be the 'mother lode' of the Double Chance deposit. If geophysical evidence confirms the presence of an Ingubinaina lode, then follow-up work by drilling or tunnelling would be required to determine its gold content.

Conclusion and recommendations

The Quartz Mountain area is not considered a valuable gold or base metal prospect.

Nothing is known of the Umuna lode primary sulphide zone and it is possible that reserves are present of sufficient grade and volume to warrant mining in depth. The most favourable site for test drilling would be near where Cooktown Creek crosses the lode.

The most favourable localities to prospect for gold are those bordering zones of greenschist in regions where porphyry outcrops are large and abundant.

It is recommended that geophysical methods should be tested and, if shown practicable, be employed in an attempt to locate other lodes which are thought to be concealed by overburden. The first target should be a north-west-striking strip stretching from Bwagaoia and running just east of Ingubinaina Creek.

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We are grateful to Pacific Island Mines Limited, who supplied us with much information on Misima Island and readily lent us their geological and mining reports.

REFERENCES

ANNUAL REPORTS (1935-1951) of Gold Mines of Papua Ltd.
(1936-1950) of Cuthbert's Misima Gold Mine Ltd.

ALLIED GEOGRAPHICAL SECTION, S.W. PACIFIC AREA, 1944. An annotated bibliography of the South-west Pacific and adjacent areas, Vol. 2.

ALLIED GEOGRAPHICAL SECTION, S.W. PACIFIC AREA. Louisiade Archipelago (AS). Terrain Study No. 34.

BOYLE, R.W., 1959. The geochemistry, origin, and role of carbon dioxide, water, sulphur and boron in the Yellowknife gold deposits, North-west Territories, Canada. Econ.Geol., 54, 1506-1524.

BROWN, L.N., 1923. Island of Misima. In: Administrator of Papua, Ann. Rep. 1921-22, 1922-23.

STILWELL, F.L., 1936. Note on ore samples from Misima, Papua. Sci. ind. Res. Org., Melb., Mineragr. Invest. Rep. 62

DAVIES, H.L., 1958. Report on a visit to Misima. Bur.Min. Resour.Aust.Rec. 1958/95 (unpubl.)

DAVIES, H.L., 1959. Geological observations in the Louisiade Archipelago. Ibid., 1959/133 (unpubl.)

DAVIS, W.M., 1922. Coral reef of the Louisiade Archipelago. Proc.nat.Acad.Sci.U.S.A., 8, 7-13.

DONALDSON, C.H., 1938. Report on the Tauhik Sluicing Co. Property. (Unpubl.rep.to.Tauhik Sluicing Co. Pty)

DONALDSON, C.H., 1939. General report of development operations at Quartz Mountain, for the year 1938-39; Report to Quartz Mountain (Papua) Ltd (unpubl.)

FYFE, W.S., TURNER, F.J., and VERHOOGEN, J.	1958	Metamorphic reactions and metamorphic facies. Mem.geol.Soc.Amer. 73.
HAMBRIDGE, F.	1935	Summary report to New Misima Gold Mines Ltd (unpubl.)
KING, H.F., MOODIE, R.O.K.T., and THOMAS, W.N.	1949	Report to Zinc Corporation Ltd on Cuthbert's Misima Gold Mine Ltd (unpubl.)
LOVE, S.	1936	General Report on the Kulumalia Leases. Report to Misima Gold Reefs (New Guinea) N.L. (Unpubl.)
MacGILLIVRAY, J.	1852	In: Narrative of the Voyage of H.M.S. Rattlesnake. London, 1852, Vol. 2, 71.
McKINSTRY, H.E.	1955	MINING GEOLOGY. New York, Prentice-Hall.
MAITLAND, A.G.	1892	Geological observations in British New Guinea. Qld.geol.Surv.Publ. 85
MINISTRY OF NATIONAL DEVELOPMENT	1951	The resources of the Territory of Papua and New Guinea. Regional Development Division, Canberra.
NYE, P.B., and FISHER, N.H.	1954	The mineral deposits and mining industry of Papua-New Guinea. Bur.Min.Resour. Aust.Rep. 9
PACIFIC ISLANDS MONTHLY	15-2-1940	Report of the death of Robert Boyd.
PALMER, A.G.	1957	Report to Oceanic Minerals Development Pty Ltd on Mineral deposits, Misima Island. (Unpubl.)
PALMER, A.G.	1959	Report to Oceanic Minerals Development Pty Ltd on Mineral Deposits, Misima Island (Unpubl.)
RUTLEDGE, C.G.	1935	Report on New Misima Gold Mines Ltd (Unpubl.)
SMITH, F.	1938	Report to Quartz Mountain Ltd (Unpubl.)
STANLEY, E.R.	1915	Report on the geology of Misima (St. Aignan) Louisiade Gold Field. (With plans). Bull.Terr.Papua. No.3

REFERENCES (cont'd)

STANLEY, E.R. 1917 Louisiade Gold Field. Ann.Rep. for Papua, 1914-15, 141.

STANLEY, E.R. 1923 The geology of Papua. Melbourne, Govt Printer.

THOMSON, B.H. 1889 New Guinea: Narrative of an Exploring Expedition to the Louisiade and d'Entrecasteaux Islands. Proc.Roy.Geogr.Soc. 11, 525-542.

TURNER, F.J., and VERHOOGEN, J. 1960 IGNEOUS AND METAMORPHIC PETROLOGY. N.Y., McGraw Hill.

QUARTZ MOUNTAIN (PAPUA) LTD (Prospectus) 1934 A mountain of quartz. Dunedin, Evening Star Co. Ltd.

PACIFIC ISLAND MINES LTD., 1959 (Prospectus). R.T. Kelly Pty Ltd, Sydney.

Warden's Reports at the District Office, Bwagaoia.

Plate 1
GEOLOGICAL MAP
MISIMA ISLAND
PAPUA
RELIABILITY DIAGRAM
Detailed mapping: dense network of traverses.
Reconnaissance: few traverses.
Geology by F. de Keyser and D.S. Trail.
Compiled by F. de Keyser.
1000 0 1000 2000 3000 4000 5000 METRES
1000 0 1000 2000 3000 4000 5000 YARDS
LOCALITY MAP
NEW GUINEA
NEW BRITAIN
PAPUA
PORT MORESBY
SAMARAI
MISIMA ISLAND
REFERENCE
QUATERNARY
Qa Recent deposits - alluvium, sago swamp, thick soil.
Ql Raised reef limestone
TERTIARY (MIOCENE)
Tml Liak Conglomerate - pebble and boulder conglomerate.
Tmg Gulewa Formation - conglomerate, sandstone, greywacke, siltstone, claystone, pebbly sandstone, sedimentary breccia, tuff(?); limestone member
Tmk Kobel Volcanics - agglomerate, volcanic conglomerate, flows, tuffs, ash beds.
PALAEOZOIC or MESOZOIC ?
M/Pzu Umuna Schist - phyllite, graphitic schist, mica schist, quartz schist, banded schist.
M/Pzs St. Patrick Limestone - marble
M/Pza Ara Greenschist - chlorite-albite-epidote-actinolite schist (metamorphosed basic volcanics).
lower grade metamorphics
M/Pzo Oiatau Gneiss - gneisses and schists composed of varying amounts of quartz, plagioclase, muscovite, biotite, hornblende, garnet; minor amphibolite.
M/Pzl Lalama Amphibolite - massive plagioclase amphibolite, foliated amphibolite, banded hornblende gneiss, garnetiferous in part; minor intercalated gneiss.
Lalama Amphibolite - idem, migmatised, intruded and veined by trondhjemite.
higher grade metamorphics
INTRUSIVE IGNEOUS ROCKS
Acid (dacitic) and basic (lamprophyric) dykes, post-metamorphic.
"Porphyry" - dacitic, andesitic feldspar porphyries and felsites, some granodiorite.
Trondhjemite
Hornblendite - coarse hornblende rocks, with small amounts of pyroxene, scapolite, plagioclase, quartz.
Strike and dip of bedding
Horizontal bedding
Strike and dip of schistosity
Plunge of lineation
Horizontal lineation
Definite fault, position accurate
Probable or inferred fault
Geological boundary, accurate
Geological boundary, approximate
Geological boundary, inferred
Road suitable for 4-wheel drive vehicles
Main tracks
Mine or prospect
House or hut
Mountain top with altitude in feet above sea level
Coral reef fringing Managun lagoon
Plunge of minor anticline
Top of bed indicated by cross-bedding
Vertical foliation
Generalized strike and dip of undulating strata
Prevailing strike and dip of disturbed strata.
Sink hole
TRUE
MAG.
Cape Ebora
Ebora
Bwanewa
Ewena
Lalama
Manihuna
Bagalina
Liak
MT OIATAU
Tubula Point or Bwagabwaga Point
Bwagabwaga
Patnai
Awaibi
Panahahala
Boroma
Alhoga
Lahora
Tonowak Lamwana Point
Elaus
Sikeku
Habalona
MT AFATIKAIGEIAN
MT NAULLIA
MT VISUVIOURA
MT NOGULEHAN
Kakamwa
Gulewa
Patilu Point
Guntuka
Kalotawa
Siagara
Nigom
Rokia Point
Nigul
Bolou or Iwahara
Kerabebera
Kaubwaga
Hinauta
Cape Henry
MT SISA
Mararoa
QUARTZ MOUNTAIN
Kulumalia
Balmatana
Bwagaoia Village
Managun Lagoon
Managun Islet
BWAGAOIA
Silibidai Islet
Giabobo
Lapipai or Narian
Misima
1350'
1650'
152°35'
152°40'
152°45'
152°50'
DIAGRAMMATIC SECTION
(Not to scale)
ACROSS THE TERTIARY BEDS, SHOWING PROBABLE FACIES RELATIONSHIPS
SW
NE
Pre - Tertiary basement
SECTIONS SHOWING INTERPRETATION OF REGIONAL GEOLOGICAL STRUCTURE
VERTICAL SCALE = HORIZONTAL SCALE
4000'
3200'
2400'
1600'
800'
Sea level
Kobel C
Ara C
Lapipai
Kulumalia
Imgubinaina C
Lobo
LINEAMENT PATTERN
DERIVED FROM AIRPHOTO INTERPRETATION
MINING AREAS:
1 Umuna
2 Mt Sisa
3 Kulumalia
4 Scottish Queen (Mararoa)
5 Double Chance
6 Quartz Mountain
Bureau of Mineral Resources, Geology and Geophysics. February, 1961.
P.N.G. 16 B - 21


Plate 2.
LOCALITY MAP
MISIMA ISLAND
PACIFIC OCEAN
DETAILED TAPE AND COMPASS TRAVERSES ALONG TRACKS AND CREEKS
IN THE KULUMALIA-UMUNA-MARAROA-ARA CREEK AREA
Scale
0
500
1000 Feet
"Mararoa"
"Red Point"
"Waramata"
"Kulumalia"
"Umuna"
Ara Ck.
Cuthbert's Ck.
Cooktown Ck.
NATIVE GARDEN
To: Bolou
Gossanous quartz rubble
Mica schist
Quartz veins
Some malachite staining porphyry with schist bands & quartz.
Quartz rubble & magnetite & some malachite staining.
Abundant quartz veins
Quartz
Quartz bands
Small bodies of schist throughout porphyry.
Abundant quartz veins
Pink, weathered, sheared schist or porphyry.
Drusy quartz veins.
Schist in porphyry
To: "Double Chance" open cut gold mine.
Many schist bodies in porphyry
WELL'S TUNNEL
To Bwagaoia
Weathered greenstone with magnetite octahedra.
Mixed schist & porphyry
Flat lying mica schist
WATERFALL ADIT
Approach of Adit.
LODE
Various ill-defined schists.
Nº7 LEVEL ADIT.
RUINS
MAG
TRUE
REFERENCE
Intrusive porphyry
Umuna schist, predominantly micaceous.
Umuna schist, predominantly graphitic.
St. Patrick Limestone : marble.
Ara Greenschist.
Strike and dip of schistosity or foliation.
Vertical schistosity.
Lineation, inclined.
Lineation, horizontal.
Shearzone, zone of quartz veining.
Lode quartz rubble.
Fault, showing dip of fault plane.
Geological boundary, position approx.
Geological boundary, position inferred.
Road.
Track.
Creek.
Old diggings or trenchings
Adit.
Bureau of Mineral Resources, Geology & Geophysics. Jan. 1961.
PNG 16B-19