COMMONWEALTH OF AUSTRALIA.

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

RECORDS.

1959/32

THE GEOLOGY OF THE AJURA KUJARA RANGE

by

H.L. DAVIES

THE GEOLOGY OF THE AJURA KUJARA RANGE.

by H. L. Davies.

RECORDS 1959/32

APPENDIX.

TABLE OF CONTENTS.

Abstract

Introduction

Situation and access

Physiography

Topography

Climate

Geology

General:

Ajura Kujara Complex

(a) Petrology

(b) Structural observations and interpretation.

Metamorphics

(1) Owen Stanley Metamorphics

(2) Kemp Welch Group

Quaternary volcanics and sediments

Structure -

Faulting

Folding

Geomorphology

Regional Geological History

Economic Prospects

Nickel

Cobalt and Iron

Gold, osmiridium, platinum

References

Appendix I- Petrographic Report by W.B. Dallwitz and W.R. Morgan.

Appendix II - Petrographic Report by W.R. Morgan.

PLATES

1. Locality Map. Scale 16 miles = 1 inch approx.
2. Ajura Kujara Range - Topographic Zones. Scale 2 miles = 1 inch
3. " " " - Geological Map with Section. Scale 2 miles = 1 inch.
4. " " " - Geological Detail and Specimen Localities. Scale 2 miles = 1 inch.

ABSTRACT

The Ajura Kujara Range is composed of basic and ultrabasic igneous rocks and is a part of the Papuan Ultrabasic Belt, which is thought to be of Upper Mesozoic or Lower Tertiary age. The rocks range in basicity from non-feldspathic ferro-magnesian types in the east and south to gabbroic types in the east and northeast. Lateritic concentrations of nickel occur in soils developed over olivine-bearing rocks, but sampling has not yet revealed grades high enough for exploitation.

Other rock-groups in the vicinity are the Palaeozoic (?) and Mesozoic (?) metamorphics of the Owen Stanley and Kemp Welch (?) series, and Quaternary alluvium and volcanics.

INTRODUCTION:

The first European to visit the area was Sir Wm. MacGregor, who in 1893 explored the Kumusi and Mambare rivers. He recorded amygdaloidal basalt, partly coloured green, 35 miles upstream on the Kumusi, and diorite in the Ajura Kujara foothills which flank the Mambare River above loma. In the Mambare River he also noted traces of gold and "large boulders of quartz containing iron pyrites". (Annual Report for Papua 1893-1894).

Shortly after this came the rush to the Ioma and Gira alluvial goldfields. In 1896 the miners had followed the Mambare River upstream to the Yodda Valley and fourteen men were engaged in mining the alluvials of the McLaughlins Creek area. By 1900 their number had increased to 150, but by 1909 had dropped to 9.

In 1916 Government geologist Evan R. Stanley visited the Yodda goldfield to site a shaft intended to test the alluvium at depth. In 1917 he crossed the island from Rigo to Buna Bay, and, en route, investigated a report of edible earth, called munoki, occurring in the Mamama River. This he records as a mud at the base of a conglomerate formed from the peridotites and serpentines of the area, and containing 0.14% nickel oxide. He traced the serpentines and peridotites along the Mamama Valley and the western flank of the Ajura Kujara Range.

By 1926 almost 77,000 oz of gold had been won from the Yodda Valley, but from then until 1933 there was practically no activity. In the period 1933-42 a further 8,000 oz of gold was produced, making a total for the field of about 85,000 oz.

Washington Gray (1955), after a visit to Kokoda, wrote of the possibility of nickel silicate concentrations of the New Caledonia type at the contact between serpentine and the overlying soil. In 1957, Thompson drew attention to the nickel potential of the soil itself in the Waria Valley and hence over the entire Papuan Ultrabasic Belt, which he delineated for the first time.

The object of the survey with which this report is concerned, was to reconnoitre the Ajura Kujara Range, a part of the Ultrabasic Belt, to prepare the way for more detailed work.

The party, consisting of the writer and 25 natives, entered the area from Kokoda early in July, 1957. A traverse was made down the Mambare River to within a mile of the Mambare Gorge and eastwards into the range for a distance of five miles. Soil samples were taken, using post-hole augers, from depths of up to 25 feet. Owing to the dense rain forest and the lack of native tracks, this took six weeks. The party returned to Kokoda where it was joined by Dr. R. de Vletter of International Nickel and J.E. Thompson, and spent two weeks assisting Dr. de Vletter in a programme of augering and costeaning. In early September the party moved eastwards along the vehicle road to Oivi and Aguru Creek and turned northwards from Ilimo Rest House to traverse the eastern flank of the range. At Oititandi fresh supplies were received and the party turned westwards, crossing low foothills, to the lower Mambare Gorge. The Gorge was followed upstream for four miles, the topography becoming increasingly severe. On return to Oititandi the party went west again, following Sisa Creek upstream. The party returned to Oititandi and moved by vehicle to the Kumusi crossing via Popondetta, thence to Kokoda with a brief look at Ita'u Creek on the way. The writer returned to Port Moresby in early November.

The labour line consisted of seven Southern Highlanders, and eighteen Orokaivas from villages around Kokoda. Only natives able to swim were employed owing to the number of large water courses in the area traversed.

Almost a hundred samples were collected and the localities marked on aerial photographs and subsequently plotted on photo-compilation maps.

In June 1958, a systematic programme of soil sampling was carried out in the foothills hear Arumu Creek by W. Balmain of the Department of Lands, Surveys and Mines. In September, 1958, the writer visited the area briefly, spending a week in the high country west of the Arumu Creek headwaters, where further soil samples were collected, and several days in the Owen Stanley foothills near the Kumusi River.

The writer would like to express his appreciation of the assistance given by Kokoda and Popondetta District Offices and the hospitality of Mr. and Mrs. G.W. Pritchard and the Kokoda people, in particular Mr. and Mrs. H. T. Kienzle.

SITUATION AND ACCESS:

The Ajura Kujara Range lies in the Northern District of Papua between latitudes 8°30' and 8°50'S, and longitudes 147°38' and 148°oo'E, and is covered by the Mt. Parkes and Kokoda, and part of the Menga, one-mile sheets. It is bounded on the north by the Mambare River Gorge, on the east by the Kumusi River and to the west and south by the Yodda Valley.

Kokoda Government Station, in the Yodda Valley, was connected to the coast by road until the eruption of Mt. Lamington in January 1952, when floods carried away the Wairope bridge across the Kumusi River. There are now no vehicle bridges or fords over the river, though vehicles have been rafted across. From the east bank the road runs through Saiho and Popondetta, the District Headquarters, to the coast at Cape Killerton, Buna, and Oro Bay.

From Saiho another road runs north to Oititandi and Siai where the Kumusi may be crossed by canoe. From the left bank a motorcycle track leads through Gorisata Mission to the Ioma patrol post. The roads are open only to four-wheel-drive vehicles, and can be impassable after heavy rain.

There are no native villages within the Ajura Kujara Range and foot-tracks run around the flanks of the range but never any distance into it. Early in the century the miners used a track through the Mambare Gorge on the north bank, but this would be overgrown now.

Movement is to some extent governed by the rivers. In the dry months the Mambare may be forded as far downstream as its junction with Misana Creek, and crossed by raft at several points below this, notably the Kanga-Mambare junction. Within the Gorge rafting would be difficult, if not impossible.

Popondetta and Kokoda airstrips are open to DC3 aircraft and Ioma is open to light planes. Sea cargo is handled at Cape Killerton.

PHYSIOGRAPHY

TOPOGRAPHY:

The principal topographic provinces are the Ajura Kujara Range, the Owen Stanley Range, the Yodda Valley, the Kumusi flats and the alluvial fan of Mt. Lamington.

Ajura Kujara Range:

The Ajura Kujara Range is a block about eighteen miles across and twenty-four miles long, trending north-north-west, and is continuous with the Otavia Range to the north-west. The main divide is five or six miles from the western margin, a twelve mile ridge reaching a height of more than 7,000 feet at Mt. Parkes.

The main western drainage is by the Orkawu, Arumu, and Athoro Creeks. Aguru Creek flows to the south, and Aeta, Iropa, and Hointapa Creeks flow eastward into the Kumusi River. The Opi River and its tributary, Sisa Creek, rise at the main divide and flow north-eastwards.

Study of aerial photographs has revealed six types of topography within the range, and these are described under the following headings; Western, Northern, Central, Eastern Foothills, Eastern Razorback and Southern.

The Western Zone lies for the most part west of the main divide and is bounded to the south by Arumu Creek. The topography is mature with an intricate pattern of small streams, which are generally slow and meandering. Although much of the area is at about 3,500 feet the relief is very moderate except where the major streams have cut steep valleys and gorges. Two major scarps lie parallel to the Mambare River, and the internal drainage may be evidence of uplift along the western margin. In the higher areas the rainfall appears to be very heavy, the vegetation is slightly sparser, and the soils very deep.

The Central Zone in the centre of the range, is five or six miles wide and is characterized by an irregular drainage pattern and the number and density of deeply incised streams. The interfluves are consequently less prominent than elsewhere in the range.

The Northern Zone triangular in outline, is situated immediately south of the Mambare Gorge and appears to continue into the Otavia Range. The straight valleys and the broad simple slopes of the mountain, only slightly dissected by numerous consequent streams, are the distinguishing features. Many of the valleys are oriented east-west and are colinear, suggesting that they are the reflection of major structural features.

The Eastern Razorback Zone - Two areas of razorback ridges are noted in the eastern part of the range. In the south-east, sharp ridges and spurs, including Mt. Hegahorte, extend to the Kumusi River. Farther north a triangular pocket of similar country occurs near the Mambare River and is dominated by the 1,700 ft. ridge Avaeti Dijari.

The Eastern Foothills Zone is characterized by low spurs and small hillocks rising from the flats north of Hointapa Creek, and is an area of rich soils, and meandering creeks. The boundaries to west and south are so marked as to suggest that they are structural features.

The Southern Zone: Only limited photo coverage is available for the southern part of the range and from this it appears that the topography conforms to none of the above types. The main features are the wide valley of Athoro Creek and the east-west ridge, Mt. Momo, which reaches 4,000 feet, between this and Aguru Creek. Drainage is generally neither as close as the Central nor as open as the Northern zones.

Owen Stanley Range:

The Owen Stanley Range is the main range of eastern Papua; Mt. Victoria, west of Kokoda, is 13,363 feet high. The steep north-eastern front of the range swings in an arc behind Kokoda from a northerly to an easterly direction, and southwards again at the Kumusi River. This front is dissected by a series of swift consequent streams flowing in deep valleys.

Yodda Valley:

The Upper Mambare River was sometimes referred to in the early days as the Yodda River. The name Yodda now denotes a tributary flowing east from the Owen Stanley Range but the Upper Mambare valley has retained the earlier name.

The valley is two to four miles wide and 22 miles long. Its floor is terraced between 1100 and 1200 feet, except near McLaughlins Creek, where there is an area of low hills about 500 ft. high.

Although the low divide at Oivi marks the south-eastern limit of the Mambare drainage basin, the structural depression continues eastwards as the valley of the Luwuni River. Less than a quarter mile of flat country separates the headwaters of the two rivers. The depression also forms the lower valley of the Chirima River north of the Mambare-Chirima junction.

The continuity of the Yodda and Luwuni valleys has led to the theory, first expounded by Sir. Wm. MacGregor (Annual Report for Papua, 1899-1900), that the Upper Mambare River once flowed eastwards into the Kumusi River. Faulting (Stanley, 1917) or volcanic deposits (Washington Gray, 1955) may have subsequently blocked the river at Oivi Hill and the dammed-up river formed a lake which was finally captured at the northern end by the Chirima River.

Kumusi Flats:

East of the Kumusi River almost unbroken lowlands stretch away to the coast. West of the river the Opi Flats stretch northwards to the Mambare River. This low country is swampy in places, and around the Opi River is subject to occasional flooding.

Mt. Lamington Alluvial Fan :

Long slopes of unconsolidated alluvial volcanic material dissected by swift consequent streams stretch from the higher parts of Mt. Lamington to within a few miles of the Kumusi River.

Climate:

Rainfall is heavy throughout the year, although governed to some extent by the monsoonal seasons. The north-west season is from middle December to middle March; the south-east from early May to the end of October. Monthly rainfall figures are as follows:-

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Kokoda	12.9	12.1	16.0	13.6	12.9	7.6	6.5	9.5	10.6	11.3	14.4	15.0
Ioma	17.3	15.3	15.4	12.0	10.7	9.6	6.8	9.2	10.7	11.9	18.5	18.4

(Nat.Dev., 1951).

The average annual rainfalls are 143 and 156 inches respectively. Ioma is on the flats of the lower Mambare River; Kokoda at an elevation of about 1,100 feet. Rainfall within the Ajura Kujara Range, particularly above two or three thousand feet, considerably exceeds these figures. Most rain falls in the afternoon and evening.

GEOLOGY

The object of the survey was a reconnaissance of the Ajura Kujara Range, which proved to be entirely composed of basic and ultrabasic igneous rocks. In the adjacent country the Owen Stanley Metamorphics - ?Kemp Welch Group, and Quarternary Alluvium and volcanics, were observed.

AJURA KUJARA COMPLEX.

The basic and ultrabasic rocks of the Range were faulted or intruded into their present position in Upper Mesozoic or Lower Tertiary time.

Petrology

Only a general outline of the petrology of the range may be made from fieldwork to date. Peridotite, pyroxenite, and minor hornblendite form the western flank of the range and predominate in the south. To east and north the complex becomes less basic, with the gradual introduction of feldspar and quartz so that the northeastern margin is mainly quartz dolerite. As topography and rock-type appear to be related, the petrology of each of the topographic zones will be considered separately.

Western Zone - Non-Feldspathic Basic Rocks.

The rejuvenated mature topography of the Western Zone appears to coincide with the belt of non-feldspathic rocks. The chief rock-type is a partly-serpentinized dunite of chrysolite-olivine, Fo_{90} Fa_{10}.

The other rock-types within this zone are pyroxene-peridotites, enstatite-pyroxenite, and hypersthene-bearing hornblendite. The last appears to be confined to a narrow belt lying west of the Ajura Kujara Fault scarp. The pyroxenite is coarsely crystalline with drystals up to 11mm in length recorded, and is seen to intrude the dunite in upper Orkawu Creek. One boulder from the eastern limit of the Orkawu Creek traverse contain 10% plagioclase. The pyroxene-peridotites are composed of varying proportions of orth- and clino-pyroxene and olivine and, where petrological description is not available, have been referred to as harzburgite. Commonly the pyroxene is confined to discontinuous bands within the olivine, giving the effect of bedding. ?

Plentiful boulders of feldspathic rock in Arumu Creek (Washington Gray, 1955) indicate that the stream rises outside this zone. Further north only the ultrabasic rock-types were seen and the absence of feldspathic boulders in the eastern headwaters of Orkawu Creek confirms that here the belt extends at least to the main divide.

Central and Southern Zones - non-feldspathic and feldspathic basic rocks.

These zones were entered on Aguru and Ita'u Creeks in the south, and Iropa Creek in the east. From this brief investigation they appear to be composed of a mixture of basic and ultrabasic rocks, which, in the Southern Zone at least, are in roughly equal proportion. On Aguru Creek there are gabbroic rocks, including norite and intrusive gabbro pegmatite, as well as dunite, pyroxenite and wehrlite. The wehrlite is composed of diopside and chrysolite-hyalosiderite $Fo_{70} Fa_{30}$ (see Appendix I, specimen P87.) Ita'u Creek olivine rocks contain from 5% to 20% anorthite and thus vary in composition from dunite to allivalite. A small stream traversed north of Afa village exposes quartz-dolerite and coarse-grained eucrite, the latter being composed of anorthite, augite, actinolite and olivine. This locality may be within the Razorback Zone.

Iropa Creek runs from the Central through the Eastern Zone, but traversing did not reveal any marked geological change at the boundary between the two. In the Central Zone, forsterite dunite and dolerite were seen.

Washington Gray (1955) took samples from river boulders in Arumu Creek, which drains Central, Southern and Western Zones. Dr. E. den Tex made the following identifications:

micro-hypersthene gabbro, micro-olivine gabbro, mela-gabbro, troctolite (plagioclase-bearing peridotite), cortlandite (diallage-bearing peridotite) and diallage serpentinite. Outcropping near Arumu Creek were chrome-bearing diallagite, olivine-bearing diallagite and serpentinized dunite.

Eastern Razorback Zone - chiefly dolerite rocks.

Doleritic types, some quartz-bearing and some amygdaloidal, are the main rocks in this zone, though olivine and pyroxene-rich rocks are present in minor quantities.

Quartz dolerite crops out near the Luwuni River, and in the hills north of Embeti Creek, where picrite composed of enstatite, olivine, augite and tremolite-actinolite also occurs. Further north, at Mt. Hogahorte, quartz pyroxenite and quartz microdiorite intruding quartz bytownite are seen. Lower ridges to the northeast are chiefly quartz dolerite.

In a separate segment of this zone on the Mambare River, to the north, quartz dolerite again predominates, and is seen to intrude older gabbroic and doleritic rocks, and eucrite.

Eastern Foothills Zone - chiefly quartz dolerite.

Sisa Creek runs into this area from the Central Zone with good exposure near the boundary, despite a cover of piedmont and alluvial deposits. As on Iropa Creek, there is no marked geological change at the boundary. Fine-grained quartz dolerite intrudes a coarser quartz dolerite, and granophyric granophyric granodiorite crops out, this latter being an acid differentiate from a basic magma (Appendix I). Further east is a coarse-grained olivine-bearing gabbroic rock, probably a eucrite. Generally exposure is poor but the evidence of residual boulders suggests that, as in the Razorback Zone, quartz dolerite predominates.

In both the Razorback and Foothills Zones amygdaloidal basalt and dolerite is common but field evidence indicates an intrusive origin for these rocks. The occurrence elsewhere of amygdules in shallow intrusives is recorded by Walker (1930) and W.R. Morgan (Appendix II). Williams, Turner and Gilbert (1954) confirm that vesicles, or amygdules, may be found in lavas and shallow intrusions.

Northern Zone - gabbroic types with minor ultrabasics.

Medium-to-coarse-grained gabbro, eucrite and norite are intruded by gabbro pegmatite and quartz dolerite, the dolerite being the more recent and the more abundant. Peridotite and pyroxenite are present in minor quantities and there is a little vein quartz. When the river is low there is excellent exposure in the Mambare Gorge.

Aweo-Sirorata Area.

On the southern flank of the Luwuni Valley is another exposure of ultrabasic rocks, forming the foothills of the Owen Stanley Range. The main rock-types are non-feldspathic being dunite, brecciated dunite with secondary silica veining, and banded harzburgite. However, one outcrop of pyroxene-rich gabbro was seen.

Summary

The Western Zone appears to coincide with the belt of non-feldspathic rocks; the Southern, Central, and Northern Zones comprise a mixture of feldspathic and non-feldspathic rocks, the feldspathic types predominating in the Northern Zone. The Eastern Zones comprise largely doleritic rocks. Outside the range the non-feldspathic rocks are seen again in the Aewo-Sirorata hills.

(a) Structural observations and interpretation.

The age and mode of emplacement of the complex is not definitely known. The contact between dunite and Kemp Welch(?) sediments described later in this report in Lasa Creek is marked by a wide shear zone, suggesting a faulted contact. The dolerite at Oivi Hill probably intrudes the Kemp Welch (?) sediments and Paterson (1956) records local contact metamorphic effects in the Owen Stanley Metamorphics east of Kokoda. In the middle Waria Valley, Thompson (pers. comm.) has observed contact metamorphic effects in the Kemp Welch(?) sediments and, in the Musa Valley, unmetamorphosed Plio-Pleistocene sediments overlying the ultrabasics. The Kemp Welch Group is thought to be of Mesozoic age. Thus the Ajura Kujara Complex probably solidified in Lower Tertiary time.

The mode of emplacement is dealt with under Structure.

The petrology of the Ajura Kujara Range may be broadly ascribed to differentiation of a basic magma resulting in rock-types varying from peridotite and pyroxenite to granodiorite and vein quartz. The complete order of solidification is not known, but the following relationships have been observed.

(i) pyroxenite intrudes dunite;

(ii) gabbro pegmatite intrudes harzburgite and the gabbroic suite;

(iii) quartz dolerite intrudes the gabbroic suite and harzburgite.

Unfortunately no contact of dunite and gabbroic types was seen but the small proportion of dunite seen in the lower Mambare Gorge suggests that the dunite may intrude the gabbroic suite.

The following table shows the apparent order of crystallization:-

1. Harzburgite, wehrlite and dunite; the gabbroic suite including norite and eucrite.

2. Pyroxenite.

3. Gabbro pegmatite

4. The younger dolerite

The close field association of harzburgite, dunite and pyroxenite, and their related mineralogy, suggest that the three solidified almost simultaneously from the one magma.

Writing of basic and ultrabasic intrusive rocks in the Cycloop Ranges-Sentani Lake area of Dutch New Guinea Baker (1955) records the following observations on the order of crystallisation of the intrusive complex.

1. Serpentinite, serpentinized harzburgite and serpentinized dunite.

- phase of strong regional metamorphism and recrystallization -

2. Altered dolerite.

3. Gabbros.

METAMORPHICS

(a) Owen Stanley Metamorphics.

This series of gneisses and schists is thought to be of Palaeozoic age and does not crop out in the area examined. E.R.Stanley made several crossings of the main range and records the following rock-types (E.R. Stanley, 1923):-

"crystalline schists and gneisses, sericite and graphite schists, and epidote and chlorite schists and gneisses, intruded by granitoid rocks and porphrites". He observed that "gneissic granites and basic plutonic rocks appear to form the basement of the group", but this is not supported by reference to field observations.

Paterson (1955) records muscovite-chlorite gneiss, glaucophane-cordierite schist, calc schist and garnetiferous calc-silicate rocks near Kokoda, attributed by Paterson (Crespin et al, 1956) to metamorphism under conditions of "low to moderate temperature, mostly low hydrostatic pressure and moderate to high directed pressure".

(b) Kemp Welch(?) Group.

Sediments of much lower metamorphic grade than the Owen Stanley Metamorphics were observed in Lasa Creek. They are lithified fine greywacke and mudstone with some calcareous veining. Sericitic siltstone, probably intruded by dolerite occurs in the Oivi Hill area. These rocks are steeply dipping and, in Lasa Creek, show much minor faulting. These two exposures are thought to represent a series of sediments underlying the alluvia of the Yodda Valley and faulted out near Oivi. They are probably equivalent to the calc-silicate rocks observed in the Waria Valley (Thompson, pers. comm.) and are tentatively correlated with E.R. Stanley's Kemp Welch Series, of probable Mesozoic age.

Stanley (1917) records an unfossiliferous blue crystalline limestone cropping out at Oivi Hill, on the Mamama River, on the Kumusi-Moni divide, and within the main range. He places it in the Kemp Welch Group and on his accompanying map shows Kemp Welch sediments in the Mamama valley and along the eastern front of the Ajura Kujara Range Stanley, 1923). This party traversed the Oivi area but did not see the limestone. Local natives, who value limestone as a source of lime, reported that the nearest exposure is on Aeora Creek, within the Owen Stanley Range.

The Kaindi Series, exposed in the Wau area, is thought to contain formations equivalent to both the Owen Stanley and Kemp Welch Groups. Of it Fisher (1943) writes:

"The basement rocks, which so far it has been possible to map only as a metamorphic complex, probably were originally deposited in several different stages, with possibly diastrophic periods intervening".

QUATERNARY VOLCANICS AND SEDIMENTS

These comprise two groups -

(i) Pleistocene bedded volcanic ejecta and lava;

(ii) Pleistocene and Recent tuff, piedmont and alluvial material.

The bedded volcanics are seen on Ipoi creek and in the Kumusi River bed, near the Asisi bridge, and consist of interbedded tuff and agglomerate, lithified and gently folded with dips of up to 10^{o}. These minor contortions may be due to irregularities in the depositional surface. Lava crops out on the Kumusi and Mamama Rivers near Sirorata.

The younger series is unconsolidated and comprises the piedmont and alluvial deposits of the Yodda and Luwuni valleys and the Kumusi flats, and the alluvial volcanic fan of Mt. Lamington. Piedmont deposits, consisting of angular rock fragments set in a rock flour matrix, are prominent along the flanks of the Owen Stanley and Ajura Kujara Ranges.

The alluvials of the Yodda Valley are mostly conglomerate, greywacke and mudstone, but further east, on the Kumusi River tuff also is interbedded. Remnants of unconsolidated tuffaceous cover are seen on Ilimo Creek, at Oivi Hill and as far west as the hills north of Arumu Creek.

STRUCTURE

Faulting:

The major structural feature is the Owen Stanley Fault, a sinuous fault 220 miles long, on which the main movement is vertical. The faceted spur ends of the Owen Stanley mountains in the Yodda Valley suggest Quaternary activity along a fault plane which dips to the northeast. The probable fault bounding the Ajura Kujara complex and the Kemp Welch (?) sediments, though observed as a shear zone at Lasa Creek, is generally concealed by Recent sediment and is not discernible on aerial photographs. This fault probably runs roughly parallel to the Owen Stanley Fault, swinging to join it east of Oivi Hill.

The name Ajura Kujara Fault is proposed for the probable fault represented by a scarp about ten miles long which lies about a mile east of the contact fault and marks the western limit of the higher country of the Western Zone. On the eastern flank of the range straight-line features observed on the aerial photographs may represent faults. One such runs north-south along Sisa Creek and marks the contact of Eastern and Northern Zones. Inspection of the area revealed no sign of faulting, though major fractures were in evidence. The aerial photographs also reveal a series of parellel ridges in the Central Zone. This area was not visited.

In the vicinity of McLaughlins Creek buckling of the Owen Stanley Fault is suggested by curvature of the faultline, local elevation of the Yodda Valley floor and of the ultrabasic rocks immediately to the east.

J.E. Thompson (1957) believes that the belt of Kemp Welch (?) sediments and the Ajura Kujara block owe their position to medium-angle thrust-faulting from the northeast over an imbricate zone of which the Owen Stanley Fault is the major member. Later upward movement of the Owen Stanley block along the Owen Stanley Fault has tilted the adjoining Kemp Welch(?) slice and the Ajura Kujara block. Tilting of the latter and subsequent erosion has resulted in exposure of the non-feldspathic rocks which, it is assumed, originally formed, by gravity differentiation, below the feldspathic rocks.

Folding

That the schists and gneisses of the Owen Stanley Metamorphics have been strongly folded is indicated by the isoclinal minor folding which the writer observed in boulders in the Mambare River. Washington Gray traversed the Kokoda Trail, which crosses the range south of Kokoda. He records (Washington Gray, 1955) that on the northeastern flank of the range all dips observed were between 27° and 40° to the NNE. South of the divide he notes a 70° NNE dip at Efogi. This might suggest isoclinal folding overturned so that the fold axes dip to the north-north-east, as has been ovserved in similar rocks on Sudest Island (Davies, 1958b.)

The small section of Kemp Welch sediments examined showed slump-folding and tectonic folding with much minor faulting.

GEOMORPHOLOGY

The high grade metamorphics of the Owen Stanley Group and the igneous mass of the Ajura Kujara Complex form the two mountain ranges in the area. It is thought that the Yodda Valley is cut into soft mudstone and fine greywacke, which may have been further weakened by minor faulting associated with the major thrusts.

Within the Ajura Kujara Range some relationship between rock-type and topography has been demonstrated. The distinctive topography of the Western Zone may indicate that the olivine-bearing rocks weather in a different manner from the gabbroic rocks, and J.E. Thompson (1957) has suggested that chemical weathering is more active in these rocks than elsewhere. This idea is supported by the observation of a karst topography in several places, notably near the junction of Anaua Creek and Mambare River.

Alternatively, the topography may represent a period of slackened erosion, followed, recently, by increased erosion. This sequence could be explained by tectonic activity or variation in rainfall. It is likely that both chemical weathering and slackened erosion have played a part.

The reason for the slightly less distinctive topographies of the other zones is not clear. The rocks of the Eastern Zone are generally more fine-grained and more closely related in composition than those of Central or Northern Zone.

REGIONAL GEOLOGICAL HISTORY

The geosynclinal sediments now comprising the Owen Stanley Metamorphics are thought to have been derived in Palaeozoic time, from a Precambrian Landmass lying to the south-west. Orogeny was followed by uplift which has continued into Recent time. Flanking sedimentation on both northern and southern flanks of this elongate mountain chain formed the Mesozoic Kemp Welch Series.

It is suggested that thrust-faulting on the northern front of the Owen Stanley block has caused the uplift of both the Kemp Welch series and the Ajura Kujara block, and the tilting of the latter.

Late-stage doleritic magmas have intruded the gabbroic part of the complex, and, at Oivi, the Kemp Welch(?) sediments.

Vulcanism and erosion have combined to form a thick cover of Quaternary material in the low-lying area.

ECONOMIC PROSPECTS.

Nickel

The chief interest in the Ajura Kujara Range lies in the possibility of ore-grade nickel concentrations in the deep soils overlying the olivine-bearing rocks. A systematic programme of soil sampling using hand augers has since been completed on the flank of the range near Arumu Creek. The highest grades found were around 1.8% nickel.

A series of twenty holes in the mature uplands of the Western Zone all bottomed in pisolitic ferruginous laterite at about 18 feet. The highest grade was 0.7% nickel and values were increasing with depth. Deeper holes should be sunk when equipment capable of penetrating the lateritic hard-pan is available.

The values obtained in sampling to date, and difficult access, augur against economic lateritic-type nickel prospects.

Garnierite is, in places, associated with the secondary silica which veins the Sirorata dunite breccia. The possibility of garnierite ore in this area has not been thoroughly investigated.

Cobalt and Iron.

In the Ajura Kujara soils there are lateritic concentrations of these two metals but investigations to date have not indicated economic grades.

Gold

In all over 85,000 oz. of gold have been won from the alluvia of the Yodda Valley, most of it before 1923.

The source of probably all the gold is the Owen Stanley Range. It has been concentrated by streams reworking the alluvial deposits which cover the Yodda Valley floor.

A little osmiridium has also been produced, the source being, probably, the Ajura Kujara Range. There is a possibility of alluvial platinum also derived from the Ajura Kujara Range.

REFERENCES

1. Baker, George, 1955 & 1956

Basement complex rocks in the Cycloop Ranges - Sentani Lake region of Dutch New Guinea. Nova Guinea, new ser., Vol. 6, Part 2, 1955 and Vol. 7, Part 1, 1956.

2. Crespin, I., Kicinski, F.M., Paterson, S.J. & Belford, D.J. 1956.

Papers on Tertiary Micropalaeontology - BMR Report No. 25.

3. Davies, H.L., 1958a.

A note on the geology of the Aewo-Sirorata area.

4. Davies, H.L., 1958b.

Geological observations in the Louisiade Archipelago.

(In preparation).

5. Fisher, N.H., 1943

Outline of the geology of the Morobe Goldfield. New Guinea Administration Report.

6. Gray, K. Washington, 1955

The peridotite-serpentine belt in Papua and its mineral association. Australasian Petroleum Co. Report (KWG/55/10/1).

7. Nat. Dev., 1951

The Resources of the Territory of Papua and New Guinea; Dept. of National Development, Canberra.

7a. Paterson, S.J., 1955 Report on a Geomorphological and Geological Reconnaissance of the Buna-Kokoda Area of Papua. Land Research series, C.S.I.R.O.

8. Stanley, E.R., 1916

Annual Report for Papua for 1916-17.

9. Stanley, E.R., 1917

Geological expedition across the Owen Stanley Range. App. D, Ann. Rep. Papua 1917-18.

10. Stanley, E.R., 1923

The Geology of Papua.

11. Thompson, J.E., 1957

A report on the Papuan Ultrabasic Belt.

12. Walker, F, 1930

Geology of the Shiant Islands. Q.J.G.S. Vol LXXXVI.

13. Williams, H. Turner, F.J., & Gilbert, C.M., 1954

Petrography, an introduction to the study of rocks in thin sections.

APPENDIX I.

Petrographic report by W.B. Dallwitz and W.R. Morgan.

APPENDIX II.

Petrographic report by W.R. Morgan.

APPENDIX I

PETROGRAPHIC REPORT ON SPECIMENS FROM THE AJURA KUJARA RANGE, PAPUA BY W.B. DALLWITZ AND W.R. MORGAN

P30. Ivoro Creek, Mamba Estate

A partly serpentinized dunite whose average grainsize was originally between 2 and 3 mm. Abundant remnants of olivine are set in serpentine, and these remnants are optically continuous over areas measuring up to 3 mm. across. Probable chromite, which is dark red-brown in transmitted light, is the only accessory.

The olivine is biaxial positive, with estimated 2V about 85^{o}; it, therefore, contains about 90% of the forsterite molecule (Fo_{90} Fa_{10}).

P52 Coarse-grained pyroxenite, Upper Orkawu, south Branch

This is an enstatite-pyroxenite containing a little (less than 1%) anthophyllite, a few minute specks of black iron ore, and some very thin veinlets of probable serpentinous material. The rock is virtually monomineralic. The optic axial angle of the enstatite was estimated as 85^{o}, and its mean refractive index is about 1.67; these properties correspond to a composition of about $En_{85-90}Fs_{15-10}$.

P59, Upper Orkawu, east branch No. 1. Eastern limit of traverse

Enstatite-pyroxenite, medium to coarse-grained. Consists of enstatite containing lamellae of diopside. About 10% of the rock is labradorite. Texturally, the rock is allotriomorphic, inequigranular, tending to be slightly porphyritic. The grains are rounded, and extensively cracked A little magnetite is present. The rock is unaltered.

P60, Medium-coarse grained pyroxenite, upper Orkawu, east branch No. 1

This rock is very similar to specimen P52, except that the pyroxene, judging by its negative sign and optic axial angle estimated at about 85^{o}, is slightly richer in the ferrosilite molecule, and has a composition of about $En_{80}Fs_{20}$; this places it on the border of enstatite and hypersthene. The rocks are therefore an enstatite pyroxenite (enstatite) or hypersthenite; however, as refractive index measurements place the pyroxene slightly on the enstatite side of the border, it may be more appropriate to refer to the rock as an enstatite pyroxenite. As with specimen P52, a little anthophyllite and black iron ore are present, and these minerals are noticeably more plentiful than in specimen p52.

P70 "Glittering black hypersthene (?) rock. From $\frac{1}{4}$ mile wide N-S belt: Lower Orkawu River

Hypersthene-bearing hornblendite: The rock consists of pale brown hornblende, with about 5% of plagoiclase and 10% of hypersthene. The hornblende is pleochroic in brown; length slow, Z C = 10^{o}; birefringence = 0.025. Biaxial negative 2 = C 70^{o}. The felspar has R.I. greater than that of balsam, and has some pericline twinning: it is probably labradorite. Felspar is slightly sericitized. Accessory black iron ore and a little quartz are present; texture hypidiomorphic, medium to coarse-grained, with subhedral prismatic crystals of hornblende interlocking with one another. Felspar and hypersthene occupy granular interstitial places. Hornblende crystals show a little straining and bending. Some preferred orientation of the hornblende prisms is present, though this is not too obvious; it seems that the prisms are orientated parallel to a plane, and are generally orientated within that plane. Hypersthene occurs in crystals sub-poikilitically surrounded by hornblende.

The prismatic structure of the hornblendes suggests that the rock is igneous; if it were metamorphic they could be rounded granoblastic crystals. Therefore the rock is a hornblendite.

P74. Volcanic (?) Oivi Hill.

Basalt. Contains augite and plagioclase, with black iron ore, sericite, chlorite, epidote, (?) zeolite or gypsum, and hydrated iron oxide. Texturally the rock is fine-grained, porphyritic, with variolitic arrangement of the sericitized felspars. The groundmass consists of partly chloritized augite and altered plagioclase; the arrangement of these minerals suggests a sub-ophitic texture. The phenocrysts consist of augite, with some of sericitized felspar.

Some chlorite occurs in veins, as does the epidote. The (?) zeolite occurs in very thin veins. The sequence of veins, from the first to the last is:

1. Epidote, 2. Chlorite, 3. (?) Zeolite or gypsum.

The last named mineral generally follows along the chlorite veins.

P87. Harzburgite (field name). Aguru Creek, lower.

Wehrlite or augite picrite.

Diopside. Colourless. Forms anhedral grains. Birefringence 0.022. Length - slow Z C = 48°. Biaxial +, 2V = C 55°.

A diallage parting is present. Lamellae of orthopyroxene are present, parallel to the cleavage.

Olivine. Colourless anhedral. Biaxial negative, 2V = C 80° showing the mineral to have a composition between that of chrysolite and hyalosiderite, i.e. $FO_{70}Fa_{30}$. Chrysotile occurs along the cracks in olivine and is fibrous, with a greenish yellow colour.

Black iron ore is a byproduct of the serpentinization of olivine.

In texture the rock is coarse-grained (grains are about 2 mm. in size), xenomorphic-granular, the diopside and olivine grains being rounded to a certain extent.

Chrysotile mainly attacks olivine, but to a lesser extent attacks diopside. Sometimes a large amount of an olivine crystal may be attached, but usually the alteration is small. Small grains of black iron ore occur along the alteration zones. Black iron ore also occurs as irregular grains.

Harzburgite is a name given to an ultrabasic rock containing olivine and orthopyroxene, according to Johannsen. The same authority uses the name wehrlite to cover the assemblage olivine (clinopyroxene).

P92 (i) "Fine-grained granular ultrabasic"

Granulitic bytownite norite

Augite. Colourless. Biaxial positive, 2 V = C.55. Length slow, Z C = 44°. Birefringence = 0.024.

Hypersthene. Lightly pleochroic. x = colourless; Y + Z = light bronze pink. Biaxial negative, large 2v parallel extinction.

Felspar. R.I. C.B., Albite, pericline and carlsbad twinning present. Biaxial negative, bytownite (An_{85-90}), as determined in combined albite-carlsbad twins.

Black iron ore, speckled white in reflected light suggesting ilmenite.

Accessory apatite. Some (?) talc, chlorite and kaolin are present.

Texture. Medium-grained, xenomorphic, inequigranular, and resembles that of a granulite or high-grade hornfels rather than an igneous rock. However, good twinning in plagioclase and lamellae of clinopyroxene in hypersthene preclude the possibility of a metamorphic origin. Some of the felspars show slight traces of zoning. Chlorite and (?) talc are alteration-products of pyroxene. Slight kaolinization of the felspar has taken place. The chlorite and talc have commonly been squeezed along cracks to form veinlets which traverse the whole rock.

P92 (ii). Gabbroic Rock, limit of traverse, Upper Aguru Creek.

Bytownite norite. This rock is mineralogically and texturally closely similar to P92 (i), except that it is scarcely altered at all, and that the plagioclase is much more severely cracked. Ilmenite, instead of forming grains, occurs in intergranular positions, and in crystal cracks.

P95 Serpentized Dunite - Upper Aguru Creek.

Mineralogy

Olivine. Colourless. Biaxial negative, 2 V=C 85. Birefringence 0.034. Crysolite.

Black iron ore. Form octahedral crystals, appear to be largely chromite, because most are translucent and dark brown.

Chrysotile. Fibrous serpentine occupying the cracks in the olivine. Has a greenish-yellow colour, and very low birefringence.

Antigorite. A little lamellar antigorite is present in the larger alteration zones. Length slow.

Texture Coarse-grained (2.5 mm. to 5 mm. grain size), xenomorphic-granular olivine (chrysolite). The black iron ore forms euhedral grains up to 0.25 mm. size. The serpentine (antigorite and chrysotile) forms a meshwork along the cracks and crystal boundaries of the olivine, separation each grain into numerous smaller ones. The veins range between 0.025 and 0.15 mm. thickness.

The rock is, therefore, a serpentized dunite.

P100A "Fine-grained ultrabasic"

Uralitized quartz-dolerite.

Mineralogy. 50% basic andesine, slightly sencitized and kaolinized.

40% hornblende, actinolitic. Pleochroic in pale green. Somewhat fibrous. 8% quartz. Accessory black iron ore, apatite, sericite and kaolinite.

Texture Fine to medium grained, hypidiomorphic, sub-variolitic. The felspar occurs as rather long, thin tabular laths. The actinolite on its basal sections, pseudomorphs pyroxene. Quartz occurs as anhedral grains as does the black iron ore. Apatite occurs as minute circular crystals enclosed in felspar.

The rock is apparently a uralitized quartz dolerite.

P100B. "Coarse-grained basic". Tributary of the Luwini River, North of Afa Village.

Mineralogy. Felspar (Anorthite, An_{95-98}), Augite, Actinolite, Olivine. Accessory magnetite, pyrites, kaolin, chrysotile and chlorite.

Texture. Coarse-grained, xenomorphic, rather inequigranular.

Olivine occurs as crystals larger than the general groundmass. Usually it is partly surrounded by a rim of chrysotile; magnetite is present along the crystal cracks of the olivine, as a by-product of serpentinization.

Augite occurs as subhedral to anhedral grains.

Partial or complete uralitization of the pyroxene and clouding of the felspar have taken place on either side of a crack or joint; the width of the zone of alteration is up to 2.5 mm.

The rock is an autometamorphosed, partly uralitized eucrite.

P103A. "Typical fine-grained basic rock, low spurs between Embeti Creek and Hungiri".

Partly Uralitized Quartz Dolerite

Mineralogy. Labradorite, augite, hornblende, quartz, accessory black iron ore, apatite.

Texture Fine to medium grained hypidiomorphic, subophitic. Labradorite occurs as tabular laths. Augite is prismatic, and tends to be replaced by pale brownish green hornblende: the latter mineral also occurs interstitially, as a primary crystallized mineral. Quartz is interstitial and poikilitic, as is the black iron ore.

103B. "Coarse-grained pyroxene-brg. rock, Locality as 103A"

Olivine pyroxenite (picrite)

Mineralogy. Enstatite 30%, Olivine 25%, Augite 20%, Tremolite-Actinolite 15%, Accessory antigorite, partly saussuritized plagioclase, magnetite, chrysotile, zeolite.

Texture Coarse-grained xenomorphic inequigranular. Olivine occurs as rounded grains, with chrysotile and black iron ore are present in the crystal cracks, and antigorite around the margins. Pyroxene trends to be prismatic. The actinolite and tremolite occur interstitially, or replacing diopside. Zeolite occurs in thin veins cutting the other minerals.

The name "olivine pyroxenite" is given because of the presence of olivine in essential quantities; however, there is insufficient of that mineral to warrant the name "Lherzolite", which requires a ratio of olivine to pyroxene of at least 3:1.

P106 "Medium-grained basic rock". Limit of traverse up Iropa River.

Dunite. Forsterite. Biaxial positive, 2V = C.85°. Accessory antigorite, dhrysotile and black iron ore, probably chromite. In texture the rock is xenomorphic granular and coarse-grained, the olivine forming somewhat rounded grains. The serpentine minerals form an irregular mesh work of veins of alteration along the cracks of olivine grains. The olivine shows pronounced undulose extinction. Black iron ore forms euhedral, squarish and six-sides grains; some grains are reddish black and translucent, and are, therefore, probably chromite.

P110B. "Medium-grained basic rock". Between Corta Creek and Hoija No. 1 Creek.

Partly Chloritized Dolerite

Mineralogy. Felspar, probably labradorite, augite, chlorite, accessory black iron ore, nontronite, prehnite.

Texture Medium-grained amygdaloidal, sub ophitic hypidiomorphic, slightly porphyritic. The felspar forms tabular laths, in places intergrown with augite. Augite forms subhedral prisms. Chlorite replaces augite partially or wholly. Black iron ore forms squarish grains, except where associated with cloritized augite.

The amygdules are filled with nontronite, prehnite and some chlorite. The nontronite and chlorite are fibrous the former radially so; prehnite forms radial fibroprismatic crystals.

P115. "Black Doleritic rock". typical of Eastern flank Avaeti Dijari, Upper Hoija No. 1 Creek.

Quartz-dolerite.

Mineralogy Felspar, either andesine or labradorite. Augite, actinolite, chlorite, quartz, accessory black iron ore.

Texture. Medium-grained,.hypidiomorphic. The felspar occurs as tabular laths. Augite is primmatic and largely altered to actinolite and chlorite. Quartz occurs as anhedral, sub-poikilitic grains. Black iron ore is more abundant than in most dolerites.

P118(i). "Medium grained basic rock". Bank of Membare River, near change in topography.

Party uralitized eucrite.

Mineralogy. Olivine (chrysolite) 35%; actinolite, colourless or very light green 10%, augite 20%, felspar, badly sericitized and kaolinized 25%. Accessory black iron ore, chlorite, antigorite, and chrysotile, 10%.

Texture. Coarse-grained, zenomorphic. The olivine forms ovoid, cracked crystals, with serpentine and black iron ore filling the cracks. Pyroxene tends to be poikilitic about olivine, and is anhedral to subhedral, prismatic in shape.

Actinolite is poikilitic about olivine and pyroxenes it forms fairly large "plates" which may enclose two or three olivine crystals. Also actinolite forms a thin alteration rim around both olivine and pyroxene. Felspar is subhedral to anhedral, poikilitically enclosing olivine and pyroxene; it is badly altered to sericite and kaolin. Some grains of black iron ore occur.

P118 (ii) "Medium grained basic rock", as P 18 (i).

Partly uralitized eucrite.

A similar mineralogy to P118(I) is present, except that the felspar is fresh; albite and pericline twinning are present, the optic sign is biaxial negative, and measurement of the angle between basal cleavage and the pericline twinning showed it to be Ab_{27}, sodic bytownite.

This specimen is texturally similar to P118(i) as well. Estimated mineral percentages are follows:

Olivine 35; augite 15; actinolite 20; feldspar 25; alteration-products of olivine, etc. 5.

P119. "Lighter coloured basic rock". Mambare River, near change in topography.

Uralitized quartz dolerite (possibly the lamprophyre spessartite). Mineralogy; Felspar, possibly andesine, hornblende, quartz. Accessory black iron ore, apatite, chlorite, prehnite, epidote, some sericite.

Texture. Medium-grained, hypidiomorphic, sub-ophitic. Felspar is tabular, lath-like, texturally rather doleritic, and is partly kaolinized. Hornblende is prismatic, tending to be enclosed by felspar. Quartz occurs as interstitial, sub-poikilitic grains. Black iron ore is present as squarish to rounded grains. Hornblende may be chloritized, or very occasionally altered to a mixture of prehnite and epidote. Apatite occurs as very small, acicular euhedra.

P122. Specimen where fine-grained rock intrudes coarser gabbroic rock, Mambare River, west of P119 and of topographic change.

Coarser rock. Uralitized and serpentinized metagabbro.

Mineralogy Bastite (probably derived from diallage iron rich diopside characteristic of e.g. gabbros) 55%; actinolite 15%; bytownite-anorthite (An90) 15%; diallage 13%) accessory black iron oxide, hydrated iron oxide; sericite, apatite 2%.

Texture. Hypidiomorphic granular, medium-grained (0.5-1 mm.), showing a flow texture, with a little protoclastic straining of the crystals, shown more definitely by the slightly crenulate boundaries of the crystals. Bytownite is tabular and lineated parallel to flow texture. It is very slightly sericitized in patches. Diallage tends to be primmatic, and is largely replaced by bastite. The latter mineral is fibrous, and pseudomorphs diallage often in these pseudomorphs, small irregular remnants of diallage occur. Bastite occurs as veinlets in plagioclase; it seems to have been squeezed along cracks in the felspars. A very narrow vein of actinolite derived from bastite occurs cutting through the slide parallel to the felspar lineation. A very few grains of black iron ore occur. Some irregular particles of hydrated iron oxide occur close to altered diallage in one or two places. Apatite occurs as minute acicular euhedra enclosed in felspar. Adjacent to the fine-grained intrusive bastite has been wholly converted to actinolite over a width of about 3.5 mm.

P122 Fine Rock. Uralitized basalt or fine-grained dolerite (or lamprophyre ((?) spessartite))

Mineralogy. Labradorite-bytownite (An_{70}), hornblende, accessory black iron ore, epidote, chlorite, carbonate, and quartz.

Texture. Fine-grained (0.1-0.2 mm)size) indiomorphic, porphyritic, sub-variolitic. Felspar is tabular lath-shaped; hornblende is prismatic, tending to be acicular, it forms phenocrysts and present in the groundmass, though some apparent pseudomorphs of pyroxene are present. Small granules of epidote occur with the hornblende. Quartz occurs as a very narrow vein, cutting through the rock; these veins may contain epidote. Black iron ore occurs as small irregularly shaped granules throughout the rock. Chlorite occasionally replaces the hornblende.

The naming of this rock is uncertain; it probably has the composition of a basalt or dolerite, but has the texture of a lamprophyre. However, the plagioclase is too calcic for spessartite.

P122 The Junction

The fine-grained intrusive becomes exceedingly fine-grained, showing the presence of a chilled margin, and confirming that the basalt does intrude the gabbro. The chilled margin is porphyritic, showing phenocrysts that are clearly hornblende pseudomorphs of a pre-existing pyroxene. Tabular phenocrysts of felspar are present, aligned in a flow texture parallel to the margin of the intrusion. The groundmass consists of a hypidiomorphic, flow-textured mass of tiny hornblende and felspar crystals. Right at the border the texture is so fine-grained that the minerals present may hardly be seen by the microscope, though it is still porphyritic.

The coarse-grained rock maintains its textural characteristics, i.e. coarse-grained, with flow structure right up to the margin. The basalt cuts the gabbro at right angles to the latter rock's flow texture. For a distance of 3.5 mm. into the gabbro from the junction, the bastite in the gabbro has been converted to actinolite or light green hornblende. This denotes an increase in the tenor of iron, lime, and (?) alumina, possibly supplied from the basalt.

At the junction the two rocks are separated by vein 0.18 mm. thick. The vein is apparently intruded along the junction; a very thin layer of the chilled margin of the basalt is present in places on the gabbro side of the vein: also there are one or two small "islands" of chilled margin rock within the vein, usually closer to the gabbro side, as though a minor offshoot from the main, vein had enclosed some of the thin layers mentioned above. The vein consists of quartz and prehnite, the latter mineral being in much greater quantity than the former.

Two very thin veins were noted, consisting mainly of quartz, but with a little prehnite present; these veins cut the previously mentioned vein.

P125(i) "Coarse grained grey pyroxene (?) with interstitial serpentine (?)". Mambare River, W. of P122.

Serpentinized harzburgite or enstatite picrite

Mineralogy. Enstatite, 2V near 90^o. Parallel extinction. Olivine, chrysolite. 2V = C 85^o, negative. Serpentine replacing olivine. (?) talc and tremolite replacing enstatite. Accessory black iron ore, partyly original grains, partly by-product of alteration of olivine.

Texture. Very coarse-grained zenomorphic granular originally. Much of the olivine is replaced by serpentine, while the pyroxene is partly replaced by (?) talc and tremolite. Black iron ore occurs in subhedral grains.

The rock is therefore a harzburgite or enstatite-picrite in which a good deal of alteration to serpentine and talc has taken place.

P125 (ii) "Coarse-grained grey pyroxene fine granular texture"

Enstatite pyroxenite. The rock is composed almost entirely of very coarse grains of enstatite, being 10 or 11 mm. across in the thin section. The enstatite has been slightly altered to (?) talc and tremolite, especially along the crystal boundaries; however, thin zones of alteration may be present along the cleavages and cracks within the crystal. A little black iron ore is present in the alteration zones.

P125 (iii) "Extra fine grained intrusive rock".

Uralitized quartz-dolerite. Mineralogy: quartz, labradorite (Ab_{40}), hornblende. Accessory black iron ore, epidote, very little kaolin, apatite, thomsonite.

Texture. Fine-grained, hypidiomorphic, variolitic, equigranular. The felspar occurs as lean tabular laths. Quartz is interstitial and sub-poikilitic. Hornblende is light green and somewhat fibrous: it appears to pseudomorph pyroxene. Black iron ore occurs as irregular grains. Epidote and kaolin slightly replace felspar. Thomsonite forms a vein intruding the rock.

P125 (iv) "Intrusive felspar - hornblende pegmatite"

Mineralogy: Gabbro pegmatite, actinolite, labradorite, tremolite.

Texture. Very coarse, inequigranular, xenomorphic. The felspar shows a tendance to be tabular; actinolite is anhedral, tending to be fibrous. Tremolite occurs as finely fibrous clots interstitial between plagioclase grains. Small amounts of the mineral are intergrown with the felspar. Quartz was not noted in the section available.

129 (i) Mambare River, w. of p.125.

Uralitized bytownite gabbro.

Mineralogy. Bytownite an_{75}, slightly kaolinized, augite, actinolite, hornblende (olive-green), accessory apatite. Black iron ore, nontronite (?), and zeolite (natrolite (?)).

Texture. Coarse-medium grained, hypidiomorphic-xenomorphic, granular with occasional phenocrysts. Felspar is anhedral-subhedral, show some tendency to be tabular; some grains are zoned. Actinolite and green hornblende occur replacing augite; very often all that is seen of augite is a few grains within a hornblende crystal or enclosed in fibres of actinolite.

Hornblende also occurs as a previously crystallized mineral, and is interstitial and poikilitic. Black iron ore occurs as irregular grains, often associated with hornblende.

Commonly actinolite is seen to be surrounded by a thick envelope of a large crystal of hornblende, i.e. a hornblende crystal has a core of fibrous actinolite, indicating that the fibrous material probably replaced augite, whereas the outer shell of hornblende crystallized directly from the magma.

Nontronite occurs as radial fibres, along with small, interlocking prismatic crystals of (?) natrolite in an interstitial position between plagioclase crystals.

P129 (ii) Mambare River, W. of P.125

Eucrite or Olivine-anorthite gabbro.

Mineralogy. Augite, anorthite, An_{90-95}, olivine (chrysolite), enstatite, tremolite and actinolite, replacing augite, Accessory black iron ore occurring along the cracks in olivine, serpentine, altering from olivine; clinozoisite; kaolin; bowlingite.

Texture. Coarse-medium grained, hypidiomorphic, granular, with occasional phenocrysts. Felspar is anhedral to subhedral, tending to be tabular. Augite shows rather similar characteristics. Olivine is anhedral, forming rather irregularly shaped grains, possibly due to resorption. Actinolite and tremolite replace augite, though in relatively minor quantities. Black iron ore is associated with olivine, as is serpentine. Clinozoisite and kaolin attack felspar only slightly.

Enstatite occurs as the only phenocryst. It forms a very large, irregular crystal, enclosing small grains of augite, and is embayed by plagioclase. It is uralitized and serpentized along cracks. Bowlingite replaces olivine; sometimes while crystals are replaced.

P130 (i) "Fine-grained basic intrusive" Mambare River, western limit of traverse.

Uralitized fine-grained dolerite.

Mineralogy. Labradorite (An_{58}), hornblende, accessory black iron ore.

Texture Fine grained, slightly porphyritic, somewhat doleritic. Felspar occurs as subhedral tabular laths, with rather crenulate margins. The laths show a tendency to criss-cross and radial arrangements. Hornblende tends to be acicular, though a few pseudomorphs after pyroxene are seen. The porphyrocrysts consist of acicular hornblende, and rare euhedra of felspar.

Black iron ore forms irregular granules scattered throughout the rock. This rock is similar to P122 in having the mineral assemblage plagiocase-hornblende, but is coarser-grained. The hornblende in this specimen has a deeper green colour, and the felspar is slightly more basic.

P130 (ii) slightly coarser basic rock intruded by (i).

Altered granulitic norite.

Mineralogy. Labradorite (An_{55}), altered hypersthene (and hypersthene), augite and pigeonite, tremolite and actinolite, fibrous, replacing augite.

Accessory bastite black iron ore, hydrated iron oxide, chlorite.

Texture. Medium-grained granulitic pyroxenes, tending to be glomeroporphyritic, with a slight preferred orientation of the longer axes of the grains, and also of the albite twin lamellae of the labradorite. This mineral is anhedral forming rounded grains. Former grains of hypersthene have been replaced by fine-grained (?) talc and subordinate bastite; very little hypersthene remains. Augite and pigeonite are, in places, replaced by actinolite and tremolite. Black iron ore forms irregular grains in the groundmass, and is also associated with the ferro-magnesian minerals, as is hydrated iron oxide.

The hypersthene remains as relict grains within a mass of bastite and "talc". The latter minerals forms extremely fine flakes which are colourless, and which have high birefringence. They appear to be aligned parallel to the original cleavage of the hypersthene. The mineral has a slightly higher refractive index than bastite and chlorite. It may possibly be talc, which is a rare alteration product of orthopyroxene. Chlorite occurs in very thin veins cutting across felspar at right angles to the preferred orientation.

The rock is obviously of a gabbroic type. The origin of its present form is open to a doubt. Actinolite rimming augite, and remnants of hypersthene and bastite remaining in an area of "talc", together with the prevalence of lamellar twinning in felspar, with a little zoning, all suggest a magmatic origin for the rock: if the preferred orientation is taken as magmatic, this suggests that the gabbro was intruded as a partially solidified mass. However, if this was so, then one might expect to see straining and granulation of crystals, especially the felspars, where the twin lamellae would be bent and fractured; in fact, this is absent. Hence the alternative presents itself, i.e. that it is a fairly high grade pyroxene granulite which has suffered some retrograde metamorphism, involving the introduction of hydroxyl minerals. The texture of the rock suggests that it is a pyroxene-plagioclase granulite derived from a basic igneous rock, but the presence of pigeonite and of good albite twinning in plagioclase preclude this possibility (cf. specimen P92 (i).

P136 (i) "Fine-grained basic intrusive". Sisa Creek gorge, near Sisa-Diwor junction.

Chloritized and epidotized quartz dolerite.

Mineralogy. Intermediate -basic plagioclase, rather badly kaolinized; chlorite, pseudomorphing amphibole; epidote, pseudomorphing amphibole; quartz; black iron ore; calcite veinlet.

Texture. Fine-grained, hypidiomorphic, sparsely porphyritic. Felspar is in the form of lean laths; these are faintly radially arranged. Chlorite and epidote pseudomorph probable amphibole as acicular crystals. The phenocrysts are now composed of epidote, but some of them show pyroxene-like basal section shapes. Quartz occurs as interstitial and poikilitic crystals. There is some doubt about the exact identity of this rock, but it appears to have been originally a fine-grained quartz dolerite.

P136(ii) "Coarse-grained basic rock". Sisa Creek Gorge. near Sisa-Diwor junction.

Granophyric Granodiorite, probably a differentiate from a basic rock.

Mineralogy. Quartz 15%; (?)andesine 35%(?); orthoclase 15%(?); actinolite 25%; accessory black iron ore, kaolin, sericite, epidote, apatite.

Texture. Coarse-grained, hypidiomorphic, inequigranular, partly myrmekitic and suggestively doleritic in part. Pale green actinolite is prismatic, though interstitial to euhedral plagioclase. It tends to be rather fibrous, especially in the crystal centres. Plagioclase is euhedral, tabular; it is patchily kaolinized, with occasional flakes of sericite, and is, in places, surrounded by extensive growths of micropegmatite and/or myrmekite. Some crystals appear to have been altered wholly to epidote. Orthoclase is interstitial and poikilitic, anhedral in habit: only a small amount remains as much appears to have been converted to a myrmekitic innergrowth of quartz and plagioclase. Where this has happened, and where the original orthoclase neighboured or surrounded plagioclase, the latter's margin has been corroded and fretted. Quartz occurs as interstital, subpoikilitic grains.

The myrmekitization appears also to have affected one of the plagioclase crystals, as blebs and plumose structures of quartz appear in a belt across this grain.

The alteration processes appear in irregular areas in this section: one area may be relatively unaltered, with fresh plagioclase, etc. In another area all the felspars may be extensively kaolinized. Again, in yet another area, epidotization of felspar has taken place. All these alterations together with the myrmekitization of orthoclase, suggest extensive later stage alteration by magmatic fluids. The rock appears to be a granophyric "granodiorite", and is almost certainly an acid differentiate from a basic magma. The percentages of amphibole is too high for a granodiorite, and, in any case, it appears to have been formed by a process of uralitization. The distribution of the plagioclase is, in places, very suggestive of that seen in dolerite. The rock as a whole is reminiscent of granophyric differentiates from dolerite and/or gabbro which have been found in South Alligator and Davenport Range areas of the Northern Territory. These have been discussed with Professor F. Walker, late of Capetown, and he agrees that they are almost certainly derived from dolerite or gabbro.

P138 "Medium grained basic rock". Uralitized Qtz dolerite

Mineralogy. Andesine 45%, zoned with labradorite at the core and oligoclase at the edge, actinolite 40%, quartz 5-10%, augite 5%. Accessory black iron ore, kaoline and sericite.

Texture. Medium to coarse-grained, hypidiomorphic, equigranular doleritic. Plagioclase is subhedral-suhedral, forming tabular crystals. Actinolite is fibrous to prismatic, replacing augite, and filling interstitial positions: it sometimes occurs in veins cutting across feldspar, and also as small fibres included in feldspar. Some plagioclase crystals which are partially enclosed in fibrous actinolite show corroded and fretted margins. Only a very small amount of augite remains, included as irregular grains within actinolite. Black iron ore, possibly ilmenite, is associated with the ferromagnesian minerals. Quartz is interstitial and, in places, poikilitic.

P139 Basic Rocks from Itau Creek.

1. Partially serpentized anorthite-bearing dunite.

Mineralogy. Chrysolite. Biaxial, 2V = C.90°. Birefringence = 0.036. The alteration products of olivine are, firstly, a mineral which is pleochroic in light green and light yellow, with a very low birefringence, and whose R.I. is slightly higher than that of Canada balsam. It occupies cracks cutting across the olivine and appears to be in minute fibres whose direction is at right angles to the vein. This is taken to be chrysotile. Secondly, there is a very light green fibrous, or chlorite-like mineral occupying the spaces between olivine crystals and corroding their margins. It has a rather higher birefringence than chrysotile; this mineral is antigorite. Magnetite is a byproduct of the serpentinization of olivine. Thirdly, intergranular actinolite is present in small amounts, it is pleochroic in light green, and has a birefringence of 0.021. Its extinction angle is 18°. It is fibrous, though the fibres are thicker than those of antigorite. Only small amounts are present, again around the margins of olivine crystals.

Minor amounts of felspar are present. It has albite and pericline twinning. Extinction angles on the former show a composition o. An_{95}, anorthite. It has a biaxial negative, interference figure. The anorthite has thin irregular cracks which are filled with an opaque mineral.

Accessory black iron ore is present as euhedral "square" crystals. A little hydrated iron oxide occurs in some of the serpentine "veins" in olivine, where weathering of product magnetite has taken place.

Texture. Coarse-grained, xenomorphic granular. Chrysolite forms coarse, anhedral crystals. Anorthite is present in minor quantities, less than 5%, and occupies interstitial spaces between the chrysolite crystals.

Chrysotile occupies cracks in olivine crystals. The cracks form a general mesh work in the rock, with some dominant direction of parallelism. The cracks also occur in anorthite, but in this mineral they are filled with an opaque substance, and have not been widened by alteration as in olivine. The rock is a partially serpentized anorthite-bearing dunite.

ii. This specimen is practically the same as (i), except that a small amount of calcite occurs occasionally in the intergranular spaces.

ii. Tractolite or allivalite (if plagioclase is anorthite).

Mineralogy. 70% chrysolite. Biaxial, 2V=C90°.

Birefringence = 0.034. The alteration products of olivine are:

(1.) A brown, minutely fibrous mineral occupying the cracks. This mineral's birefringence is rather strong. Possibly xylotile.

(ii.) Some chrysotile is also present in the cracks as minute fibres. It is pleochroic in a very light green and has low birefringence.

8% tremolite, colourless, with amphibole-type prismatic cleavage. Length slow along the cleavage, 2 C = 22°.

Birefringence = 0.021.

20% felspar. Biaxial negative, with a 2V = C80-85.

Albite and pericline twinning are present, but in the section they are rather indistinct, making extinction methods difficult. Composition is bytownite or anorthite.

Accessory black iron occurs as euhedral "square-shaped" grains: it also occurs as minute grains along the alteration cracks of olivine.

Texture. Coarse-grained, zenomorphic. Olivine occurs as large, anhedral grains with a mesh work of cracks along which serpentinization has taken place. Tremolite is interstitial about olivine. Felspar is also interstitial to olivine. Numerous cracks appear in the felspar, radial to the grains of olivine: these were caused by the expansion of olivine on alteration (in part) to serpentine.

This rock is very similar to specimens (i) and (iii) of P139, and it is suggested that all three are differentiates from the same magma.

APPENDIX II

PETROGRAPHIC REPORT BY W.R. MORGAN ON SPECIMENS FROM THE AJURA KUJARA RANGE, PAPUA.

P.80. Oivi Hill. -basalt intruding dolerite.

Hand Specimen. A medium to fine-grained, basic porphyritic and amygdaloidal rock is seen to be in sharp contact with a very fine-grained, porphyritic rock. The junction appears to be fairly straight, though slightly irregular - the hand specimen is too small to show if either of the rocks has a chilled phase.

Thin Section

(1) Medium-grained rock. In texture, this specimen is medium to fine-grained and holocrystalline. It is hypidiomorphic sub-ophitic, variolitic and glomeroporphyritic. Some amygdules are present.

In the groundmass, labradorite forms numerous lean, lath-like crystals, with rough margins, and ragged terminations. It is in sub-ophitic intergrowth with augite. Symmetrical extinction angles measured on albite twinning show an approximate composition of An61. Its refractive index is greater than Canada balsam. Augite forms colourless or very faintly green anhedral crystals, commonly enclosing labradorite. It is biaxially positive with 2V = 55°. The birefringence = 0.019, while ZAC = 41°. Some alteration to chlorite may be seen, particularly in certain sphernlite-like masses, which consist of radially arranged laths of labradorite, some fibrous chlorite, and anhedral augite.

The phenocrysts consist of labradorite and augite. The former occur as large tabular crystals, of about a millimeter size in the section, often in the clusters. They are commonly strongly kaolinized and sericitized. Albite and carlsbad twinning are present. The feldspar is biaxially positive, with 2V =85°. An extinction angle measured from the (001) cleavage on a section normal to the X-bisectrix showed a composition of An70. The crystals are zoned to more acid labradorite at the margins. Sometimes a labradorite phenocryst appears to partly enclose part of the groundmass, i.e. as if it had grown around an ophitic mixture of augite and labradorite laths. Augite phenocrysts measure up to 0.75 mm., and are subhedral prismatic, sometimes ophitically enclosing groundmass feldspar at their margins. Augite crystals are often clustered. Black iron ore is restricted to the groundmass, and forms "cubic" subhedral grains.

The amygdules have a circular to irregular shape, the mineral infilling quite often partly enclosing groundmass feldspar. The greater part of the infilling is a green, rather fibrous chlorite. Small amounts of radially arranged fibres of a zeolite, possibly thomsonite, are present. This latter mineral has a refractive index less than that of labradorite, and greater than that of Canada balsam. Its birefringence = 0.005, while the fibres are length fast.

The rock is cut by very thin veins containing a mixture of green chlorite and dusty opaque material, thin veins of chlorite cut feldspar along cleavage planes.

An estimation of the mineralogical composition is:- labradorite: 40% augite: 35%, chlorite: 20%, black iron ore: 5%. The rock is an amygdaloidal dolerite.

(2) Fine-grained rock. In texture it is holocrystalline and very fine-grained, and is hypidiomorphic, porphyritic and sub-vanolitic. The groundmass appears to consist of laths of feldspar, and prismatic pyroxene, with some chlorite. The phenocrysts consist of feldspar and pyroxene. The feldspar has a refractive index greater than that of Canadian balsam, while extinction angles on combined carlsbadalbite twins give a composition of An54 (labradorite). It occurs as rather lean, tabular crystals, or as rhomb-shaped grains, and as larger, rather broken, kaolinized and sericitized crystals. Augite phenocrysts occur as euhedral, prismatic crystals, or as apparently broken up crystals. The broken crystals of augite and feldspar occur close to the junction with the dolerite, all within 2-3 minutes, as seen in the section. The rock becomes exceedingly fine-grained against the dolerite.

Thin veins of chlorite cut the fine-grained rock at right angles to the junction. The rock contains very fine-grained and granular black iron ore.

The fine-grained rock is a basalt. The broken crystals of feldspar and pyroxene mentioned above appear to be xenocrysts from the neighbouring medium-grained dolerite. Again, it was mentioned above that the basalt becomes even more fine-grained at the junction. Hence it is suggested that the basalt intrudes the dolerite.

P.104 Mt. Hegahorte - 9tz microdiorite intrudes 9tz- bytownite.

Hand Specimen. Two rocks in contact may be seen. The apparently older rock is medium to coarse-grained, and contains quartz, white feldspar and hornblende, and has the appearance of an igneous rock. The younger is fine-grained and porphyritic and contains white feldspar and a ferromagnesian mineral, with the possibility of quartz. The feldspar has the form of laths, which have a rough flow texture. A fragment of the older rock is enclosed in the younger, the fragment's margins being gradational to the younger. The actual contact, excluding the fragment, is sharp, and a white mineral occurs in a vein between the two.

Thin section.

(1) The older rock & fragment. In texture the rock is medium-grained, hypidiomorphic, and very inequigranular; porphyritic quartz forms anhedral, interstitial and poikilitic grains, partly enclosing feldspar. By townite occurs as euhedral to subhedral laths, enclosed by both quartz and actinolite. Albite, carlsbad and pericline twinning is present. It is biaxially negative, with $2V=85^{\circ}$: several extinction angles measured on combined albite-carlsbad twin showed a composition of approximately An70 (?). Orthopyroxene has now been replaced by both bastite and a pale green actinolite. The former mineral sometimes occurs on its own, pseudomorphing prismatic crystals, but more commonly it is surrounded by a vein of, or entirely replaced by, fibrous actinolite. Black iron ore occurs as irregular grains. Some hydrated iron oxide occurs in thin veins associated with actinolite. Small amounts of an apparent clino-pyroxene are present as anhedral crystals, mantled by actinolite.

An estimation of the mineralogical composition is: quartz 25%, bytownite 35%, actinolite and bastite 30%, black iron ore 5%, the rock is an uralitized quartz-bytownite (?) microdiorite.

(2) The younger rock, Texturally, the specimen is fine to medium-grained, hypidiomorphic and inequigranular. It is

sparsely porphyritic, while the sub-parallel laths of labradorite suggest a flow texture. Quartz occurs as anhedral, interstitial and poikilitic crystals. Labradorite is present as tabular laths, partly enclosed by quartz and actinolite. It has a refractive index greater than that of Canada balsam, while albite and carlsbad twinning were observed. Symmetrical extinction angles on albite twin planes, and on a combined carlsbad - albite twinned crystal both show a composition of An59. Pale green actinolite forms anhedral, interstitial crystals: it is partly interstitial to quartz. Black iron ore occurs as subhedral to anhedral crystals.

The phenocrysts are composed of strongly kaolinized feldspar, and are tubular to rhomb-shaped. They appear to be of a similar composition to that in the groundmass.

A thin vein of chlorite cuts the rock, the mineral spreading out for a short distance either side of the vein, becoming interstitial to the rock minerals.

An estimation of the rock's composition:- quartz 15%, labradorite 45%, hornblende and actinolite 35%, black iron ore 5%.

The rock is an <u>uralitized quartz (?) microdiorite</u>.

<u>P105 Mt. Hegahorte</u> - 9tz-brg pyroxenite

<u>Hand Specimen</u>. The rock is fine-grained, and porphyritic, and is composed mostly of ferromagnesian material, with some phenocrysts of a white mineral.

<u>Thin Section.</u> In texture the specimen is medium-grained, hypidiomorphic, and very porphyritic.

In the groundmass, tremolite occurs as an accumulation of sub-radiating acicular crystals; or, more rarely, as sub-prismatic crystals with fibrous terminations Occasionally quartz may be seen in the groundmass, as anhedral crystals enclosing tremolite; sometimes it occurs as a concentration of granular crystals in one or two small areas. Small amounts of (?) plagioclase are also present in the groundmass. Its refractive index is greater than that of Canada balsam, but considerably less than that of tremolite, which it encloses. It has low birefringence, while a biaxially positive figure with a large 2V was obtained: some indistinct (?) albite twinning is present, and some symmetrical extinction on this suggested a composition of An40.

The phenocrysts consist of pyroxene, tremolite and (?) talc. The pyroxene forms euhedral, prismatic crystals: it is biaxially positive, with a 2V, very approximately, of 50°-60°, Z C = 40°-45°. Its birefringence is moderate. Very often it is rimmed by tremolite. The latter mineral very often forms euhedral pseudomorph phenocrysts after pyroxene: sometimes small, irregular patches of the pyroxene may be seen enclosed in tremolite. The latter is biaxially negative, with $2V=85^\circ$, and has a moderate birefringence, with a low extinction angle. Its refractive index is less than that of the pyroxene: tremolite is colourless. Fine-grained aggregates of talc and tremolite have pseudomorphed phenocrysts of pyroxene; talc occurs as fine-grained, irregularly-shaped flakes, which may at first be taken for sericite. Elsewhere (?) talc encloses irregular patches of tremolite, which are in optical continuity, and so the mineral is inferred to be an alteration product of amphibole. Winchell (1951) states that talc is one of the results of alteration of amphibole. Another phenocryst in this specimen shows long, acicular crystals of tremolite, separated by thin "layers" of (?) talc.

Black iron ore occurs as granules, and "cubic" shaped crystals enclosed in tremolite.

The rock is a quartz-bearing uralitized (?) pyroxenite. From its texture it appears to be a minor intrusive.

P.110 B (ii) Between Corta Creek and Hoija No. 1 Creek.

Hand Specimen. The rock is very fine-grained, basic and amygdaloidal. It is composed of tubular feldspar and a ferro-magnesian mineral. A white mineral occupies the amygdules.

Thin Section In texture, the specimen is holocrystalline, fine-grained, hypidiomorphic, with a sub-variolite and pilotanitic fabric. It is amygdaloidal. Albite occurs as rather ragged, lath-like, crystals. Its refractive index is less than that of Canada balsam, while some albite twinning is present. Some symmetrical extinction angles on the twin planes suggest a composition of An2. Chlorite occurs interstitially as anhedral flakes. It is faintly pleochroic in pale green, and the birefringence = 0.0085. It is length slow showing it to be optically negative, while its refractive index is rather less than that of neighbouring prehnite. Granular epidote, faintly pleochroic in yellow, occurs in the groundmass. Black iron ore and hydrated iron oxide form anhedral grains. Albite is lightly kaolinized in the section.

The amygdules ranging between 0.2 and 2.1 mm. in size, contain quartz, prehnite, chlorite and epidote, though not all these minerals may be present in any one. Green chlorite, rather similar to that in the groundmass, occurs as a fringe on the edges of the larger amygdules and completely fills the smaller ones: sometimes granular, yellowish epidote occurs with chlorite in the latter case. Quartz and prehnite occur as larger, equidimensional grains inside the chlorite rims in the large amygdules, sometimes with epidote. Commonly a fibrous or acicular chlorite is included in prehnite and epidote: it has a higher refractive index than the groundmass chlorite.

A thin vein of epidote cuts the rock, but its relationship to the amygdules is not seen in the section. A very thin vein of hydrated iron oxide is present, its course skirts around the amygdules.

The mineralogical composition of the rock, excluding the amygdules, is: albite 50%, chlorite 35%, epidote 5%, black iron ore and hydrated iron oxide 5%. The rock is an albitized and chloritized amygdaloidal basalt.

Comment. The present section was compared with P.110B of the original report. The following differences may be noticed:-

1. (a) In texture the present section is fine-grained, whereas the original is medium-grained.

   (b) a slight flow texture is seen in the present section.

   (c) The present section is non-porphyritic.

2. Mineralogy

   (a) This section has albite, while the original has (?) labradorite.

   (b) Augite is entirely altered to chlorite in the present section.

P.111. Hoija Creek.

Hand Specimen. The rock is a very fine-grained, apparently basic, igneous rock, which is slightly porphyritic. It has numberous large amygdules, often up to 2.5 mm. across, which are sometimes joined by veins.

Thin Section. In texture the specimen is found to be holocrystalline, fine-grained and porphyritic; its fabric is hypidiomorphic, sub-variolitic and interstitial. Numberous amygdules are present in the section.

The phenocrysts consist of euhedral, tubular crystals of albite, and are occasionally clustered. They have a refractive index less than that of Canada balsam, while they are biaxially positive, with 2V=85°. An extinction angle measured on a section normal to the X-bisectrix gave a composition of An5. Some of the phenocrysts have irregular areas of prehnite occupying their centres.

The groundmass feldspar appears to be of an approximately similar composition. It occurs as a mass of subhedral to euhedral laths, often showing albite and carlsbad twinning. A very slight amount of kaolinization has taken place. Some prismatic crystals of very pale green to colourless augite occur, with Z C = 42°, and a birefringence of 0.021. More often a pale green chlorite occurs, holding a position interstitial to albite.

The amygdules are rather similar to those of P.110B (ii) in that they have an outer rim of chlorite, surrounding quartz and prehnite. Either mineral may be dominant, and commonly occurs as large, roughly equidimensional crystals. In one or two amygdules, prehnite may occur as a mass of very small, irregular grains.

Black iron ore occurs as minute granules in the groundmass. Hydrated iron oxide has a similar occurrence, and is present also as thin veins cutting both amygdules and groundmass. Green chlorite occurs in irregular veins, joining amygdules.

An estimation of the mineralogical composition excluding the amygdules, is : albite 50%, augite and chlorite 45%, black iron ore and hydrated iron oxide 3%.

The rock is an albitized and partially chloritized amygdaloidal basalt.

P.117. Mt. Avaeti Dijari. Silicified basalt.

Hand Specimen. The rock is fine-medium grained, and is light grey and marginally stained with hydrated iron oxide. The cut surfaces show several, larger, spherical mineral accumulations, reminiscent of amygdules.

Thin-Section. The major constituent of this specimen is quartz, which is present, commonly, as a fine-grained, granular mosaic of crystals, showing sutured margins to one another. Occasionally, rounded aggregates of much coarser quartz grains occur, having a similar relationship to one another as in the groundmass, except that the grains tend to be elongated, nearly parallel to the C-axis. These aggregates are the "amygdules" of the hand specimen.

Occurring in lesser quantities are other minerals separating quartz areas are regions composed of a mixture of fibrous chlorite, pleochroic in pale green, and granular epidote, faintly pleochroic in yellow. Some hydrated iron oxide is present in clots, staining chlorite. In the quartz-rich areas, chlorite and (?) nontronite are present as fibrous material, holding an intergranular position. Both these minerals are often stained by hydrated iron oxide. Granular epidote is also present, enclosed by chlorite and quartz. Some rather prismatic, iron stained actinolite may also be seen.

The coarse-grained quartz aggregates are mostly free from the chloritic and (?) nontronitic matter, and instead have associated with them rather coarse-grained, sometimes roughly tabular, crystals of epidote. Enclosed in the quartz are very long, acicular needles of actinolite, or ferrotremolite, slightly pleochroic in very pale green: the needles have no general orientation. Very thin veins of hydrated iron oxide cut the rock.

If, for the moment, the quartz is ignored, the textural attitude of the remaining minerals is basaltic. Again the quartz aggregates are suggestive of amygdules. Hence, on these slender grounds, it is very tentatively suggested that the rock is a silicified basalt.

DISCUSSION

H.L. Davies stated in the covering letter that accompanied the specimens that often the quartz dolerites, etc., are observed to be intrusive, but that the amygdaloidal nature of some of them argues for an extrusive origin.

Williams, Turner & Gilbert (1954) state that vesicles, or amygdules, may be found in lavas and shallow intrusions. The writer has observed amygdules in a suite of spilitic dykes in Alderney, in the British Islands of the English Channel. Likewise, Walker (1930), during a description of the Shiant Islands, describes amygdaloidal structures in a dolerite sill of that locality. From the above, there is no reason why the dolerites etc. should not be intrusive. The fact that some of these rocks have been called basalt is not necessarily meant to imply that they are extrusive. Shallow and/or narrow basic dykes commonly have a basaltic texture and certain of the rocks here described have been called basalt on the basis of grainsize and texture.

REFERENCES

WALKER, F., (1930) — Geology of the Shiant Islands. Q.J.G.S. Vol. LXXXVI.

WILLIAMS, H., TURNER, F.J. & GILBERT, C.M. (1954) — Petrography, an introduction to the study of rocks in thin sections. W.H. Freeman & Co., San Francisco.

WINCHELL, A.N. & WINCHELL, H., (1951) — Elements of optical mineralogy Part II. Descriptions of the minerals John Wiley & Sons, Inc. New York.

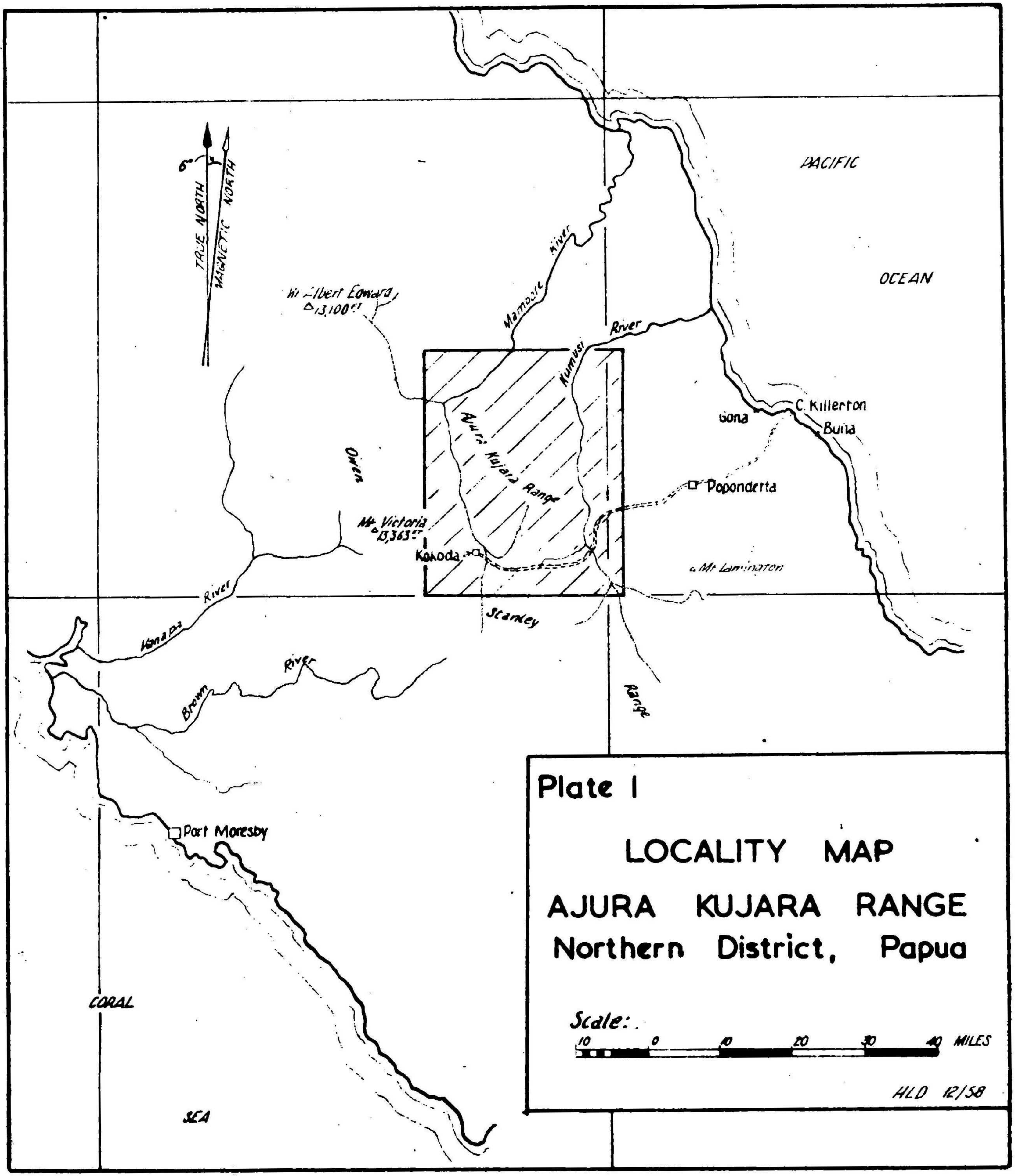

Plate I

LOCALITY MAP
AJURA KUJARA RANGE
Northern District, Papua

Plate 2


TOPOGRAPHIC ZONES
AJURA KUJARA RANGE
SCALE:- 1 0 1 2 3 4 5 MILES
Eastern Razorback Zone
Mt. Awaeh Ojari
Eastern Zone
Foothills
OPI RIVER
KUMUSI FLATS
UTAVIA RANGE
GORGE
Northern Zone
Eastern Foothills Zone
MAMBARE
Western Zone
AJURA KUJARA RANGE
Central Zone
KUMUSI FLATS
Eastern Razorback Zone
Mt Hegahorte
YODDA
UPPER MAMBARE RIVER VALLEY
Western Zone
Iropa Creek
Eastern Razorback Zone
Southern Zone
YODDA VALLEY
Mt Momo 4000 FT
TRUE NORTH
MAGNETIC NORTH
6°
OWEN
KOKODA
MT LAMINGTON ALLUVIAL FAN
Divi Hill
Luwuni Valley
Aewo
Aewo - Sirorata Hills
STANLEY
MOUNTAINS
HLD 12/58
LEGEND
Boundary of topographic province.
Boundary of zone within topographic province.
Vehicle road.
Foot track.
Route of party.
Village.

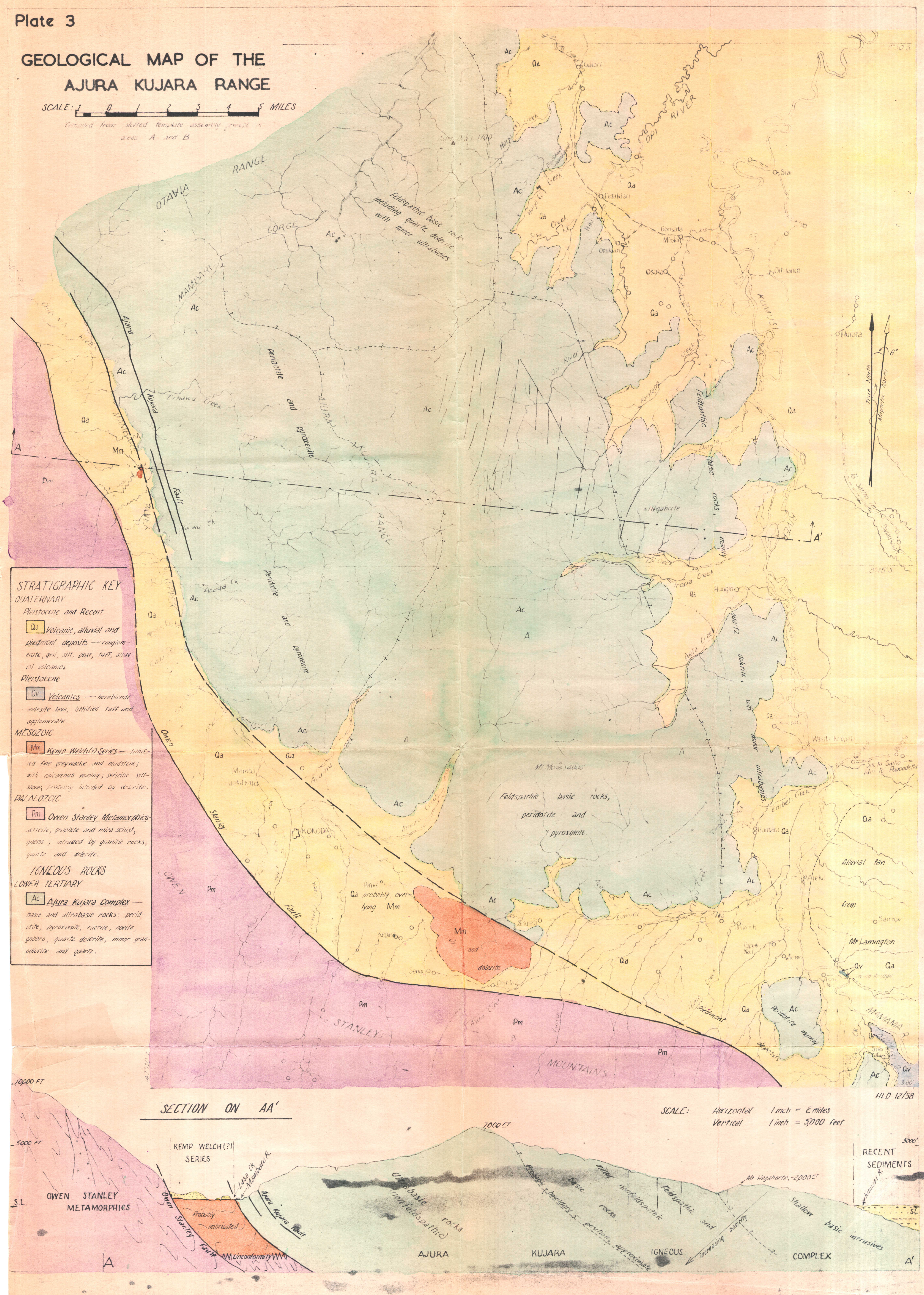
Plate 3
GEOLOGICAL MAP OF THE
AJURA KUJARA RANGE
SCALE: 1 0 1 2 3 4 5 MILES
STRATIGRAPHIC KEY
QUATERNARY
Pleistocene and Recent
Qa Volcanic, alluvial and piedmont deposits — conglomerate, grit, silt, peat, tuff, alluvial volcanics.
Pleistocene
Qv Volcanics — hornblende andesite lava, lithified tuff and agglomerate
MESOZOIC
Mm Kemp Welch(?) Series — limited fine greywacke and mudstone; with siliceous veining; sericitic siltstone, probably intruded by dolerite.
PALAEOZOIC
Pm Owen Stanley Metamorphics — sericite, graphite and mica schist, gneiss; intruded by granitic rocks, quartz and dolerite.
IGNEOUS ROCKS
LOWER TERTIARY
Ac Ajura Kujara Complex — basic and ultrabasic rocks: peridotite, pyroxenite, eucrite, norite, gabbro, quartz dolerite, minor granodiorite and quartz.
OTAVIA RANGE
GORGE
Feldspathic basic rocks including quartz dolerite with minor ultrabasics
OPI RIVER
Ajura Kujara Fault
peridotite and pyroxenite
AJURA KUJARA RANGE
Feldspathic basic rocks
Mt Ilegaharte
Iropa Creek
dolerite, with minor ultrabasics
Mt Moiwi 4000
Feldspathic basic rocks, peridotite and pyroxenite
Owen Stanley Fault
OWEN STANLEY MOUNTAINS
Qa probably overlying Mm
Mm and dolerite
Alluvial fan from Mt Lamington
Piedmont deposits
peridotite mainly
True North
Magnetic North
6°
A
A'
HLD 12/58
SECTION ON AA'
SCALE: Horizontal 1 inch = 2 miles
Vertical 1 inch = 5000 feet
10000 FT
5000 FT
S.L.
7000 FT
OWEN STANLEY METAMORPHICS
KEMP WELCH (?) SERIES
Probably imbricated
Unconformity
Owen Stanley Fault
Ajura Kujara Fault
Ultrabasic rocks (non-felspathic)
Feldspathic and basic rocks
Shallow basic intrusives
increasing basicity
Mt Ilegaharte - 2000 FT
AJURA KUJARA IGNEOUS COMPLEX
RECENT SEDIMENTS

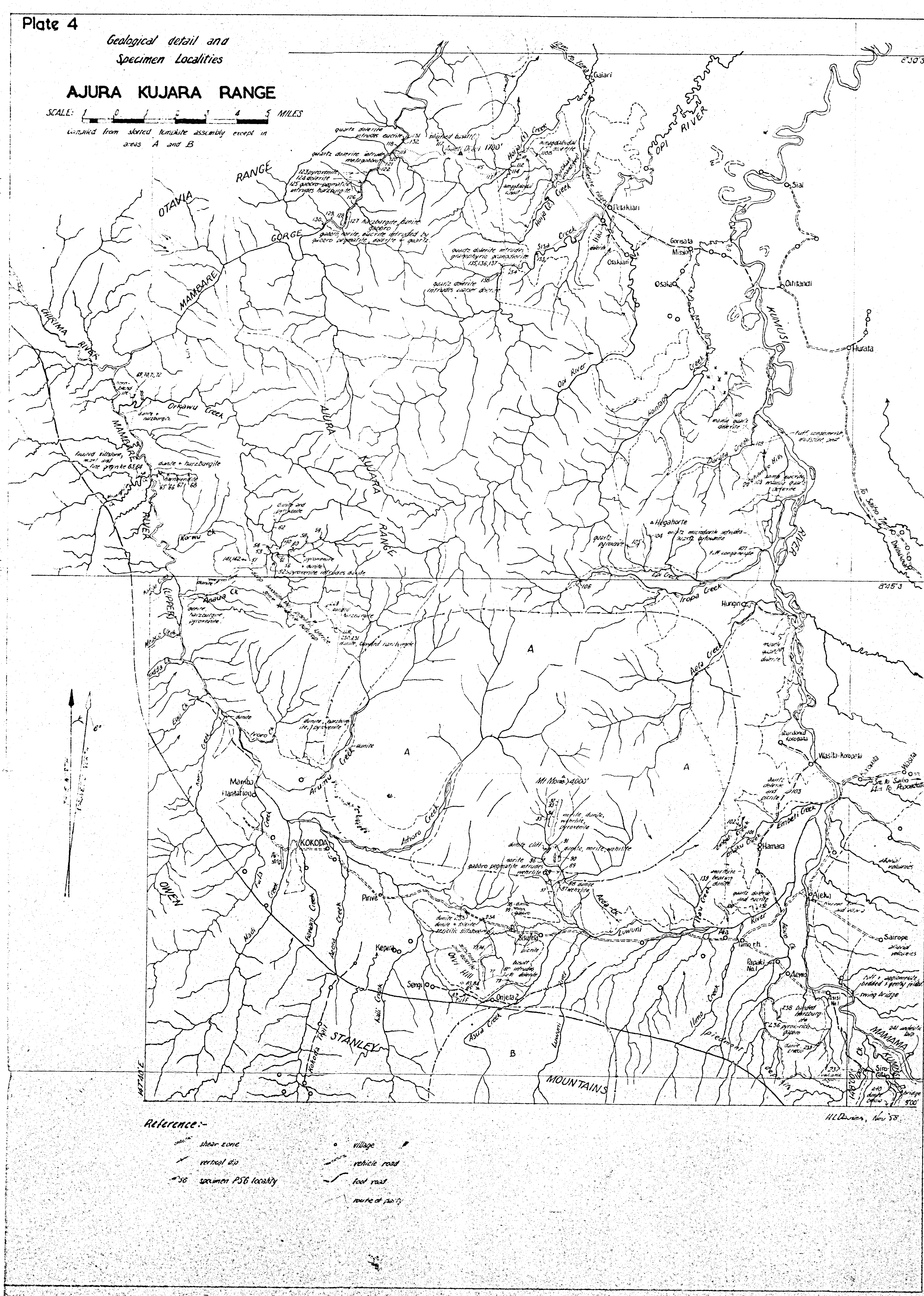
Plate 4
Geological detail and Specimen Localities
AJURA KUJARA RANGE
SCALE: 1 0 1 2 3 4 5 MILES
compiled from slotted template assembly except in areas A and B
OTAVIA RANGE
GORGE
MAMBARE
CHIRIMA RIVER
AJURA KUJARA RANGE
OPI RIVER
Opi River
KUMUSI RIVER
Gaiari
Sial
Gorisata Mission
Osaka
Ombandi
Hurata
Hungiri
Iropa Creek
Aela Creek
Wasila-Koropata
Hamara
Embeli Creek
Ajeka
Sairope
Aewo
Siro
MAMAMA
Mt Momo 4000'
Mamba Plantation
KOKODA
Pirive
Kepara
Sengi
Onjeta
Sisureta
Ala
Iumo r.h.
Papaki No.1
OWEN
STANLEY
MOUNTAINS
Kokoda Trail
Asua Creek
Luwuni
Arhoro Creek
Orkawu Creek
Korowu Ck
Anaua Ck
UPPER
RIVER
Hegahorte
8°30'S
8°45'S
A
B
H.L.Davies, Nov 58.
Reference:-
shear zone
vertical dip
56 specimen P56 locality
village
vehicle road
foot road
route of party