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# Notes on Papuan Ultramafic Belt Mineral Prospects,

## Territory of Papua and New Guinea

*by*

*H.L. Davies*



BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS DEPARTMENT OF NATIONAL DEVELOPMENT AUSTRALIA

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TERRITORY OF PAPUA AND NEW GUINEA

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## SUMMARY

In the course of geological mapping of the Papuan Ultramafic Belt in 1965-8 several mineral discoveries were made. A lens of nickel sulphides in peridotite and gabbro on Doriri Creek south of the Musa valley has been tested by two mining companies and abandoned. Chalcopyrite mineralization on the lower Waria River, and elsewhere in the Cretaceous basalts, warrants further investigation. All lateritic nickel prospects within the Ultramafic Belt have been tested by either BMR or mining companies, and apparently no economic prospects have been found. The only occurrence of massive chromite which has been found is poorly exposed and rather inaccessible. A geological outline of the Gira-Aikora alluvial goldfield is presented for the first time.

## INTRODUCTION

During the course of geological mapping of the Papuan Ultramafic Belt from 1965-8 several mineral discoveries were made, and some new data on the geological setting of known deposits have come to light. This report has been compiled to summarize the latest data and ideas.

The report is not a complete summary of the mineral potential of the Papuan Ultramafic Belt; rather, it supplements, and brings up to date, previous reports by Smith and Green (1961), Thompson (1962), Dow and Davies (1964) and Macnab (1967).

New information includes reports of nickel sulphide mineralization at Doriri Creek, south of the Musa valley; copper mineralization on the Lower Waria River; a brief account of the Gira-Aikora goldfield; and a review of the search for lateritic nickel.

### Prospecting Techniques

Mineral search in Papua - New Guinea is hampered by lack of outcrop away from stream beds, by extreme relief, and by difficult access. Geochemical stream sediment sampling of major streams in the Papuan Ultramafic Belt has proved ineffective (see discussion in Davies and Haldane, in prep), but sampling of minor streams may be more effective.

The most effective prospecting tool is the search for mineralized float, but this cannot be applied so easily to the many streams where boulders are coated with moss and algae.

Normal airborne geophysical methods are ineffective because of the extreme relief; it may be possible to develop effective techniques by the use of helicopters instead of fixed-wing aircraft.

C.R.A. has demonstrated that once a prospect has been found analysis of residual soil samples will distinguish barren from mineralized ground.

## GEOLOGY OF THE DEPOSITS

### ALLUVIAL GOLD, PLATINUM, AND OSMIRIDIUM

Alluvial gold, platinum, and osmiridium have been won from four areas in the Papuan Ultramafic Belt. These are:

1. Bowutu Mountains: Waria, Wuwu, Wiwo, Mo, and Maiama Rivers (Dow and Davies, 1964, p.25) - see Plates 1 and 2.
2. Gira - Aikora - Ioma area: the Gira and Aikora Rivers and the streams draining into the lower Mambare River near Ioma (Nye and Fisher, 1954, p.7) - see Plates 2 and 3.

3. Yodda valley: the tributaries of the upper Mambare River north of Kokoda (Davies, 1959; Thompson, 1962, pp. 37-8).

4. Keveri valley: the Adau River headwater tributaries south of the Musa valley (Smith and Green, 1961; Macnab, 1967) - see Plate 5.

These goldfields have been described elsewhere and will be only briefly discussed here.

New information and a map (Plate 3) are presented for the Gira - Aikora area, along with a little new information for the Bowutu Mountains. Table 1 summarises production figures.

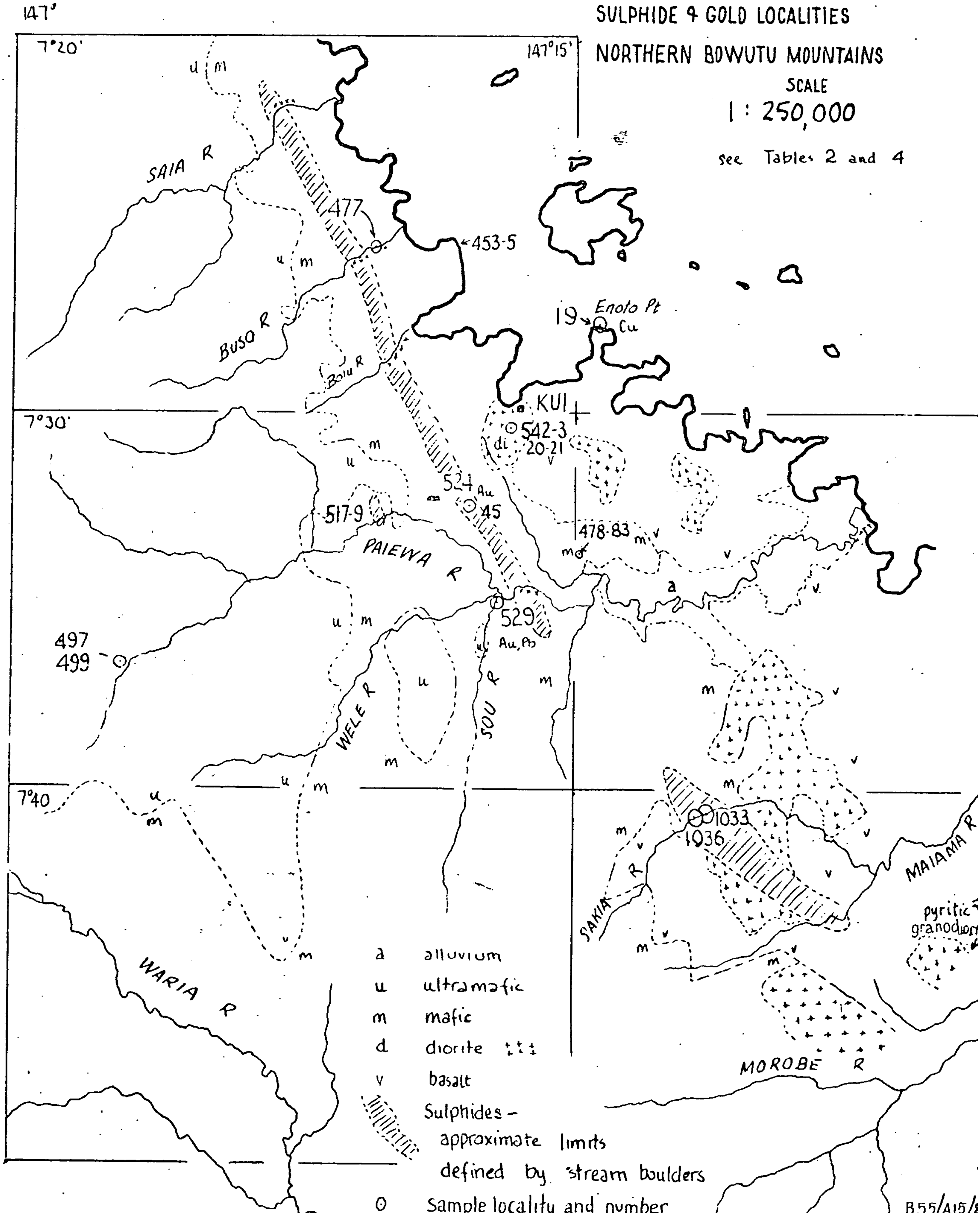
TABLE 1

ALLUVIAL GOLD PRODUCTION

| Area | Gold (fine oz) | Platinum & osmiridium |
|---|---|---|
| Bowutu Mountains | abt 1000 | a little |
| Mostly from middle and lower Waria River<br>Probably does not include pre-1914 figures<br>From Dow and Davies (1964) | | |
| Gira-Aikora-Ioma | 67,880 | abt 700 fine oz |
| Proclaimed 1898<br>Total includes 60,622 oz produced between 1898 and 1909<br>From Nye and Fisher (1954) | | |
| Yodda field | 85,000 | some |
| Proclaimed 1900<br>Most production before 1923<br>From Davies (1959) | | |
| Keveri field | 4770 | probably none |
| Proclaimed 1904<br>Most production before mid-1920s<br>From Macnab (1967) | | |

Most of the gold has been shed from the granitic intrusives and sialic metamorphics of the Owen Stanley Range; three exceptions are the coastal rivers of the Bowutu Mountains, the southern part of the Gira - Aikora - Ioma area, and the Keveri area.

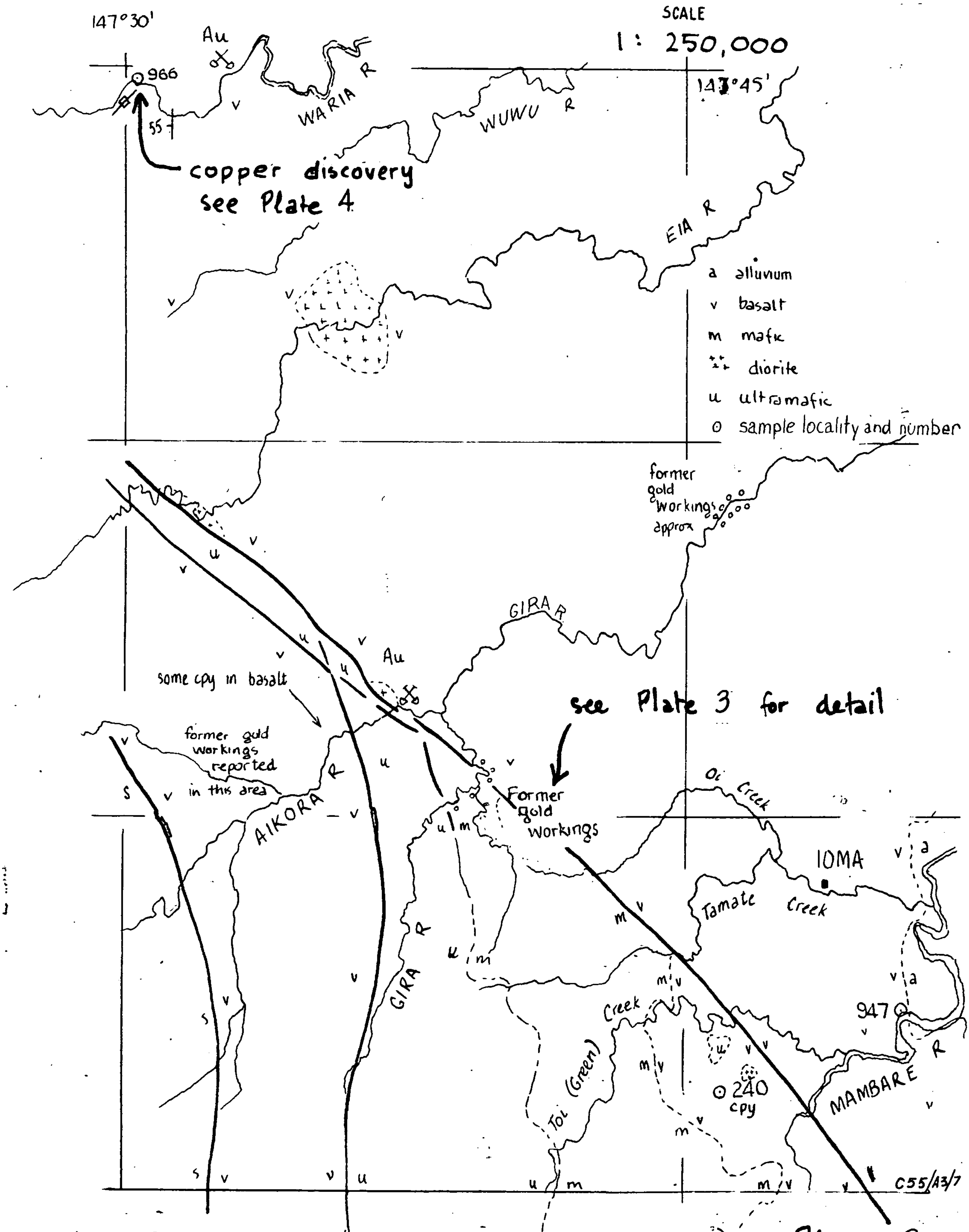
The coastal rivers of the Bowutu Mountains (Wuwu, Wiwo, Mo, and Maiama) derive their alluvial gold from within the outcrop area of Cretaceous basalt and Eocene quartz diorite. Some of the




To accompany Record 1969/67

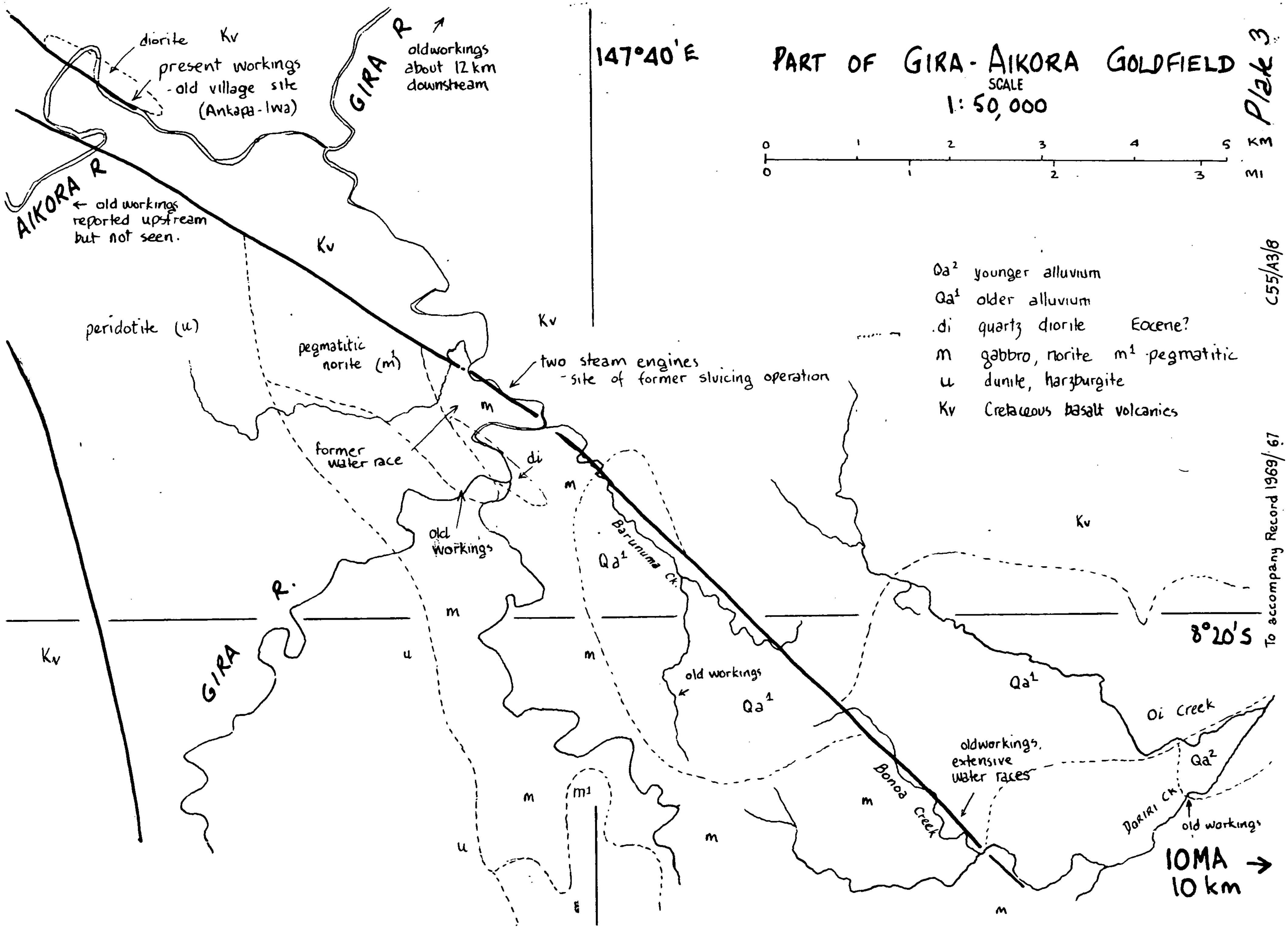
Plate 1

# GOLD WORKINGS & SULPHIDE LOCALITIES
# LOWER WARIA, GIRA-AIKORA MAMBARE AREAS




To accompany Record 1969/57

Plate 2


PART OF GIRA-AIKORA GOLDFIELD
SCALE
1: 50,000
0 1 2 3 4 5 KM
0 1 2 3 MI
Plate 3
C55/A3/8
To accompany Record 1969/67
147°40'E
8°20'S
Qa² younger alluvium
Qa¹ older alluvium
di quartz diorite Eocene?
m gabbro, norite m¹ pegmatitic
u dunite, harzburgite
Kv Cretaceous basalt volcanics
diorite
Kv
present workings - old village site (Ankapa-Iwa)
GIRA R
oldworkings about 12 km downstream
AIKORA R
← old workings reported upstream but not seen.
peridotite (u)
pegmatitic norite (m¹)
two steam engines - site of former sluicing operation
former water race
di
old workings
Barunuma Ck
Qa¹
GIRA R.
old workings
Oi Creek
oldworkings, extensive water races
Bonoa Creek
Doriri Ck
Qa²
old workings
IOMA → 10 km
m
u
m¹

mineralization is in vein quartz: two vein quartz boulders from the Paiawa drainage each contain about $\frac{1}{4}$ oz gold per long ton (524, 529 in Table 3). Gold is possibly associated with quartz - epidote - pyrite - chalcopyrite mineralization in the basalts (see "Lower Waria copper discovery").

Fineness of gold currently being won from the lower reaches of the Waria River ranges from .750 to about .920, according to purchase statements held at Ioma patrol post.

In 1960 D.B. Dow found gold and platinum traces in the Saia and Buso Rivers, which flow through an area of gabbro and peridotite. (Dow and Davies, 1964).

The upper part of the Gira River apparently derives its gold from either the plutonic rocks of the Papuan Ultramafic Belt, or from the fault slice of Cretaceous basalts which lies between the Papuan Ultramafic Belt and the Owen Stanley Range metamorphics. Gold in the nearby tributaries of the lower Mambare River (Oi, Tamate, Clunas, Green, and Fish Creeks) sheds from an area of basalt, gabbro, and peridotite. It is possible that some of the "older alluvium" (see Plate 3) has been displaced from its source by Recent left-lateral strike-slip faulting.

The Keveri gold sheds from hills of Lower Miocene basalt intruded by acid porphyries (Macnab, 1967).

Platinum and osmiridium are known from the Waria, Gira-Aikora, and Yodda fields; they probably shed from nearby ultramafic rocks in each case. A prospector's sample from the lower Gira contained platinum but no osmiridium (A.D. Haldane, BMR analyst, pers. comm., 1966).

## BEACH SANDS

Beaches along the length of the Papuan Ultramafic Belt have not been mapped in detail. Only a few general statements can be made.

Between Salamaua and the Waria River mouth there is a sunken coastline with rocky headlands, and some beaches, at the river mouths. The rivers drain peridotite, gabbro, and basalt, and the predominant heavy minerals would probably be magnetite, chromite, and a little platinum and gold. The volume of beach sand above sea level in any one area is probably insufficient to support a mining operation.

The coastline between the Waria River mouth and lat. 8°30'S is made up of Lower Miocene volcanogenic sediments and detritus from the Owen Stanley Range sialic metamorphics and the Papuan Ultramafic Belt. Detritus from the metamorphics might be expected to predominate, and this is seen in samples of sediments from the Mambare and Gira River mouths (Table 2; Plate 8). However, almost pure concentrations of ultramafic detritus can be found, for example, in Douglas Harbour (Table 2; Plate 8). These may have been concentrated by winnowing of the lighter metamorphic detritus or, possibly, reworking of older alluvium laid down by an earlier river system draining only the Ultramafic Belt.

TABLE 2

| Mineral | Mambare beach | Douglas Harbour beach |
|---|---|---|
| rutile | 0.3 | trace |
| ilmenite | not detected | 0.5 |
| zircon | 0.1 | 0.1 |
| monazite | trace | trace |
| chromite | not detected | 0.1 |
| magnetite | 0.3 | 1.3 |
| haematite | not detected | 0.2 |
| leucoxene | 1.1 | 1.3 |
| limonite | 1.9 | n.d. |
| pyrite | not detected | 0.1 |
| hornblende | 0.9 | 0.8 |
| soda tremolite | 0.5 | n.d. |
| epidotite | 0.6 | 0.1 |
| chlorite | 26.9 | trace |
| quartz | 43.6 | 0.4 |
| calcite | not detected | 2.9 |
| pyroxene | not detected | 92.1 |
| muscovite | 21.7 | unknown 0.1 |
| feldspar | 1.9 | |
| garnet | 0.2 | |
| staurolite | trace | |

Sample from mouth of Gira River almost identical with sample from mouth of Mambare River.

Pyroxene in Douglas Harbour sample ranges from very dark to pale green. The high pyroxene content and lack of recorded olivine in this sample suggests that the analyst failed to distinguish between the two.

The Mambare River mouth is immediately west of Cape Ward Hunt at latitude $8^{o}03$'S; Douglas Harbour is just south of Cape Ward Hunt at about $8^{o}05$'S.

The coastline south of lat. $8^{o}30$'S is not favorable for heavy mineral prospects because great quantities of volcanic sediment have here diluted or masked any heavy mineral concentrations.

Some gold, platinum, and osmiridium must have been carried out to sea by the Waria, Gira-Aikora, and Mambare Rivers, and may possibly be concentrated in the near-shore sediments. It may be possible in the future to locate and mine such deposits.

## TABLE 3: ASSAYS AND ANALYSES

### BASE METAL SULPHIDES

| Rock no. (6552..) | Cu ppm | Cu % | Pb ppm | Pb %% | Zn ppm | Zn % | Ni ppm | Ni % | Co ppm | Co % | Cr ppm | Mn ppm | Au oz/long ton | Ag oz/long ton |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | 1250 | | 700 | | 870 | | 17 | | | | | | 0.01 | 1.7 |
| 240 | | 0.95 | | | | | | | | | | | | |
| 669 | | 13.3 | | | | | | <0.01 | | | | | | |
| 677 | | <0.01 | | | | | | <0.01 | | | | | <0.01 | <0.01 |
| 725 | 550 | | <50 | | 27 | | | 1.80 | 470 | | 40 | 260 | | |
| 726 | 700 | | <50 | | 19 | | | 3.15 | 800 | | 50 | 350 | | |
| 727 | 1025 | | <50 | | 33 | | | 3.20 | 900 | | 70 | 380 | | |
| 728 | | 0.01 | | | | | | 0.24 | | | | | | |
| 966 | | 9.25 | | 0.02 | | 0.08 | | <0.01 | | 0.01 | | | | |
| 1033 | | 0.14 | | <0.01 | | <0.01 | | <0.01 | | 0.02 | | | | |
| 1036 | | 0.06 | | <0.01 | | <0.01 | | <0.01 | | 0.02 | | | | |

### GOLD ± SILVER

| Rock no. (6552..) | Au oz/long ton | Ag oz/long ton |
|---|---|---|
| 477 | <0.01 | — |
| 524 | 0.26 | — |
| 529 | 0.27 | — |
| 542 | <0.01 | — |
| 947 | <0.01 | — |
| 1951 | <0.01 | 0.1 |

### Locality Data (Refer Appendix 4)

| | | | Lat. | Long. |
|---|---|---|---|---|
| 64 | Girewa R., Pongani | Shear in basalt | 09°05½'S | 148°31'E |
| 240 | Hoia (Fish) C., Ioma | Basalt bldr in situ | 08°27½'S | 147°46'E |
| 669 | U. Adau R. | Stream bldr | 09°55' S | 148°53'E |
| 677 | U. Adau trib. | Fuchsite outcrop | 09°54 'S | 148°53'E |
| 725-8 | Doriri C. | Ni sulph shear | 09°52 'S | 148°45½'E |
| 966 | L. Waria R. | Joints in basalt | 08°00½'S | 147°30½'E |
| 1033&6 | U. Sakia R., N. Bowutu | Gabbro bldrs | 07°40½'S | 147°15½'E |
| 477 | Buso R., N. Bowutu | Bldr & malachite | 07°25½'S | 147°09½'E |
| 524 | Iawari trib., N. Bowutu | Bldr & malachite | 07°32½'S | 147°12 'E |
| 529 | Sou R., Bowutu | Bldr qtz-py-ga | 07°35 'S | 147°13 'E |
| 947 | L. Mambare Kureda | Py. shrd bslt | 08°25 'S | 147°51 'E |
| 1951 | Awala R., nr Namudei | Py. shrd bslt | 09°35 'S | 148°23 'E |
| | U. Paiawa, N. Bowutu | Chromite lenses | 07°37'S | 147°03 'E |

### CHROMITE CONCENTRATES

| | $Cr_2O_3$ | Total iron as FeO | MgO | $Al_2O_3$ | $SiO_2$ | NiO | CoO | CaO | $V_2O_5$ | $TiO_2$ | $CO_2$ | $H_2O^+$ | $H_2O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 497 | 59.5 | 23.1 | 8.75 | 8.00 | 0.22 | 0.07 | 0.05 | n.d. | 0.10 | 0.05 | <0.01 | 0.24 | 0.03 |
| 499 | 45.8 | 23.6 | 11.4 | 17.1 | 0.62 | 0.15 | 0.05 | 0.16 | 0.10 | 0.13 | 0.06 | 0.45 | 0.05 |

CHROMITE LENSES

Chromite is invariably disseminated through harzburgite and dunite of the Papuan Ultramafic Belt, but is rarely concentrated. The only lenses of even moderate size which have been found are in the headwaters of the Paiawa River at lat. 7°37'S, long. 147°03'E, (see Plate 1). The main body is an irregular sheet 7-15 cm (3-6 in) thick, exposed for 1½ m (5 ft) along strike, and dipping 20° SW; above it are several thinner irregular layers or lenses, and, east of it, is a near-vertical sheet of chromite up to 15 cm (6 in) thick and 2 m (6 ft) exposed length, strike 340°.

Exposures are limited in all directions by soil cover. The locality is about 30 km (20 miles) from the coast, and at an elevation of about 1290 m (4300 ft).

Chrome mica occurs in altered basalt in a tributary of the upper Adau River (sample 677 Table 3); this has no economic significance.

COPPER

Lower Waria Copper Discovery - Lat. 8°00'30"S, Long. 147°30'30"E.

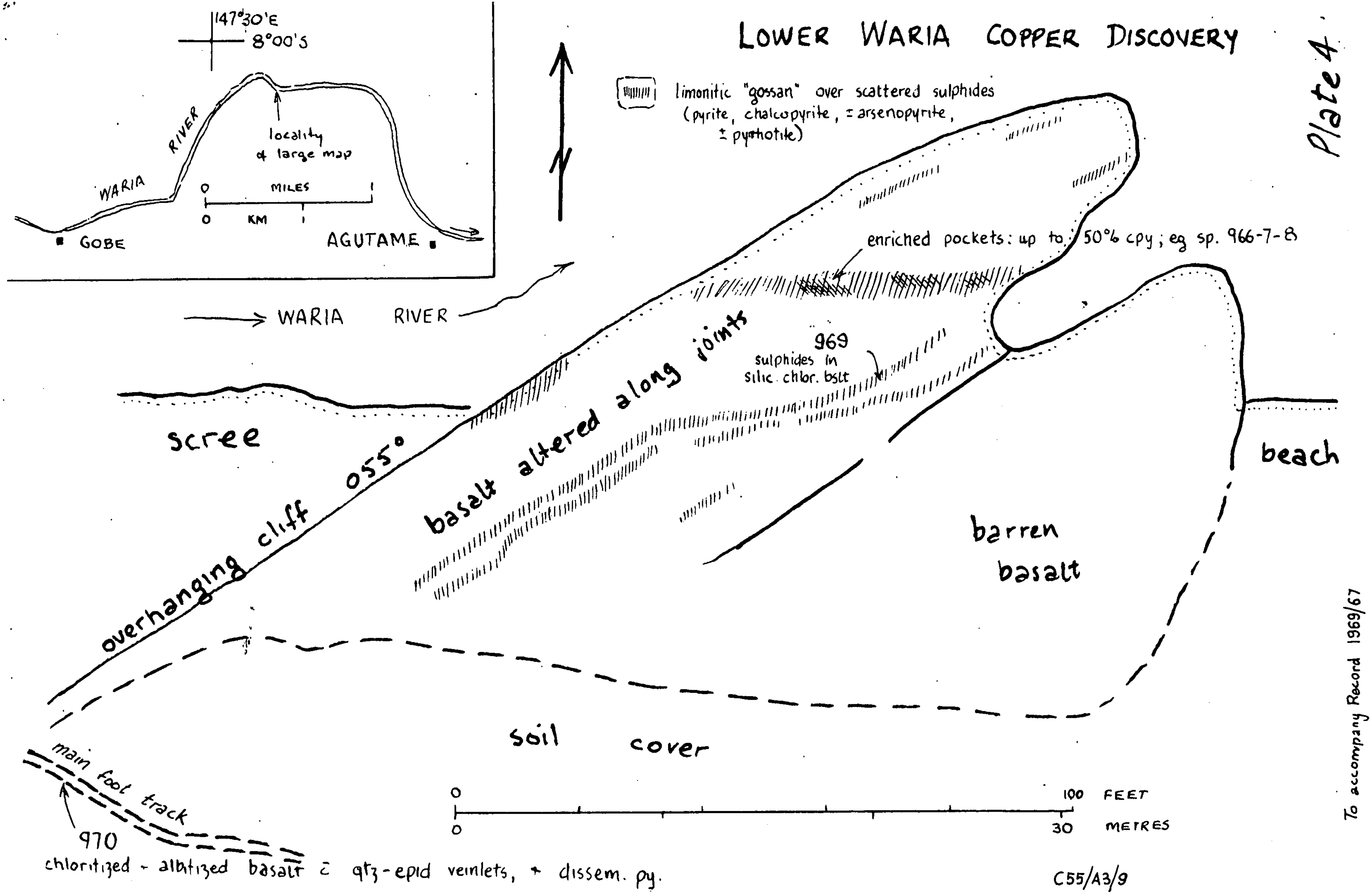
In the course of a gravity traverse by jet-boat, on 22 August 1966, the writer noticed a gossanous coating on waterworn basalt outcrop on the right bank of the Waria River between Gobe and Agutame villages (see Plates 2 and 4).

Pyrite and chalcopyrite mineralization occurs in joints and irregularly through the rock. Of the two pyrite is probably predominant but there are pockets of chalcopyrite enrichment such as sample 966 which assayed 9.25% Cu (Table 3). The main structural control is a set of joints striking 055°.

Mineralization is associated with silicification, chloritization, and some quartz - epidote veining. It is similar to minor occurrences of copper mineralization elsewhere in the basalts of the Bowutu Mountains, notably at Enoto Point (lat. 7°28'S, long. 147°16'E).

The quartz - epidote - pyrite - chalcopyrite mineralization is possibly related to late solutions from Eocene quartz diorite intruding the basalt. Quartz veins within the quartz diorite at Kui, six km south-west of Enoto Point, carry some pyrite and chalcopyrite, and most samples from within and near the intrusive have anomalously high Cu content (see Table 4).

Copper mineralization of the Lower Waria and Enoto type is unlikely to form extensive ore bodies, but the possibility of economic concentrations of massive sulphides in veins or pods remains.



LOWER WARIA COPPER DISCOVERY
Plate 4
147°30'E
8°00'S
WARIA
RIVER
locality of large map
0
MILES
1
0
KM
1
GOBE
AGUTAME
N
limonitic "gossan" over scattered sulphides (pyrite, chalcopyrite, ± arsenopyrite, ± pyrrhotite)
WARIA RIVER
enriched pockets: up to 50% cpy; eg sp. 966-7-8
969
sulphides in silic. chlor. bslt
scree
overhanging cliff 055°
basalt altered along joints
beach
barren basalt
soil cover
main foot track
970
chloritized - albitized basalt c̄ qtz-epid veinlets, + dissem. py.
0
100 FEET
0
30 METRES
C55/A3/9
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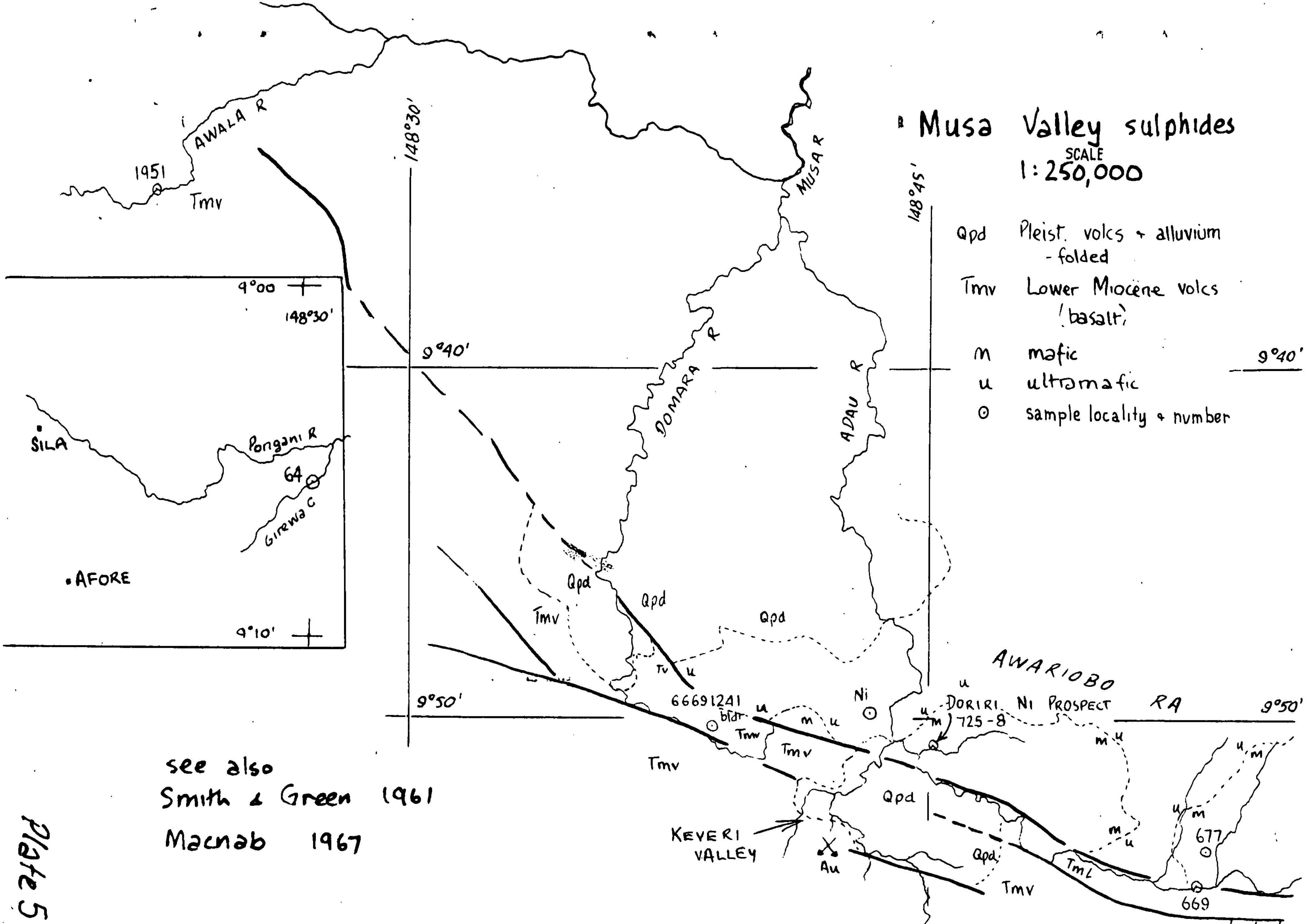



Plate 5

To accompany Record 1969/67

## TABLE 4

COPPER ENRICHMENT IN AND NEAR KUI QUARTZ DOLERITE

| | LOCALITIES PLOTTED PLATE 1 | Cu ppm | Zn ppm | Ni ppm |
|---|---|---|---|---|
| 20 | Road cut S. of Kui; silicified dolerite | 123 | 43 | 20 |
| 21 | N. of road, nr Kui; typical qtz diorite | 113 | 79 | 15 |
| 45 | W. trib of Iawari C; mtsmd fg aug. norite | 1830 | 38 | 95 |
| 453 | Promontory between Buso & Bolu Rs; silicd basalt | 105 | 20 | 33 |
| 454 | Promontory between Buso & Bolu Rs; silicd basalt | 303 | 20 | 18 |
| 455 | Promontory between Buso & Bolu Rs; silicd basalt | 850 | 17 | 26 |
| 543 | Kui quarry: silic'd ural'd basalt | 1150 | 17 | 6 |
| 478 | N. of Paiawa gravel pit; urald silicd fg norite | 282 | 22 | 26 |
| 483 | Nr saddle on road n. of gravel pit; silic'd dolerite | 215 | 14 | 33 |
| 19 | Enoto Point; cpy-brg epid'd & silic'd basalt | 3630 | 60 | 10 |

Granodiorite which forms low-lying country between the lower Maiama and Morobe Rivers (lat. 7°45'S, long. 147°27'E; see Plate 1) is strongly pyritic in places; it might be worthwhile to check this area more closely for indications of porphyry copper type mineralization.

### Copper Mineralization in the Musa Area

Smith and Green (1961) and Macnab (1967) describe several occurrences of chalcopyrite mineralization in the Lower Miocene Urere Metamorphics and their equivalent, the Wavera Beds; mineralization is commonly in shear-zones. The same type of mineralization is seen in an outlier of the Urere-Wavera type rocks in the Girewa River north of the Musa area at lat. 9°05'S, long. 148°31'E (see Plate 5); a sample from here shows some enrichment in Ag, Pb, and Zn as well as Cu (64 in Table 3). Cupriferous float in the upper Adau River (sample 669 in Table 3) has probably shed from a silicic vein or alteration zone in gabbro or Lower Miocene basalts. Macnab (1967, p.20) found native copper in vesicles in a Lower Miocene basalt in the eastern Keveri valley, and there is a little chalcopyrite associated with the nickel sulphides in the Doriri nickel prospect (see under separate heading).

## COPPER AND NICKEL SULPHIDES

### Northern Bowutu Mountains

Gabbro boulders with varying concentrations of iron, copper, and nickel sulphides were first noted in the Saia and Sou (Paiawa) Rivers by D.B. Dow in 1960 (Dow and Davies, 1964, p27). The boulders stand out in the flood channels because of their rusty surfaces. Similar boulders have since been found in the two rivers between the Saia and the Sou, the Baso and the Bolu, and we infer that there is a narrow and perhaps discontinuous mineralized belt up to one km wide and about 30 km long which runs parallel to the coast and to the gabbro-peridotite contact (see Plate 1). Similar mineralization is found along strike in the Sakia-Maiama drainage twelve km south-east of the Sou, but is separated from the Sou by barren gabbro. Analyses of samples 1033 and 1036 from Sakia River are shown in Table 2. Analyses of boulders from the other rivers are shown in Table 4.

G.J. Greaves has described samples from the Saia and the Sou (Dow and Davies, 1964) and records pyrite, marcasite, chalcopyrite, and nickel sulphide (millerite?) in one, and pyrrhotite, pyrite, and chalcopyrite in the other.

The sulphide minerals are disseminated in the gabbro, and are sometimes concentrated around basaltic xenolithes. The lack of exotic gangue minerals in many samples suggests that mineralization has stemmed from within the gabbro; silicification and uralitization in other samples suggests an external source such as the Eocene quartz diorite. The low assays (0.4% Cu maximum) and the general lack of boulders with more than ten percent sulphides argues against the existence of economic concentrations at their source. However, there remains a possibility of richer concentrations which either (a) are not being actively eroded at present, or (b) are being reduced by chemical rather than mechanical erosion.

CRA Exploration investigated this mineralization from the Paiawa drainage northwards in 1967, first with helicopter-borne geochemical reconnaissance, then with more detailed ground survey (Atkinson, 1967). The company found weak chalcopyrite, pyrrhotite, and pyrite mineralization in gabbroic rocks near the mafic- ultramafic contact, and particularly in the valley of the Sou River. The highest copper content in the Sou River rock samples was 8700 ppm, and values were generally around 1600 ppm; the pyrrhotite was not nickeliferous in all but one case.

## TABLE 5

### NORTHERN BOWUTU MOUNTAINS SULPHIDE-BEARING STREAM BOULDERS

Localities indicated by Hachuring on Plate 1.

| | | Cu | Zn | Ni |
|---|---|---|---|---|
| | | p. | p. | m. |
| 441 | Buso R. gabbro boulder c̄ malachite? stain | 10 | 6 | 108 |
| 457 | Bolu R. fg. gabbro boulder c̄ sulphides | 2200 | 19 | 238 |
| 469 | Bolu R. rusty gabbro boulder | 230 | 19 | 40 |
| 470 | Buso R. boulder, gabbroic, some sulphides | 780 | 11 | 135 |
| 471 | Buso R. boulder, gabbroic, some sulphides | 144 | 29 | 33 |
| 472 | Buso R. boulder, gabbroic, some sulphides | 1400 | 12 | 233 |
| 473 | Buso R. boulder, gabbroic, some sulphides | 1100 | 28 | < 6 |
| 474 | Buso R. boulder, gabbroic, some sulphides | 1200 | 10 | 257 |
| 475 | Buso R. boulder, gabbroic, some sulphides | 148 | 80 | 37 |
| 476 | Buso R. boulder, gabbroic, some sulphides | 530 | 68 | 56 |
| 517 | Paiawa upstream sulphide zone (see Plate 2) | 233 | 20 | 83 |
| 518 | Paiawa upstream sulphide zone (see Plate 2) | 508 | 6 | 26 |
| 519 | Paiawa upstream sulphide zone (see Plate 2) | 1300 | 8 | 22 |
| 525 | Paiawa downstream, boulder | 900 | 14 | 113 |
| 540 | Wele near Paiawa confluence boulder | 41 | 10 | 22 |
| 541 | Wele near Paiawa confluence, boulder. | 3670 | 37 | 428 |

## NICKEL

### Doriri Nickel Prospect

The Doriri prospect is on Doriri Creek, a tributary of the upper Adau River, at lat. $9^{\circ}52'$S, long. $148^{\circ}45\frac{1}{2}'$E (see Plates 5-7). It was discovered by Nawa Waria and the writer on 26th May, 1966; mineralized boulders have been noted at the Doriri-Adau confluence in the course of a helicopter reconnaissance the day before. The prospect was investigated by C.R.A. in 1966, and by INSEL in 1967-8; C.R.A. used costeans and residual soil sampling, and INSEL added some geophysical work and drilling to the geochemical techniques. It is thought that both companies concluded that the Doriri lode is too small to exploit; both found evidence of small rich lenses of nickel and copper sulphides in the adjacent country.

The prospect is in a sheared and hydrothermally altered peridotite lens enclosed in gabbro; it is less than 1 km north of the major fault ("Adau Fault") which here bounds the Papuan Ultramafic Belt, and is about 1 km south-east of the main peridotite-gabbro contact. The mineralized shear-zone strikes at 320 - $340^{\circ}$.

Costeaning and residual soil sampling by C.R.A., as reported by Klingner (1967), have defined two sulphide-rich lenses, one 75 x 7.5 m (250 x 25 ft) maximum, and the other 27 x 7 m (90 x 13 ft) maximum; these are shown in Plate 6. The larger lens is exposed in Doriri Creek over a width of 7.5 to 7.8 m (25 - 26 ft); it averages 1.7% Ni (C.R.A. channel sample) or 2.6% Ni (my chip sample). C.R.A.'s best values are in a costean immediately north of Doriri Creek which averages 2.43% Ni over 7.5 m (25 ft), and includes one section which assays 5.71% Ni over 1.5 M (5 ft).

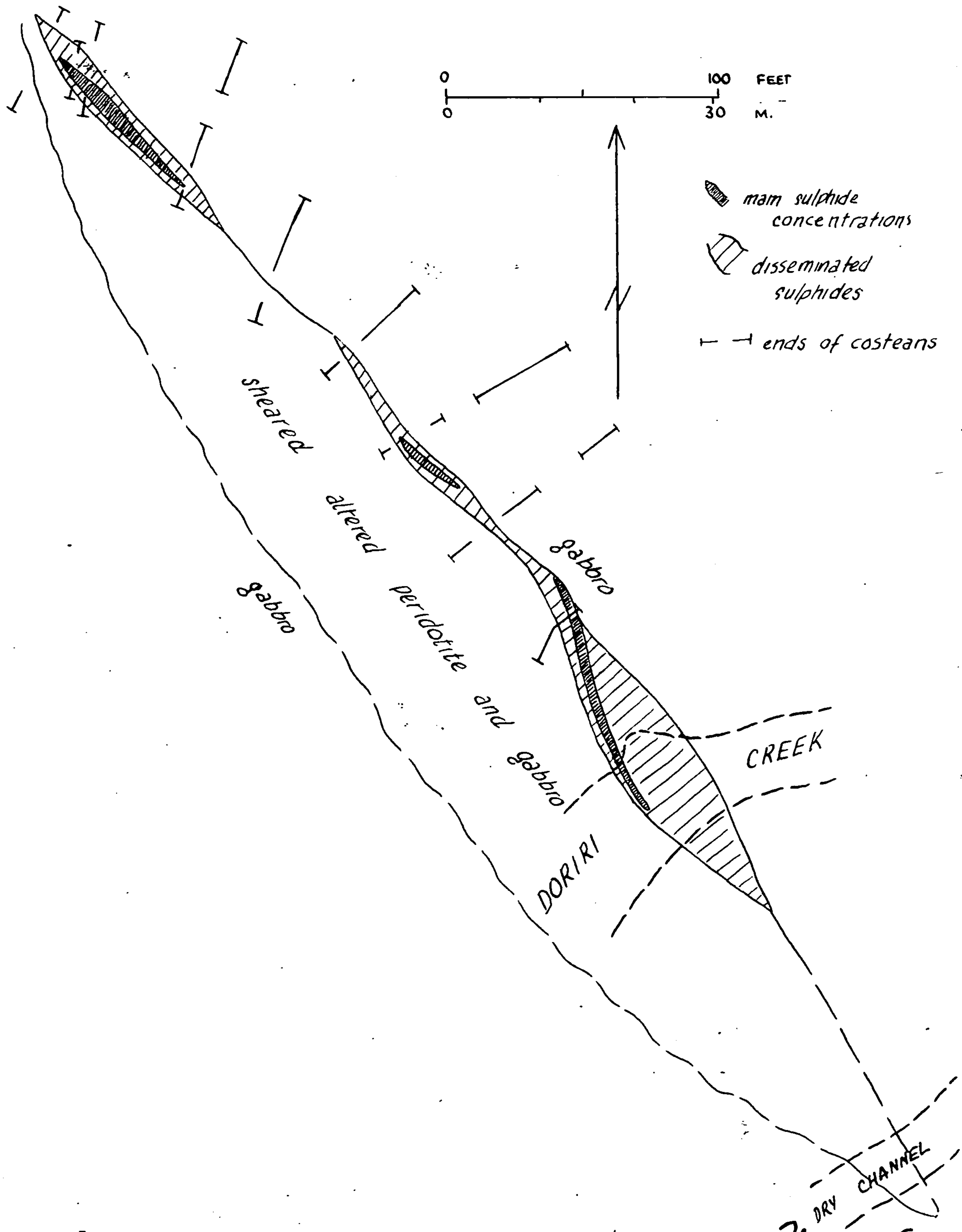
Drilling by INSEL is understood to have shown that the mineralized lenses pinch out at shallow depth.

Mineralized samples have been described by John A. McDonald of BMR (Appendices 1-3) and by mineragraphers at AMDL (Klingner, 1967). Magnetite is the most common opaque mineral (30-50%), and is in places associated with pyrrhotite and pyrite. The main nickel minerals are pentlandite which alters marginally to bravoite and may include awaruite ($Ni_2Fe$); McDonald also identified violarite($(Ni, Fe)_3S_4$). McDonald notes that the silicate minerals were brecciated before the sulphides were introduced. Prevalence of chlorite with serpentine, and presence of muscovite in one sample, indicate introduction of K and Al into the ultramafic rocks, presumably by hydrothermal solutions.

Peter Macnab (1967) found a boulder in the Domara River headwaters, 10 km west of the Doriri prospect, which assayed 34% Ni; the main sulphides in this sample are heazlewoodite, $Ni_3S_2$, and pentlandite, $(Fe,Ni)_9S_8$ (see appendix 3). The mining companies subsequently found several other nickel- and/or copper-rich sulphide occurrences; where outcrop could be tracked down it

# DORIRI CREEK NICKEL PROSPECT

AFTER C.R.A. Expl. Ltd Plan NG 342
IN REPORT BY G.D. KLINGNER, 1967.




To accompany Record 1969/67

C55/A8/16

Plate 6

# DORIRI NICKEL PROSPECT
## BEFORE COSTEANING

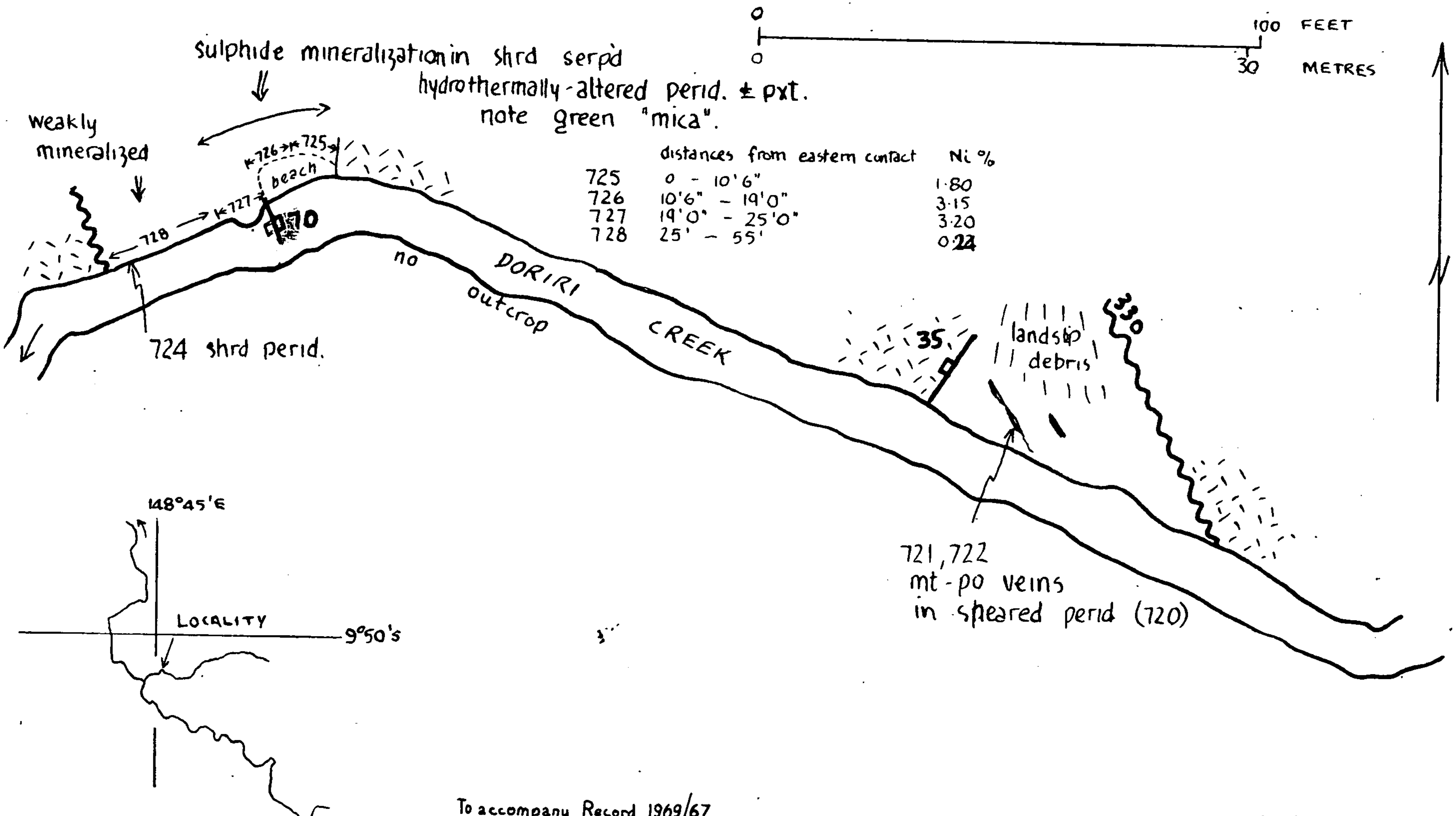



Plate 7

To accompany Record 1969/67

C55/A8/17

typically consisted of small (e.g. 15 cm x 3 m ), rich lenses, apparently isolated from other mineralization. Most or all of these discoveries are within a few kilometres of the southern margin of the Papuan Ultramafic Belt.

There is some evidence to suggest that, if we consider the Papuan Ultramafic Belt as a pluton, then these Cu and Ni prospects are near the top where late mineralized solutions might be expected to collect in response to pressure or temperature gradients. The main evidence for this is that, unlike most Papuan Ultramafic Belt gabbros, the gabbro at the Doriri-Adau confluence has zoned plagioclase. Other evidence is the apparent transition from gabbro to basalt (i.e., to a chilled margin), noted in creeks to the east of the Doriri.

Though Cu and Ni might have been concentrated by this mechanism it is most likely that the mineralization as we see it now developed after fault-controlled emplacement of the "pluton", for the sulphides form a matrix around brecciated silicate minerals. It is tempting to relate the mineralization and K and Al enrichment to late Cenozoic porphyries which intrude the nearby Lower Miocene basalts; these might have served simply to mobilize and concentrate pre-existing disseminated sulphides. One reason to call upon the young porphyries is that both they and the nickel sulphide lenses are peculiar to this part of the Papuan Ultramafic Belt.

## Lateritic Nickel

The term lateritic nickel is applied to nickel which originates in the olivine lattice of peridotite, and is subsequently concentrated in residual soils over the peridotite by normal weathering. Use of the term "lateritic" does not imply the presence of a ferruginous hardpan such as is commonly termed laterite in Australia. The rich lateritic nickel mines of New Caledonia lie only 1900 km south-east of mainland Papua. According to Jacques Avias (personal communication, 1968) the New Caledonia nickel is mined from the lower 50 m of a thick (about 150 m) Oligo-Miocene soil profile; mining is feasible only where much of the upper part of the profile has been removed by erosion.

Jack Thompson, then with BMR, was the first to draw attention to the lateritic nickel potential of Papua-New Guinea, and in particular the Papuan Ultramafic Belt (Thompson, 1957). In the succeeding years all known areas of ultramafic rocks with low topographic relief have been tested by either BMR or exploration companies (see Plate 8). A commercial concentration was found on the north coast of West Irian, but none has been reported in the Australian-administered Territory of Papua and New Guinea.

Thompson (1962) notes that soil depths over peridotite in the Papuan Ultramafic Belt are commonly about 9 m; the deepest holes are several in the Kokoda which reached 21 m, but this depth includes up to 8 m of tuff cover. Nickel values generally increase towards the bottom of the test holes, and commonly reach about 1.5% at bottom.

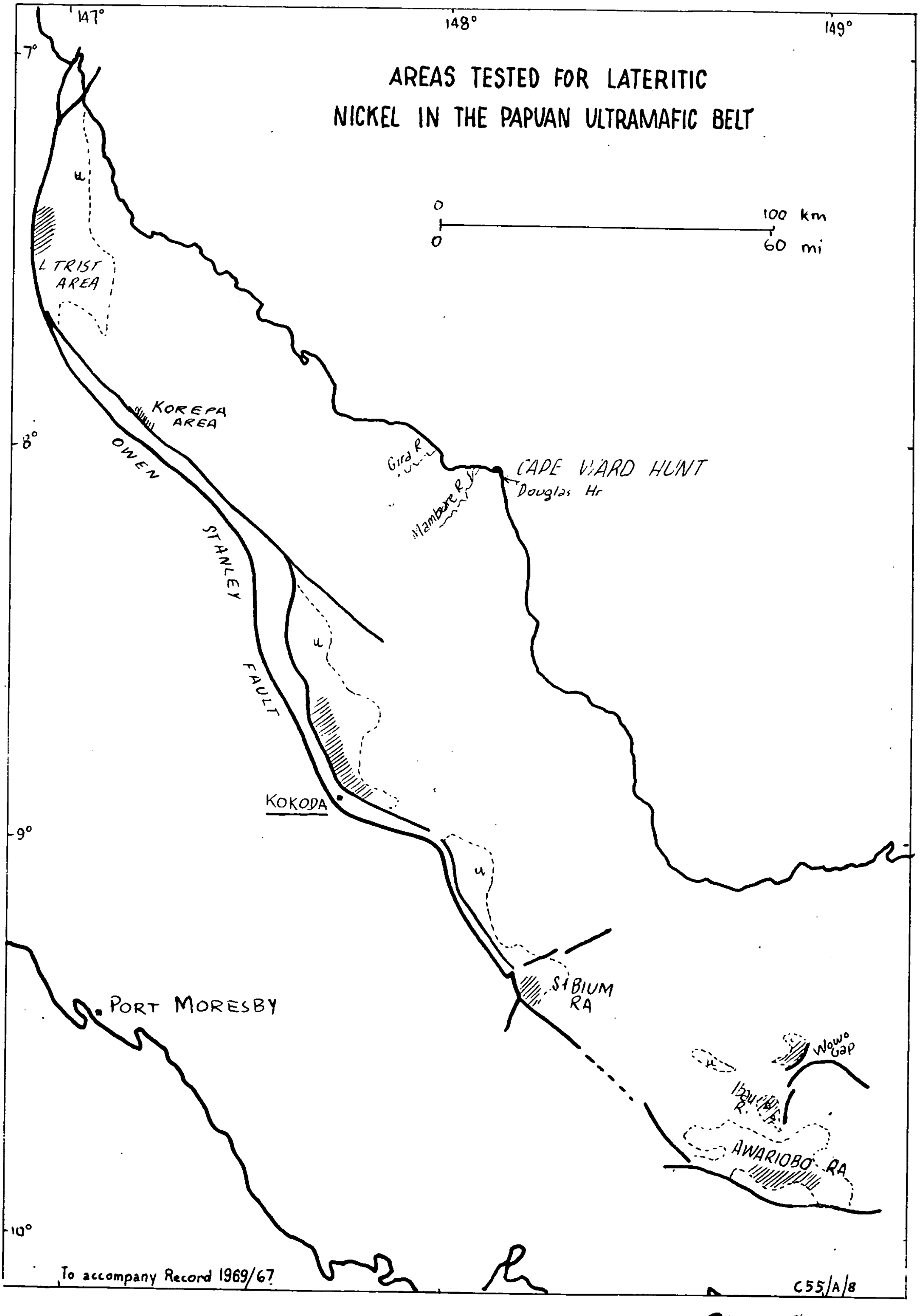
Iron is enriched throughout the soil profile (49-65% $Fe_2O_3$) and surprisingly does not decrease markedly towards the bottom, and this despite the low iron content of the peridotite (7-8% total iron oxides). Thompson thought that this might indicate that the test holes were being stopped by rock fragments somewhere short of bedrock. Though this may be true in some cases, the consistent analyses together with the evidence seen in test pits and rare landslide sections suggest that in most cases bedrock was reached and that iron enrichment does in fact persist to the bottom of the profile.

Since the current program of mapping of the Papuan Ultramafic Belt began in 1965 two lateritic nickel prospects have been outlined by BMR. These have been investigated by exploration companies with apparently negative results (see Plate 8).

One was atop the Awariobo Range north-east of the Keveri Valley at about lat. 9°50'S, long. 148°55'E. Helicopter reconnaissance in September, 1965, indicated a large area of ultramafic rock, and inspection of the airphotos revealed what appeared to be an old erosion surface, characterized by low relief and heavy rain forest, at elevations of 1800-2200 m. Geologists of International Nickel Southern Exploration Ltd (INSEL), who were working in the same general area, were advised of the prospect, and the company began a testing programme two months later. Access presented difficulties which were compounded by the crash of one of the few available helicopters at the western end of the range on Christmas Day, 1965; no one was hurt. After several months of very hard work under trying conditions the company established that soils under the old erosion surface were consistently thin (2-3 m) and presumably subeconomic.

The second area outlined by BMR was at the western end of the Sibium Range, at about lat. 9°20'S, long. 148°15'E, where regional mapping by Smith and Green (1961) in 1958, and myself in 1965, indicated a peridotite mass overlain by flat, and in places swampy, terrain at about 1000m elevation. Mines Division, Port Moresby, released an announcement of this "discovery" simultaneously to the various interested mining companies; INSEL drilled a pattern of hand auger holes with apparently negative results.

Another investigation in 1967-8 was designed to test for nickel enrichment in fractured rock immediately below the soil-bedrock interface. AMAX drilled a number of holes in the Ibau and Wowo Gap areas in the eastern and north-eastern Musa Valley (about lat. 9°40' and 9°30'S, and long. 148°50'E); apparently results were negative.



AREAS TESTED FOR LATERITIC NICKEL IN THE PAPUAN ULTRAMAFIC BELT
147°
148°
149°
7°
8°
9°
10°
0
100 km
0
60 mi
u
L TRIST AREA
KOREPA AREA
OWEN STANLEY FAULT
Gira R
CAPE WARD HUNT
Douglas Hr
Mambare R
KOKODA
SIBIUM RA
PORT MORESBY
Wowo Gap
Ibau R
AWARIOBO RA
To accompany Record 1969/67
C55/A/8


Plate 8

Conclusion: The discovery of ore-grade lateritic nickel in West Irian demonstrates that commercial concentrations can be expected in T.P.N.G., given the right combination of circumstances. The search for lateritic nickel in the Papuan Ultramafic Belt has taken in all likely areas, and results have apparently been negative. Perhaps the main reasons for this are the tectonic instability and generally extreme relief of the region. Peridotite areas in a more stable environment and with more subdued relief may be discovered as the regional mapping of Papua-New Guinea progresses.

## PETROLEUM

Preliminary gravity and magnetic data (Milsom, 1968; Compagnie Generale de Geophysique, 1969) indicate a thickness of about 1500 m of sediments under Cape Ward Hunt (lat. $8^{\circ}03'$S; see Plate 8) becoming thicker offshore to the north. The sediments are probably mostly Lower Miocene volcanogenic with some limestone. Younger detrital sediments would overlie the Lower Miocene sediments offshore. The basin has so far been neglected by companies engaged in oil search.

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## APPENDIX 1

J.A. MacDonald. 18th August, 1966.
Rich Specimen from Adau River Area, Papua.

A rock specimen (6552027) considered representative of a 15-foot wide shear zone, containing + 3.0 percent nickel, in ultrabasic rocks was submitted by H.L. Davies for petrographic and mineragraphic investigation. Two polished surfaces and one thin section were prepared for examination.

The specimen is strongly magnetic when tested with a small hand magnet. Visible sulphides form a complex of interlocking veinlets in the rock.

Polished surface A:

Magnetite and sulphide occur in roughly equal proportions, and constitute about 15 percent by volume. Both phases form abundant irregular stringers less than one mm. wide and small irregular pebbles in the rock. Magnetite occurs in a range of sizes varying from fine dusty grains about 2 microns maximum diameter to subhedral grains about 0.1 mm. in diameter. Pyrite is the main sulphide mineral and forms a fine-grained intergrowth with magnetite: it also occurs as small veinlets. Pyrrhotite forms coarse aggregates that are in parts rimmed by fine-grained intergrowths of pyrite and magnetite with small amounts of marcasite. Chalcopyrite, a trace mineral, forms small veinlets with or without associated pyrite.

Polished Surface B:

Polished Surface B contains about 60 percent opaque minerals. The rest of the sample consists of silicates distributed randomly angular fragments up to 3 x 2 mm. Magnetite forms approximately 30 percent of the opaque constituents. It occurs as fine "dusty" grains in silicates, small subhedral grains associated with pyrrhotite and as "dusty" grains together with lamellae as alteration produces of pyrrhotite. Pyrrhotite forms granular masses in the rock. This forms granular masses in the rock. These are altered to a fine-grained pyrite marcasite-magnetite assemblage in places. Pyrite occurs in these masses as well as in veinlets through the rock. Minor amounts of chalcopyrite, cubanite (?) and pyrrhotite form inclusions up to ten microns in diameter within granular magnetite.

Fine-grained secondary hematite occurs in small amounts finely disseminated through both surfaces.

Thin section examination reveals the silicates to be mainly actinolite with small amounts of accompanying ferriferous amphibole. Chlorite is intimately associated with actinolite and is an alteration product of its Chlorite is characterised by anomalous birefringence - "berlin blue" to deep orange. The outlines of the actinolite masses suggest that the amphibole is an alteration product of a pyroxene. A serpentine mineral, possibly antigorite, is present in minor amounts. The outline of these occurrences together with fracture patterns through these delineated by opaques suggests serpentine may be an alternate product of olivine.

## SUMMARY

1. Although no nickel sulphide phases were determined, nickel may possibly be found in pyrrhotite. This can be confirmed by analysis for acid soluble nickel and total nickel.

2. The sulphide-silicate texture suggests that sulphides have been introduced during or after a period of deformation to produce the sulphide-breccia appearance of some parts of the specimens.

3. Abundant magnetite accounts for the strong magnetic qualities of the specimen.

4. Alteration of silicates to amphiboles suggests that alteration agencies may have been associated with dynamic hydrothermal conditions as opposed to surficial weathering.

5. Deposition of amphibole and serpentine minerals suggest the original rock constituents were pyroxene with associated olivine.

APPENDIX 2
J.A. McDonald. 22 September, 1966.
Adau River - T.P.N.G.

SAMPLE NUMBER 6552027A

This sample represents a hand specimen of sulphide-bearing rock obtained from H. Davies and brought to Canberra by D. Dow for nickel analyses.

Analyses of the total sample as received is as follows:

| | | | |
|---|---|---|---|
| Ni | - 4.09% | Pb | - 15 ppm |
| Co | - 0.11% | Zn | - 17 ppm |
| Cu | - 0.15% | Cd | - <2 ppm |

Polished surfaces and thin sections of this specimen were examined by the writer and described. No nickel-bearing sulphide phase was noted and it was suggested that a nickel analysis of the sulphide phase be obtained.

An analysis of a sulphide concentrate scraped from the back of the specimen revealed the following:

| | |
|---|---|
| Ni | - 19.6 % |
| Co | - 0.62% |
| Cu | - 0.36% |
| Zn | - <0.02% |

Subsequent polished surface examination of the one sulphide-rich surface remaining, supplemented by X-ray powder techniques of individual has revealed that a poorly polished, inclusion-ridden phase had originally been misidentified. The powder pattern of this phase showed it to be a member of the polydymite-violerite series, $Ni_3S_4$ - $(Ni, Fe)_3S_4$. Optical examination indicates it is violerite $(Ni, Fe)_3S_4$. The mineral contains oriented intergrowths of hematite and magnetite as well as a relict orthogonal cleavage pattern.

Detailed examination of the surface in reflected light reveals no phase that can be positively identified as pentlandite. Small grains with maximum dimension of 8 microns occur and consist of pyrrhotite intergrown with a bright yellowish mineral. This yellowish mineral may be pentlandite but is tentatively identified as chalcopyrite in this report. However, violerite is a common oxidation product of pentlandite and relict orthogonal cleavage together with oriented intergrowths of magnetite and hematite indicates that pentlandite may well have been the primary phase from which violerite developed by oxidation. If this is so, pentlandite may be the main nickel-bearing sulphide below the zone of oxidation and remnants of pentlandite may persist in other samples from the level at which this sample originates.

## APPENDIX 3.

(J.A. Macdonald, October 6th, 1966.)

### Nickel-rich sulphide-bearing rock, Domara River, New Guinea.

SAMPLE NUMBER - 66691241

A sample collected by R.P. Macnab and submitted by A.Renwick to Dr. Fisher was examined for its opaque mineral content. The sample comprises about 40 per cent sulphides as uniformly distributed masses about 2 mm by 1 mm in size set in a serpentinous matrix. AMDL reportedly obtained an analysis of 34 per cent nickel from the rock. In hand specimen, two phases are discernable; a bright coloured phase and lesser amounts of a darker, tarnished phase.

Mineragraphic examination supported by X-ray identification confirmed that the two major sulphide phases are heazlewoodite, $Ni_3S_2$, and pentlandite, $(Fe, Ni)_9S_8$. These minerals occur in a ratio of about 3:1 respectively. Heazlewoodite is the brighter of the two minerals in hand specimen, pentlandite the darker. Together they comprise about 85 per cent of the sulphide mineral content. They form mutual boundary relations and occur together in most grains.

A third phase constitutes most of remaining 15 per cent of sulphide minerals. Optically, it is very similar to heazlewoodite and may possibly be a slightly altered phase. Its structure is distinctly mosaic and comprises irregularly intergrown granules. Lamellae of an anisotropic, pleochroic phase occur more abundantly in this than in heazlewoodite proper. In addition, a feathery alteration of the host mineral occurs adjacent the lamellae in this phase but not in heazlewoodite proper. Cleavage is also better developed in this phase than in more massive heazlewoodite. A powder pattern of this material indicates it is a mixture of heazlewoodite and millerite. However, three lines could not be indexed on the basis of this combination of minerals and an additional phase may be present.

## APPENDIX 4.

Notes to accompany Table 3.

64 Fieldbook HLD65.2.2 Airphoto Pongani 2.5097.9. 0905,14831
Refer this report, page 7 plate 5.
Shear zone in outlier of Urere Metamorphics (?) in Girewa River, tributary of Pongani River; rock type pyritic tholeiitic basalt; shear zone strikes 070°.

240 Fieldbook HLD65.3.14. Airphoto Ioma 4.5040.5. 0827,14746.
Refer this report, plate 2.
*In situ* boulder of amygdaloidal basalt contains blebs pyrite and chalcopyrite.

669 Fieldbook HLD66.2.18. Airphoto Keveri 3.5126.5. 0955,14853.
Refer this report, page 7 plate 5.
Chalcopyrite bearing and malachite stained silicic small riverworn boulder in upper Adau riverbed.

677 Fieldbook HLD66.2.21. Airphoto Keveri 3.5126.20,0954,14853,
Refer this report, page 6 plate 5.
Outcrop of chrome-mica bearing silicified gabbro in tributary of upper Adau.

725-8 Fieldbook HLD66.3.3. Airphoto Keveri 2.5165.2. 9052,14845.
Refer this report, page 9 plates 5, 7.
Doriri Creek nickel prospect; chip samples across face; See Plate 8.

966 Fieldbook HLD66.5.11 and 18. Airphoto Giumu River 1.5155.1. 0800, 14730.
Refer this report, page 6 plate 2.
Lower Waria copper discovery; see Plates 3 and 5.

1033 and 1036 Fieldbook HLD66.6.4. Airphoto Mageri Point W.Key 5035.5 - 0740, 14715.
Refer this report, page 8 plate 1.
Sakia River mineralized gabbro and basalt boulders with pyrite, pyrrhotite, and chalcopyrite.

477 Fieldbook HLD 66.1.11. Airphoto 105YY/823, 0725, 14709.
Refer this report, plate 1.
Felsic boulder in Buso River with malachite staining.

524 Fieldbook HLD66.1.19. Airphoto 105YY/79V, 0732, 14712.
Refer this report, page 3 plate 1.

529 Fieldbook HLD66.1.21. Airphoto 105YY/76V, 0735,14713.
Refer this report, page 3 plate 1.
Boulder quartz-pyrite-galena at mouth of Sou River.

542 Fieldbook HLD66.1.22. Airphoto --- near Kui.
Quartz vein in Kui quartz diorite; collected by Mr.P.Kelly.

947 Fieldbook HLD66.5.7. Airphoto Ioma 3.5026.947,0825, 14751
Refer this report, plate 2.
Pyritic sheared uralitized silicified basalt with quartz in vesicles; in Mambare River bank at Kurereda village.

1951 Fieldbook HLD67.3.24. Airphoto Namo 2.05.20, 0935,14823.
Awala River south of Namudei; pyritic leucocratic basalt part of Urere Metamorphics.

497 and 499 Fieldbook HLD66.1.16. Airphoto Biaru 2,5057.7, 0737,14703.
Refer this report, page 6 plate 1.
Upper Paiawa River chromite; see under "Chromite lenses" in text.