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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1966/194

GEOLOGICAL BRANCH
METALLIFEROUS SECTION - SUMMARY OF ACTIVITIES, 1966

15928/65

GEOLOGICAL BRANCH

METALLIFEROUS SECTION - SUMMARY OF ACTIVITIES, 1966

Records 1966/194

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ILLUSTRATIONS

SUMMARY

This Record summarizes the work of the Metalliferous Section from November, 1965, to October, 1966. Figures 1 and 2 show areas investigated during 1966, and those which it is proposed to cover in 1967.

Regional mapping continued in the Kimberleys, and was started in Cape York Peninsula and in the Sepik River region, New Guinea. In the Papuan Ultramafic Belt one geologist continued reconnaissance mapping. Semi-detailed mapping of the Herberton, Mount Garnet, and Ravenswood 1-mile Sheet areas, Queensland, was completed. Detailed geological mapping, auger drilling/geochemical sampling, and diamond drilling continued in the Rum Jungle area. A six weeks' training course was introduced to show new appointees the functions and laboratory facilities of the Section, as well as something of the work of the other Branches.

Highlights of the year included pioneering the use of jet boats for geological work in New Guinea, completion of about 90 percent of the reconnaissance mapping of the Papuan Ultramafic Belt, and the discovery of copper-nickel sulphides within it. The Ultramafic Belt can be upgraded to an important propsecting area for sulphide deposits; intrusive contacts appear to offer most promise. Thirty-eight samples for isotopic dating were collected in New Guinea. In the West Kimberleys a small kyanite deposit was discovered, and the Yampi iron ore deposits were shown to be the stratigraphic equivalent of the Elgee Siltstone; three new Mesozoic lampmoite plugs were found in Precambrian rocks. Mapping in Cape York Peninsula showed that the area is occupied by high- to medium-grade metamorphic rocks intruded by several types of granite; a camp manager was attached to the party with some success: he set up and struck camp, and attended to day to day administrative matters. In the Herberton-Mount Garnet area, several new granite bodies were delineated, and in the Ravenswood area a broad geological control for most of the mineralization was established. At Woodcutters, near Rum Jungle, four diamond drill holes intersected sulphide mineralization, and five drills are now working in the area.

Progress was made with the direct-reading spectrograph after air-conditioning problems were overcome. In the chemical laboratory the significance of cold extractable metals for geochemical prospecting was investigated. The X-ray laboratory is now established in the new building. Isotopic dating of samples from Australia, New Guinea, and Antarctica continued in co-operation with the staff of the Australian National University. The Baas-Becking Geobiological Research Group had a serious set-back when fire destroyed laboratories nearing completion.

Dr. K.E. Eade, of the Geological Survey of Canada, is attached to the Bureau for a year under an exchange agreement; P.W. Crohn has been seconded to the Canadian Survey for the same period.

Laboratory activities continued to be hampered by lack of technical officers and technical assistants to carry out the more routine tasks. Exploration companies continue to offer attractive salaries to our staff, and this, coupled with the lack of a professional structure in the Branch, has had an unsettling effect - officers should have the opportunity to advance to at least Class IV status.

FIG. 1

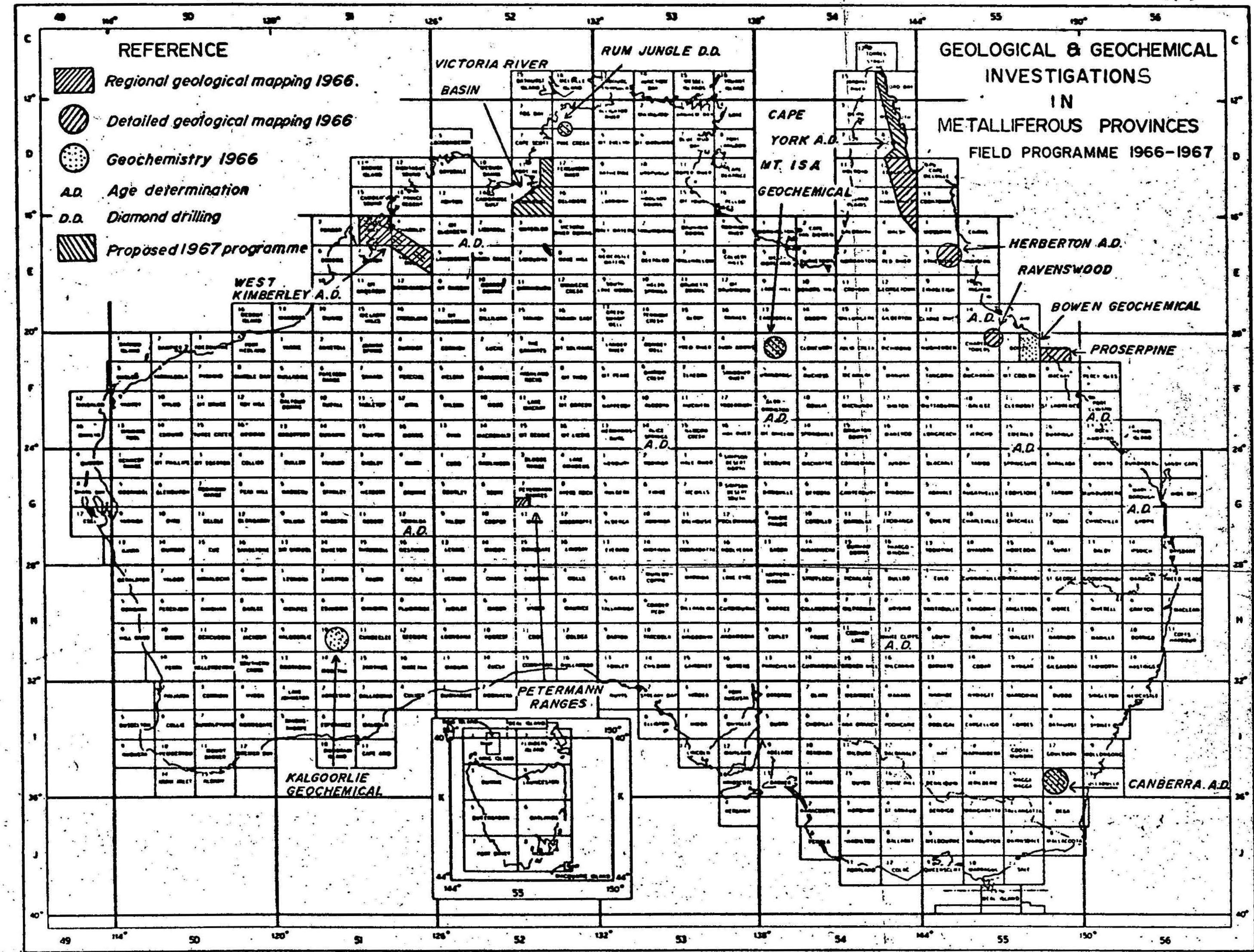
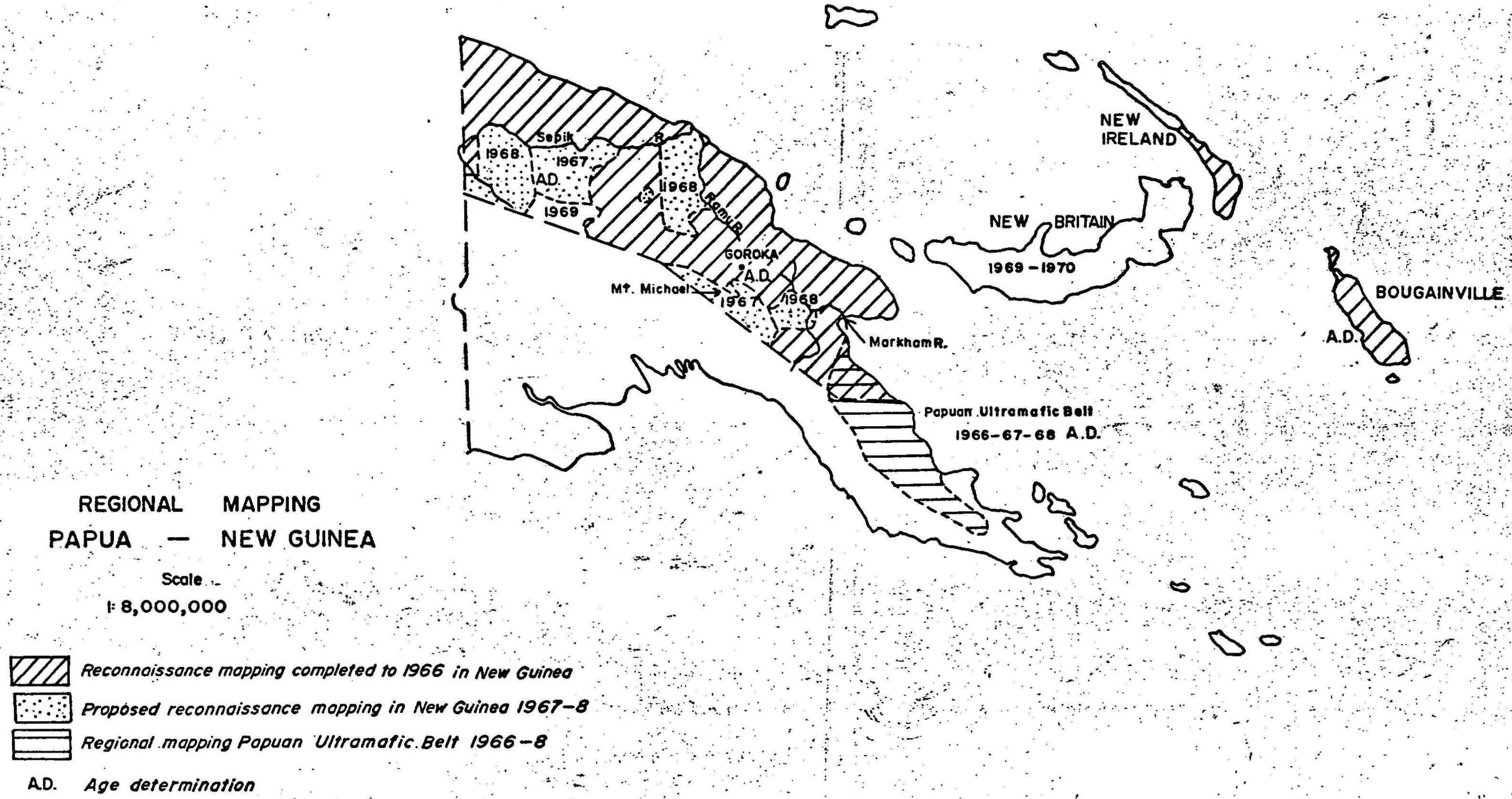

GEOLOGICAL & GEOCHEMICAL INVESTIGATIONS IN METALLIFEROUS PROVINCES
FIELD PROGRAMME 1966-1967
REFERENCE
Regional geological mapping 1966.
Detailed geological mapping 1966
Geochemistry 1966
A.D. Age determination
D.D. Diamond drilling
Proposed 1967 programme
VICTORIA RIVER BASIN
RUM JUNGLE D.D.
CAPE YORK A.D.
MT. ISA GEOCHEMICAL
HERBERTON A.D.
RAVENSWOOD
BOWEN GEOCHEMICAL
PROSERPINE
WEST KIMBERLEY A.D.
PETERMANN RANGES
KALGOORLIE GEOCHEMICAL
CANBERRA. A.D.

FIG. 2



Sepik
R
1968
1967
A.D.
1969
1968
Ramu R.
GOROKA
A.D.
Mt. Michael
1967
1968
Markham R.
Papuan Ultramafic Belt
1966-67-68 A.D.
NEW
IRELAND
NEW BRITAIN
1969 - 1970
BOUGAINVILLE
A.D.
REGIONAL MAPPING
PAPUA — NEW GUINEA
Scale
1: 8,000,000
Reconnaissance mapping completed to 1966 in New Guinea
Proposed reconnaissance mapping in New Guinea 1967-8
Regional mapping Papuan Ultramafic Belt 1966-8
A.D. Age determination

REGIONAL PROJECTS

FIELD WORK

KIMBERLEY PROJECT, W.A.

In 1962 the Bureau, in conjunction with the Geological Survey of Western Australia, began a programme of systematic regional geological mapping of the Kimberley region of Western Australia. In 1966 this programme was continued with the mapping of parts of the Yampi, Charnley, and Lennard River 1:250,000 Sheet areas by the West Kimberley Party. Mapping has now been completed in almost all of the 15 map sheet areas of the Kimberleys. The small amount of field work remaining is scheduled for completion in 1967.

Bulletins are at present in the course of preparation describing the geology of the East Kimberley and of the Kimberley Basin.

WEST KIMBERLEY PARTY

D.C. Gellatly (Party Leader); J. Sofoulis and R.A. Farbridge (G.S.W.A.), G.M. Derrick and C.M. Morgan (B.M.R.); A. Tatarow (draftsman, B.M.R.).

Field Activities.

During the field season the party was engaged in:-

(i) Regional geological mapping of the Yampi 1:250,000 Sheet area, and parts of the Lennard River and Charnley 1:250,000 Sheet areas.

(ii) The investigation of the surface and subsurface hydrology of the above areas, and the selection of water bore sites.

(iii) The collection of a preliminary batch of age determination samples from the West Kimberley area.

Geology

The rocks in the area mapped are almost all of Precambrian age. Phanerozoic rocks lying to the south of the area have been mapped previously and were not included in this survey. The Precambrian geology of the area is summarized in Table 1, and the distribution of the principal rock units is shown in Fig. 3.

Lower Proterozoic. The Halls Creek Group consists of greywacke, shale, and siltstone which have been strongly folded, and metamorphosed. Grade of metamorphism is mostly low, but a belt of high-grade metamorphics with andalusite, garnet, staurolite, and chloritoid, is present along the southern margin of the area. Three phases of metamorphism, ranging from essentially thermal to mainly dynamic and retrograde, are recognised. The Whitewater Volcanics consist of a series of autoclastic quartz-feldspar porphyries interbedded with rhyolite and tuffaceous siltstone. Rhyolites are apparently more abundant than in the East Kimberley. The Lamboo Complex consists of several distinct types of granite and intrusive quartz-feldspar porphyry, and small areas of basic intrusives. The acid rocks of the Lamboo Complex, intrude both the Halls Creek Group and the Whitewater Volcanics, and consist mainly of porphyritic biotite granite and medium-grained quartz-feldspar porphyry. The basic rocks include folded, stratiform, amphibolitized dolerite (Woodward Dolerite) intruding the Halls Creek Group, noritic gabbro intruding granite, and abundant dolerite dykes cutting the Halls Creek Group, the Whitewater Volcanics, and the granites.

Carpentarian. The Speewah Group found farther east is absent in the area mapped. The lower formations of the Kimberley Group are similar to their lateral extensions to the east, but the upper formations show considerable facies changes, mainly within the Yampi Sheet area. The Warton Sandstone includes prominent siltstone beds. The Elgee Siltstone locally has a 40-50ft thick basal conglomerate. This conglomerate transgresses the Warton Sandstone, and locally rests disconformably on the Carson Volcanics. The Yampi iron ores occur in the upper part of the Elgee Siltstone, but away from the known ore deposits the Elgee Siltstone contains only minor amounts of iron. The lower part of the Pentecost Sandstone shows lateral variations from quartz sandstone to siltstone. The upper part consists of quartz sandstone and siltstone, with a hematitic sandstone facies in the north, particularly on the islands of the Yampi Sound area. Minor glauconitic sandstone is also present.

Sills of Hart Dolerite and Juramma Porphyry* intrude the Kimberley Group rocks. The Juramma Porphyry, a coarse-grained quartz-feldspar porphyry, intrudes the Elgee Siltstone, and is found only in the Yampi Sound area.

Carpentarian and/or Adelaidean. The Oscar Range Succession crops out as an elongate inlier separated from the rest of the Proterozoic rocks by an area of Devonian limestone. The succession consists of five groups of beds separated from one another by faults or areas of no outcrop, and is characterised by cobble conglomerates at two distinct stratigraphic levels. The lower conglomerates (Ellendale Beds*) are probably molasse-type deposits, whereas the upper ones (Elimberrie Beds*) are associated with siltstones and dolomitic limestones, and may possibly be of glacial origin. A further series of conglomerates (Ninety-seven Mile Beds*) may possibly be equivalent to the Ellendale Beds.

No correlations can be suggested at present with the Kimberley Basin succession to the north, but the Linesman Beds* are, in part, lithologically similar to the O'Donnell Formation, e.g., around Inglis Gap in the King Leopold Ranges to the north. The Elimberrie Beds may possibly be equivalents of the Egan Formation of the Mount Ramsay Sheet area to the east.

Economic Geology

The only mineral deposits at present being worked in the area are the iron ore deposits of Cockatoo and Koolan Islands in the Yampi 1:250,000 Sheet area. The Napier Lead Mine in the Lennard River area ceased production in 1965, but work there is expected to resume next year. Small tonnages of copper have been mined from prospects in the Yampi 1:250,000 Sheet area, principally from Coppermine Inlet. Small amounts of tin have been recovered from the Hawkestone Creek area (King's Sound Tin Mine), and mica from Gussy's Find, near Napier Downs.

A kyanite deposit estimated to contain about 50,000 tons of bladed kyanite has been found in the Hawkestone Creek area, where it occurs at the contact of Woodward Dolerite and Halls Creek Group phyllites. Detrital emery boulders have been found in a similar geological setting a few miles south-west of Mount Broome.

In addition, several previously unreported minor showings of copper have been noted, but none of these is likely to be of economic significance.

Geochemical stream sediment sampling at ½-mile intervals has been carried out over much of the area by Pickands Mather International. Follow-up work in connection with this is in progress, and results are not yet available.

* Nomenclature not formalized

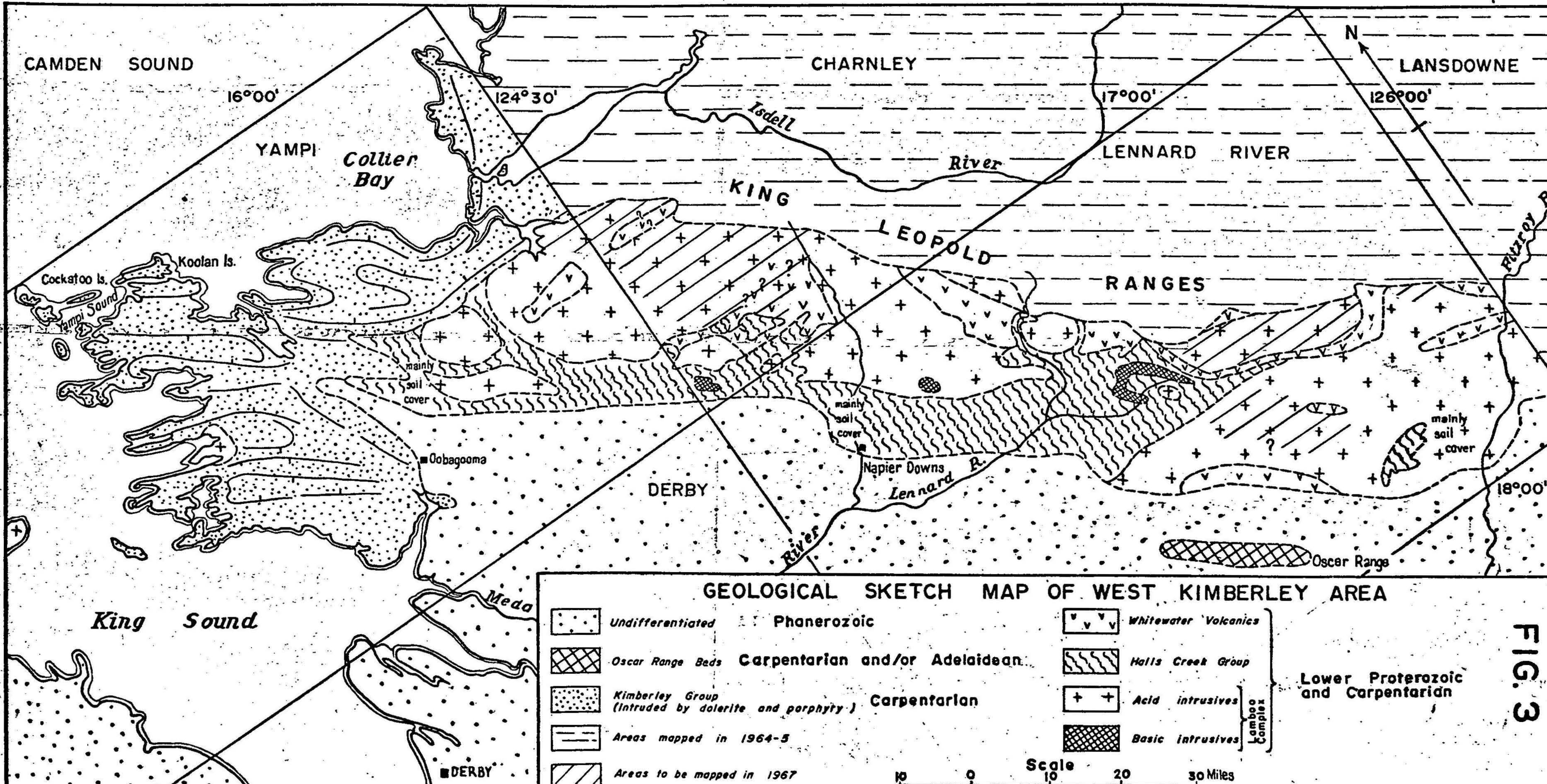

GEOLOGICAL SKETCH MAP OF WEST KIMBERLEY AREA
CAMDEN SOUND
CHARNLEY
LANSDOWNE
N
16°00'
124°30'
17°00'
126°00'
18°00'
YAMPI
Collier Bay
Isdell River
LENNARD RIVER
KING LEOPOLD RANGES
Fitzroy R.
Koolan Is.
Cockatoo Is.
Yampi Sound
mainly soil cover
Oobagooma
Napier Downs
Lennard R.
River
DERBY
Oscar Range
King Sound
Meda
DERBY
Undifferentiated
Phanerozoic
Oscar Range Beds
Carpentarian and/or Adelaidean
Kimberley Group (Intruded by dolerite and porphyry)
Carpentarian
Areas mapped in 1964-5
Areas to be mapped in 1967
Whitewater Volcanics
Halls Creek Group
Acid intrusives
Basic intrusives
Lamboo Complex
Lower Proterozoic and Carpentarian
Scale
10 0 10 20 30 Miles

FIG. 3

TABLE 1

PRECAMBRIAN STRATIGRAPHY OF THE WEST KIMBERLEY AREA

CARPENTARIAN AND/OR ADELAIDEAN

Succession	Formation	Unit	Thickness (feet)	Lithology
		7.	3500+	Quartz-feldspar porphyry and rhyolite
OSCAR RANGE SUCCESSION		6.	500	Quartz sandstone and siltstone; thin ironstone beds
		5.	300	Cobble and boulder conglomerate with silty matrix
	Elimberrie Beds*	4.	Up to 1200	Phyllitic siltstone
		3.	100-600	Quartzite, feldspathic sandstone
		2.	400	Cobble conglomerate, siltstone, and cellular limonitic sandstone
		1.	700	Limestone and dolomite; feldspathic sandstone and shale interbeds
	Probable Unconformity (Faulted)			
		3.	650	Siltstone with thin sandstone interbeds; overlaps on to 1 above
	Christophers Beds*	2.	800	Siltstone and feldspathic sandstone
		1.	4000?	Siltstone and shale
	Relations Uncertain			
	Linesman Beds*	3.	1600(+)	White quartz sandstone
		2.	?	Shale and siltstone
		1.	2500	Purple-grey quartz sandstone; minor siltstone and pebble conglomerate
	Relations Uncertain			
		4.	500	Quartzite
		3.	1000	Cobble conglomerate
	Ninety-Seven Mile Beds*	2.	500	Phyllite with minor cobble conglomerate
		1.	50-100	Amygdaloidal, epidotised basic volcanics
	Probable fault			

TABLE 1 (cont.)

CARPENTARIAN AND/OR ADELAIDEAN (CONTINUED)

(Underlies Elimberrie Beds - Unit 1)

	Unit	Thickness (feet)	Lithology
Ellendale Beds*	5.	2000?	Siltstone and shale
	4.	700-1000	Cobble conglomerate with sandstone interbeds
	3.	800?	Sheared feldspathic sandstone; minor siltstone and hematite lenses.
	2.	1000-2000?	Massive, pale grey quartz sandstone
	1.	500(+)	Dark grey-green phyllite (metabasalt?)

CARPENTARIAN OR ADELAIDEAN

INTRUSIVES INTO KIMBERLEY GROUP	Juramma * Porphyry		Quartz-feldspar porphyry; intrudes Elgee Siltstone around Yampi Sound
	Hart Dolerite		Extensive sills of tholeiitic dolerite

CARPENTARIAN

KIMBERLEY GROUP	Pentecost Sandstone	3250	Quartz sandstone, siltstone, hematitic sandstone
	Elgee Siltstone	400-550	Siltstone with thin sandstone interbeds; localised conglomerate at base; hematite ore on Yampi Sound islands
	Warton Sandstone	800-1700	Quartz sandstone with minor siltstone and feldsapthic sandstone
	Carson Volcanics	1100-2000	Amygdaloidal basalt; tuff and agglomerate; interbeds of siltstone and sandstone
	King Leopold Sandstone	3000-4000	Quartz sandstone

LOWER PROTEROZOIC

LAMBOO COMPLEX	Basic Intrusives		Amphibolitised dolerite, noritic gabbro, diorite, dolerite dykes
	Acid Intrusives		Porphyritic and non-porphyritic biotite granite and tonalite; quartz-feldspar porphyry
	Whitewater Volcanics		Quartz-feldspar porphyry, rhyolite, tuffaceous siltstone
	Halls Creek Group		Andalusite, garnet, and staurolite mica schist; phyllite; greywacke, shale, and siltstone

* Nomenclature not formalised

NEW GUINEA REGIONAL MAPPING

At the beginning of the year a review was made of the unmapped areas of New Guinea,and of the availability of airphotographs; as a result a five-year programme to map the larger areas was laid out. A number of smaller, unmapped areas will be mapped mainly by the New Guinea Resident Staff.

It is hoped at the end of the programme to have sufficient data to compile a geological map of the Territory of New Guinea which will be accompanied by a Bulletin describing the geology. A start has been made on the compilation of the map.

Aerial Photography

Planning of the regional work is hampered by the lack of air-photographs in critical regions: these regions include the western part of the South Sepik Region and a large area east and south-east of the Yuat River.

Although a programme of aerial photography is being undertaken progress will necessarily be slow if the present policy of working only in the wet season (October to April) is continued. During the past three years the aerial photography team has been withdrawn at the onset of the dry season (May to September). The wet season offers almost no chance of the necessary cloud-free conditions, as shown by the small amount of photography done in the period, and it is essential that the photography be done in the much more promising dry season.

Sepik Party (D.B. Dow, J.A.J. Smit, R.P. MacNab, and J.H.C. Bain)

The Sepik Party started mapping the largest blank on the geological map of New Guinea which covers an area about 250 miles long by about 50 miles wide in the unpopulated mountainous region south of the Sepik River (Figure 4). This area was largely unexplored, and almost nothing was known of the geology.

Jet-Boats

The area posed formidable problems in logistics, as the only access from the supply centres of Angoram and Ambunti on the Sepik River involves over 100 miles of river travel. Canoes powered by outboard motors are the normal means of transport, but these are slow, and the outboard motors susceptible to damage from logs and other underwater obstructions. Helicopters were considered, but the cost of working out of Angoram would be prohibitive, and working from an advance base camp would pose the same logistics problems.

It was therefore decided to use Hamilton jet-boats, both to supply an advance base camp close to the southern mountains, and to gain access as far as possible into the mountains by way of the tributary streams.

The boats are propelled by a jet of water which is drawn in through a grill in the bottom of the boat near the stern, and is expelled above water-level at the rear. The boat is steered by deflecting the jet to the left or right, and is reversed by deflecting the jet back under the boat. The advantages of the jet-boats over conventional craft are their extreme manoever-ability, and their completely smooth under-surface with no projections to be damaged by under-water obstacles. The boats can travel in less than four inches of water while planing. Power is supplied by conventional car engines slightly modified for marine use. The Sepik Party was equipped with two Pride 16-foot fibre-glass hulls (Fig. 5) driven by Holden 179 engines, and a Hamilton 20-foot fibre-glass hull driven by a 250-horsepower General Motors V8 truck engine.

The performance of the boats exceeded expectations, and both Government and private organisations have followed the Bureau's lead, and are equipping with jet-boats in New Guinea.

Approximate running costs of the Pride boats for the 300 hours' running that each boat did during 1966 is given below:

Amortization of boat, spares, and tools over two years	$ 1500
Petrol and oil	700
Wages for driver-mechanic	1000
Repairs and maintenance	700
	$ 3900

Running costs per hour $ 13.00

Geology

The only available information from the whole of the South Sepik Region was gained by German explorers before World War I. They made collections of diorite and schist, and since then the area has been shown on geological maps as Palaeozoic basement rocks. Probably the most important result of our mapping was to show that the rocks are almost all little-altered sediments of Mesozoic to Tertiary age, intruded by dioritic, gabbroic, and ultramafic rocks.

The geology is dominated by large west-north-west-trending faults which have broken the region into a series of horsts and grabens.

The horst between the Maramuni and Yuat Rivers contains the oldest rocks of the region: these are the Middle Triassic Yuat Shale which contains well preserved Ammonites, and the Upper Triassic Kana Formation. The Mesozoic sequence overlying the Triassic rocks has not yet been established, as it crops out in the middle reaches of the Maramuni River which proved inaccessible to the jet-boats. This area will be mapped by means of a helicopter in 1967.

Little is known of the rocks east of the Yuat River. Only a small area was mapped, and this consisted of basic volcanic rocks and interbedded sediments which we have called the Keram Beds. The rocks are probably Upper Cretaceous in age.

The area west of the Maramuni River is composed of Upper Cretaceous to Lower Tertiary marl, siltstone, and limestone, called the Lagaip Beds, which are unconformably overlain by the Karawari Conglomerate, a polymict conglomerate containing patches of agglomerate and other basic volcanics. This is almost certainly the equivalent of the Lower Miocene Burgers Formation found to the south.

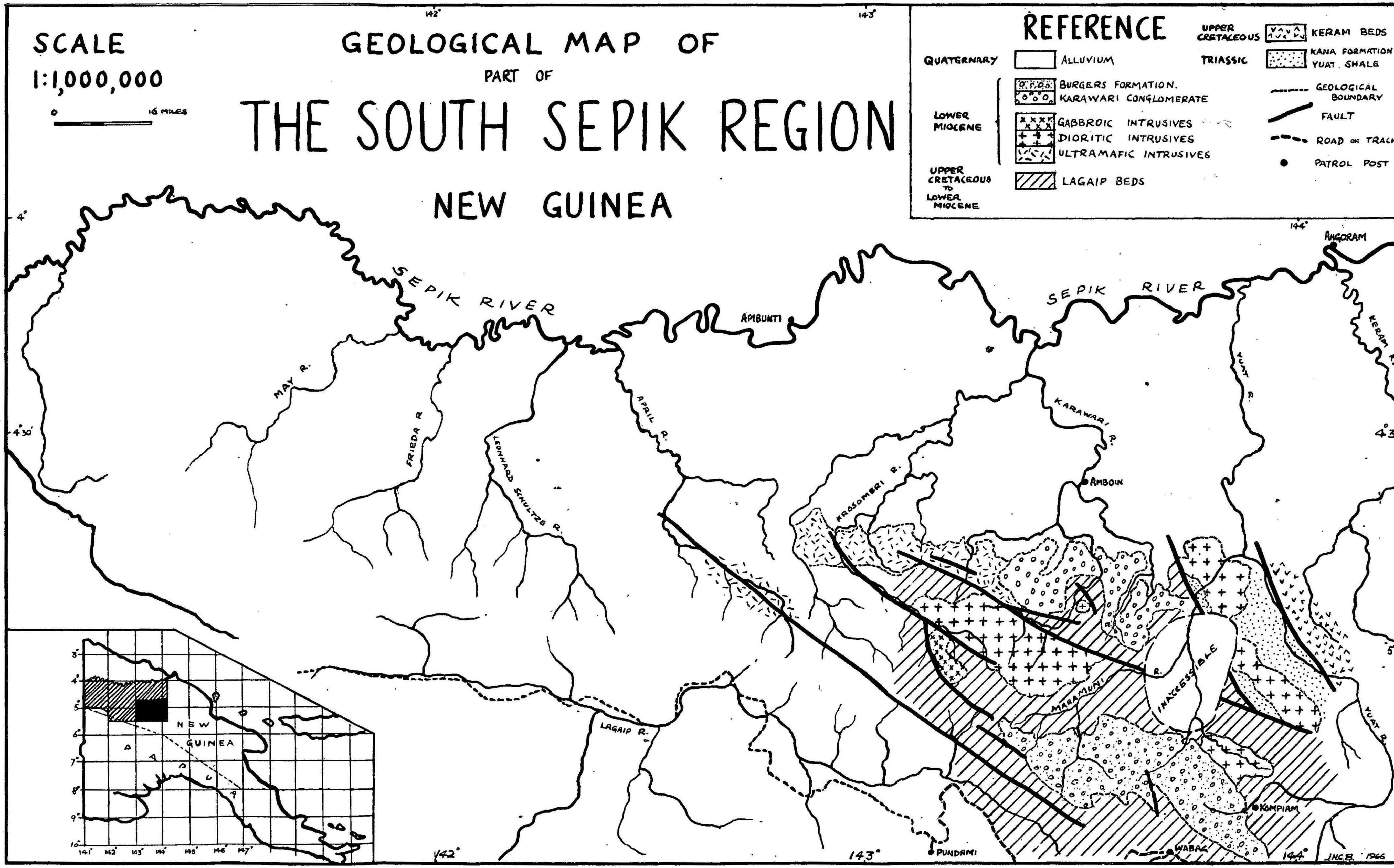
The large extent of the dioritic intrusions sampled by the German explorers was unsuspected. They were intruded in Lower Miocene time, and they are mostly diorite which grades in places into granodiorite and gabbro. Large bodies of serpentinized peridotite were mapped in the western part of the area. Where examined the peridotite bodies had faulted contacts with the Lower Tertiary sediments, but large bodies farther west, which were found during a reconnaissance into the April River, appear, from photo-interpretation, to intrude the Tertiary sediments.

Economic Geology

Most of the area mapped appears to offer little hope of economic deposits of minerals, especially in view of the difficulty of access.

Traces of copper minerals were found at several localities, but none seems worthy of further attention. The most widespread mineralization was found in the Keram Beds, and areas where these rocks are intruded by dioritic rocks are considered to offer the best prospects for finding economic

FIG 4


GEOLOGICAL MAP OF
PART OF
THE SOUTH SEPIK REGION
NEW GUINEA
SCALE
1:1,000,000
0
16 MILES
REFERENCE
QUATERNARY
ALLUVIUM
LOWER MIOCENE
BURGERS FORMATION.
KARAWARI CONGLOMERATE
GABBROIC INTRUSIVES
DIORITIC INTRUSIVES
ULTRAMAFIC INTRUSIVES
UPPER CRETACEOUS TO LOWER MIOCENE
LAGAIP BEDS
UPPER CRETACEOUS
KERAM BEDS
TRIASSIC
KANA FORMATION
YUAT SHALE
GEOLOGICAL BOUNDARY
FAULT
ROAD or TRACK
PATROL POST
SEPIK RIVER
SEPIK RIVER
AMBUNTI
ANGORAM
MAY R.
FRIEDA R.
LEONHARD SCHULTZE R.
APRIL R.
KAROSOMERI R.
KARAWARI R.
YUAT R.
KERAM R.
AMBOIN
MARAMUNI R.
INACCESSIBLE
LAGAIP R.
PUNDAMI
WABAG
KOMPIAM
NEW GUINEA
PAPUA
142°
143°
144°
4°
4°30'
5°
J.H.C.B. 1966

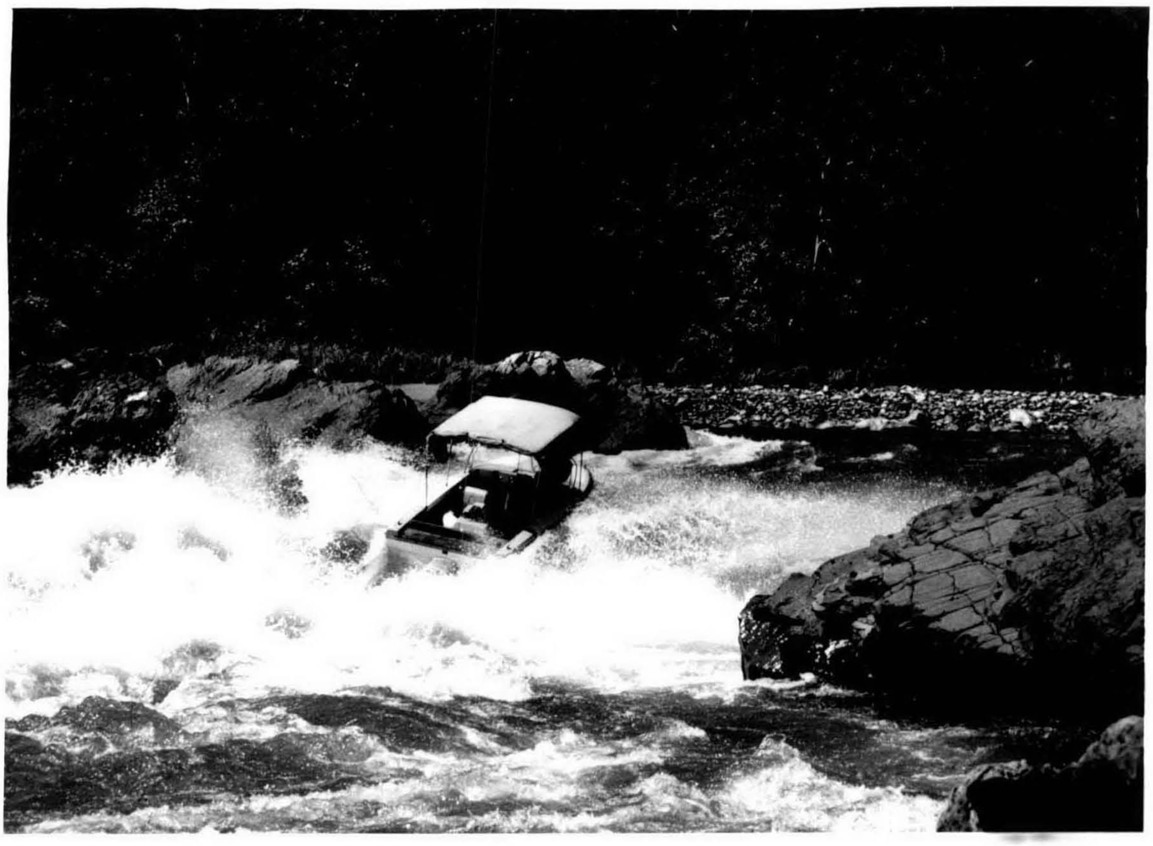


Figure 5 : 'Fireball', one of the sixteen-foot jet-boats, negotiating Number 7 Rapid in the Yuat River. This rapid was the most difficult traversed in 1966, and in the low level of the river shown the boat is at its safe limit.

concentrations of copper minerals. The area east of the Yuat River is therefore promising, and it will be mapped as soon as air-photographs are available.

Gold occurs in most streams draining the dioritic rocks, but the steep bottom gradients prevent the accumulation of economic deposits. The best prospects were found in the previously unexplored middle reaches of the April River, but in the short time we had in the area no appraisal of the alluvial gravels could be made. Platinum occurs in almost all the streams draining the ultramafic rocks, but dish prospects are poor.

PAPUAN ULTRAMAFIC BELT*, T.P.N.G.

(H.L. Davies)

The Ultramafic Belt is a body of mafic and ultramafic rock 250 miles long and up to 25 miles wide which forms a chain of mountain ranges on the north-eastern side of the Owen Stanley Range in eastern Papua-New Guinea. It extends from Salamaua (7°03'S., 147°03'E.) to the Bonua River (9°50'S., 149°08'E.) as outlined on the accompanying map (Fig. 6).

The Belt was emplaced by faulting in early Tertiary time. It may be an up-faulted segment of oceanic mantle; the scale of tectonic activity in the region is compatible with such an origin. Rocks in contact with the Belt are basaltic volcanics with minor limestones, some of Upper Cretaceous age, and sialic greenschist metamorphics some of which are Jurassic-Cretaceous.

In 1966 H.L. Davies completed the second year of a three-year programme of geological mapping, geochemical sampling, and petrological study of the Belt, and J.S. Milsom made a gravity survey. The main points arising from Davies' fieldwork are listed below:

The mafic rocks (gabbro, norite) are intrusive into the ultramafic rocks (peridotite, pyroxenite), and layering in both is thought to be tectonic rather than the result of crystal accumulation. No evidence was found for a gravity-differentiated sequence (from mafic at top to ultramafic at bottom) or for layering due to gravity settling of crystals from magma.

The basaltic volcanics and associated limestones which crop out adjacent to the Belt may represent the oceanic crust which covered the plutonic rocks before their uplift. Gabbro intrudes the basaltic volcanics in places. Some of the limestone is Upper Cretaceous.

Emplacement of the northern half of the Belt may be explained by horizontal movement from east to west of a segment of oceanic mantle, which was forced upward by collision with the sialic core of eastern Papua - New Guinea. The south-eastern half of the Belt has a completely different tectonic style: blocks of peridotite are emerging vertically, like salt diapirs, through the volcanic and alluvial cover. Horizontal subcrustal forces may be the cause of these anomalous tectonics.

The Mount Dayman-Mount Orian mountain block consists of moderately schistose basaltic volcanics and minor associated limestones, some of which are of Upper Cretaceous age.

The Goropu Mountains (Mount Suckling block) consist of chloritic, epidotic, and minor calcic schists which may be the metamorphosed equivalent of the Dayman-Orian volcanics and limestones. The "Goropu Metamorphics", as these are known, thus appear to be mostly simatic, and should not necessarily be equated with the sialic Owen Stanley Metamorphics.

Diorite which intrudes gabbro and volcanics at Kui in the Bowutu Mountains has been dated by A.W. Webb at 55 ± 2 m.y.

Nickel sulphides occur in a sulphide-bearing shear-zone in altered peridotite surrounded by gabbro, on Doriri Creek a tributary of the Adau River (9°50'S., 148°43'E.). A chip sample assayed 2.6 percent nickel over a 25 foot width (J.R. Beevers, Laboratory Report No. 25). The nickel mineral is violarite, $(Ni, Fe)_3S_4$, identified by J.A. McDonald. R.P. Macnab found nickel

* Formerly "Papuan Basic Belt" or "Papuan Ultrabasic Belt".

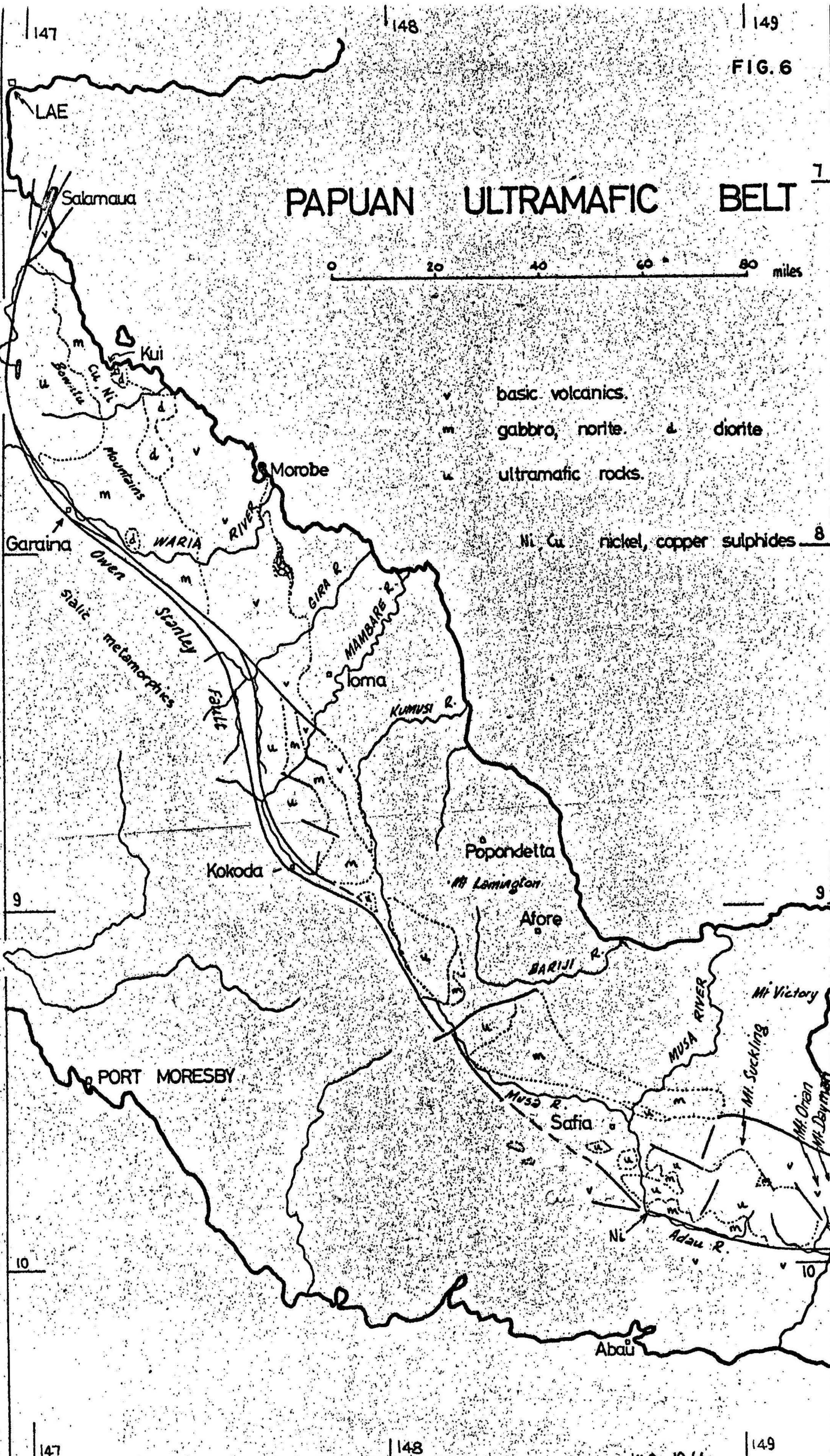

PAPUAN ULTRAMAFIC BELT
0 20 40 60 80 miles
v basic volcanics.
m gabbro, norite. d diorite
u ultramafic rocks.
Ni Cu nickel, copper sulphides
147
148
149
7
8
9
10
LAE
Salamaua
Kui
Morobe
Garaina
Mountains
WARIA RIVER
Owen Stanley Fault
sialic metamorphics
GIRA R.
MAMBARE R.
Ioma
KUMUSI R.
Popondetta
Mt Lamington
Kokoda
Afore
BARIJI R.
MUSA RIVER
Mt Victory
Mt Suckling
Mt Orian
Mt Dayman
PORT MORESBY
Musa R.
Safia
Ni
Adau R.
Abau

FIG. 6

sulphide boulders (heazlewoodite, pentlandite) in the Domara River drainage seven miles to the west. Conzinc Riotinto of Australia are investigating the prospect.

Copper and nickel sulphide indications have been found over a large part of the eastern Bowutu Mountains. Mineralization is commonly concentrated in and around basaltic xenoliths in gabbro. Chalcopyrite, pyrrhotite, and pyrite occur in basalt boulders in the Sakia River north-west of Morobe patrol post. These boulders are 3 to 4 feet across, and contain 10 to 40 percent of sulphide. Some of the basalt is brecciated, and the matrix of the breccia is rich in sulphides. The type of mineralization is similar to that in the Waria River, Papua, where chalcopyrite and other sulphides fill fractures and joints in basalt, and gossan was found over an area measuring 200 by 40 feet.

Sulphide-bearing boulders were also found in the middle and lower reaches of the Paiawa, Saia, and Buso Rivers, where pyrite, pyrrhotite, and chalcopyrite occur in fine-grained dolerite xenoliths in gabbro, in quartz diorite, and in quartz veins, some of which also contain galena.

The tremendous potential of the helicopter for mapping in this difficult terrain was only fully recognised as the season progressed. Many days of unproductive walking were saved, and work which had been scheduled for 1967 was completed. A good pilot-geologist relationship is essential for this sort of work; in this we were fortunate to have the skill and composure of Captain Evans of Crowley Airways.

Davies was in the Territory for six weeks in January-February, and from mid-April to the end of November. He spent 24 weeks in the field, and took regular field breaks in Port Moresby (one week each month) to prepare maps, and draw up reports, etc..

CAPE YORK, QUEENSLAND

Between 22nd May and 10th October, 1966, the Cape York party mapped at 1:250,000 scale the igneous and metamorphic rocks of the Walsh, Hann River, and Ebagoola 1:250,000 Sheet areas, in the southern part of the Cape York Peninsula, between latitudes 14° and 17°S. The party was composed of D. Palfreyman, I. Pontifex, D. Trail, W. Whitaker (Geological Survey of Queensland), and W. Willmott, together with a camp manager, draftsman, mechanic, cook, leading hand, and four field hands.

In the southern part of the area mapped (Fig. 7), the main outcrop of metamorphic and igneous rocks is a sub-circular inlier about 30 miles across, informally named the Yambo inlier. This occupies the north-east corner of the Walsh 1:250,000 Sheet area and the south-east corner of the Hann River 1:250,000 Sheet area, and extends a short distance onto the Mossmann and Cooktown 1:250,000 Sheet areas.

In the northern half of the Hann River and in the Ebagoola 1:250,000 Sheet areas, igneous and metamorphic rocks are exposed in a broad north-trending belt, about 40 miles wide, which continues northwards into the Coen 1:250,000 Sheet area. The southern end of this belt is separated from the Yambo inlier by Mesozoic sediments.

REGIONAL GEOLOGY

Yambo inlier

The inlier is bounded on its eastern side by the Palaeozoic sediments of the Chillagoe Formation, which are separated from it by the Palmerville Fault. Coarse-grained Mesozoic sandstone forms the northern and north-western boundaries of the inlier, and fine-grained Mesozoic sediments form its south-western and southern boundaries.

Biotite-quartz-feldspar gneiss interbanded with quartzite and amphibolite forms a belt several miles wide along the eastern boundary of the inlier. Another north-trending belt of biotite-quartz-feldspar gneiss and schist occupies the central part of the inlier; it does not contain regular and concordant bands of amphibolite, and appears to be less intensely deformed and metamorphosed than the gneiss in the east.

Sillimanite-muscovite-quartz schist interbanded with quartzite forms bodies, up to 8 miles across, in both belts of biotite-quartz-feldspar gneiss. Muscovite-bearing quartz-feldspar schists and gneisses are in places associated with biotite-quartz-feldspar gneiss.

Small dykes of doleritic rock are common in places throughout the inlier, and in the central belt of biotite-quartz-feldspar gneiss and schist, irregular masses of dolerite or amphibolite range up to a few miles in width. All these rocks are composed of roughly equal amounts of feldspar and dark mineral, either amphibole or pyroxene.

An elongate body of muscovite-biotite granite runs through the inlier from north to south, and separates the eastern and central outcrops of biotite-quartz-feldspar gneiss. The granite is a light grey, medium-grained, and even-grained rock, with a faint foliation in places. Along its eastern margin it grades into biotite-quartz-feldspar gneiss; its western margin is sharp, and is partly defined by a zone of aplite and pegmatite.

Biotite-muscovite granite forms a large, irregular body occupying much of the north-western quarter of the inlier. The granite is light grey, medium-grained to coarse-grained, and porphyritic, and contains variable proportions of phenocrysts of potash feldspar and of muscovite spotted with biotite. Smaller bodies of similar granite intrude biotite-quartz-feldspar gneiss and sillimanite-muscovite-quartz-schist.

Muscovite granite, generally light grey and coarse-grained, forms a body 1 mile across on the western boundary of the inlier, and brecciated muscovite granite is associated with fine-grained acid igneous rocks, possibly of Permian age, at the south end of the inlier.

The fine-grained acid igneous rocks form scattered dykes cutting gneisses, and closely similar tuffs and possible lavas of rhyolitic or trachytic composition extend along the Mitchell River from the Permian Nychum Volcanics of the adjacent Mossman 1:250,000 Sheet area.

Northern belt

The northern belt of metamorphic and igneous rocks, up to 50 miles wide, extends from the centre of the Hann River 1:250,000 Sheet area northwards for 100 miles to the northern boundary of the Ebagoola 1:250,000 Sheet area, and probably continues over 100 miles farther north to Temple Bay, north of Iron Range.

A large body of granite, over 100 miles long and between 5 and 25 miles across, forms the bulk of the eastern part of the belt. The western part is composed predominantly of mica schist. Bodies of sillimanite-bearing schist and quartzite, several miles long, are common in the northern part of the belt and on the eastern margin of the granite.

The belt is bounded on the west and south by sandstone and siltstone, part of which has been mapped as Cretaceous by Lucas (de Keyser and Lucas, 1965). On the east the belt is bounded by poorly consolidated sediments, whose age may be Quaternary.

The granite is predominantly muscovite-biotite granite, massive, medium-grained to coarse-grained, and even-grained. In places muscovite is the more abundant mica. Porphyritic phases, containing phenocrysts of feldspar or blocky intergrowths of quartz and feldspar, occur in places near the margin of the granite. Garnet-muscovite granite-pegmatite occurs in the granite and in schists in contact with it, and may also be concentrated near the margin of the granite body.

Within this muscovite-biotite granite a large body of biotite granite and hornblende-biotite granite extends for 30 miles along the trend of the main granite body. The contact between the muscovite-bearing granite and the other granite has not been observed, but is probably sharp.

Near the northern boundary of the Ebagoola Sheet area shearing is common in the eastern part of the granite body. The shear-zones trend northwest, and the granite is mylonitised in places.

The area occupied by granite also contains many acid or intermediate dykes, mostly no more than 20 feet thick, and a few hundred feet long. The dyke rocks are generally very fine-grained; some contain small feldspar phenocrysts. A few dykes of microdiorite may be related to a circular mass of microdiorite, a few miles across, which crops out among (?)Quaternary sediments a few miles east of the margin of the main granite area.

In the northern part of the Hann River 1:250,000 Sheet area several bodies of granite, up to a few miles across, intrude mica schist. They are generally muscovite-biotite granite or biotite granite; their contacts with the schist are sharp, and most are bordered by a zone up to half a mile wide in which reefs of milky quartz abound and the schist is silicified in places.

The mica schist which forms the bulk of the western part of the belt, is predominantly muscovite-quartz schist; biotite and graphite are common or abundant in many places. In the south-western part of the belt, the mica schist is coarse-grained and commonly gneissic within a few miles of its contact with the main granite body. Towards the western margin of the belt, the grain-size of the schist diminishes, and fine-grained muscovite-quartz schists are associated with slaty and phyllitic rocks in places.

In these fine-grained schists, thick bands of actinolite green-schist outline complex large-scale folds, up to several miles long, and a north-trending belt about 4 miles wide within the fine-grained schists is composed of quartzite, phyllite, and cleaved indurated siltstone and shale. Andalusite-bearing schists occur on either side of this 4-mile-wide belt. Knots of possible cordierite occur in many places in the mica schists.

Sillimanite-bearing schist and quartzite form elongated bodies several miles long within the granite in the northern part of the Ebagoola 1:250,000 Sheet area. Sillimanite-bearing schist and quartzite also bound at least part of the poorly exposed eastern margin of the main granite body, and a body of these rocks, 35 miles long, occurs within the mica schist in the central western part of the belt.

A schist body, 25 miles long, which runs northwards in the granite from the central part of the Ebagoola 1:250,000 Sheet area, is composed predominantly of quartz-muscovite-sillimanite schist with minor biotite-muscovite-quartz-feldspar schist, and contains no quartzite.

Bands of amphibolite occur within the sillimanite-bearing schist and quartzite at the eastern boundary of the main granite mass, in the central part of the Ebagoola 1:250,000 Sheet area.

Mesozoic sediments

Sediments mapped as Mesozoic by Lucas (de Keyser and Lucas, 1965) surround the Yambo Inlier, and extend northwards along the western boundary of the northern belt. Sandstone bounds the northern and north-western sides of the Yambo inlier and caps mesas within it. Siltstone and minor mudstone and fine-grained sandstone bound the south-western and southern sides of the inlier.

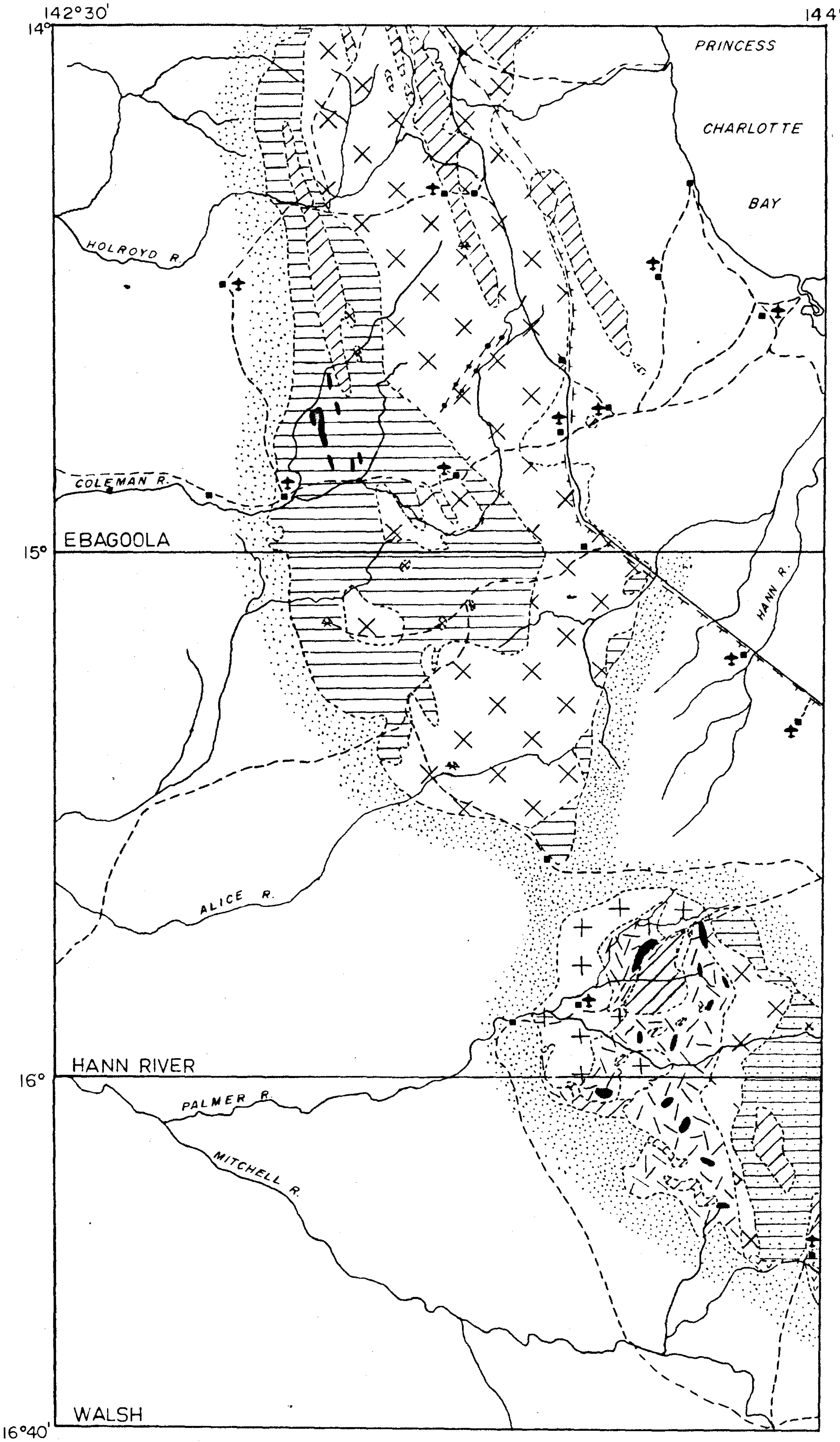
Sandstone, with minor siltstone in places, bounds the south-eastern, southern, and south-western sides of the northern belt. Northwards along the western margin of the belt sandstone continues to overlie the schists, but siltstone and mudstone predominate in sediments overlying the basal sandstone, which is only 40 feet thick near the northern boundary of the Ebagoola 1:250,000 Sheet area.

Glauconite occurs in a thin bed of siltstone near the northern margin of the Ebagoola Sheet area, and possible marine lamellibranchs occur in mudstone at the southern end of the Yambo inlier. Current-bedding in sandstone at the northern end of the Yambo inlier suggests a fluviatile origin.

STRUCTURE

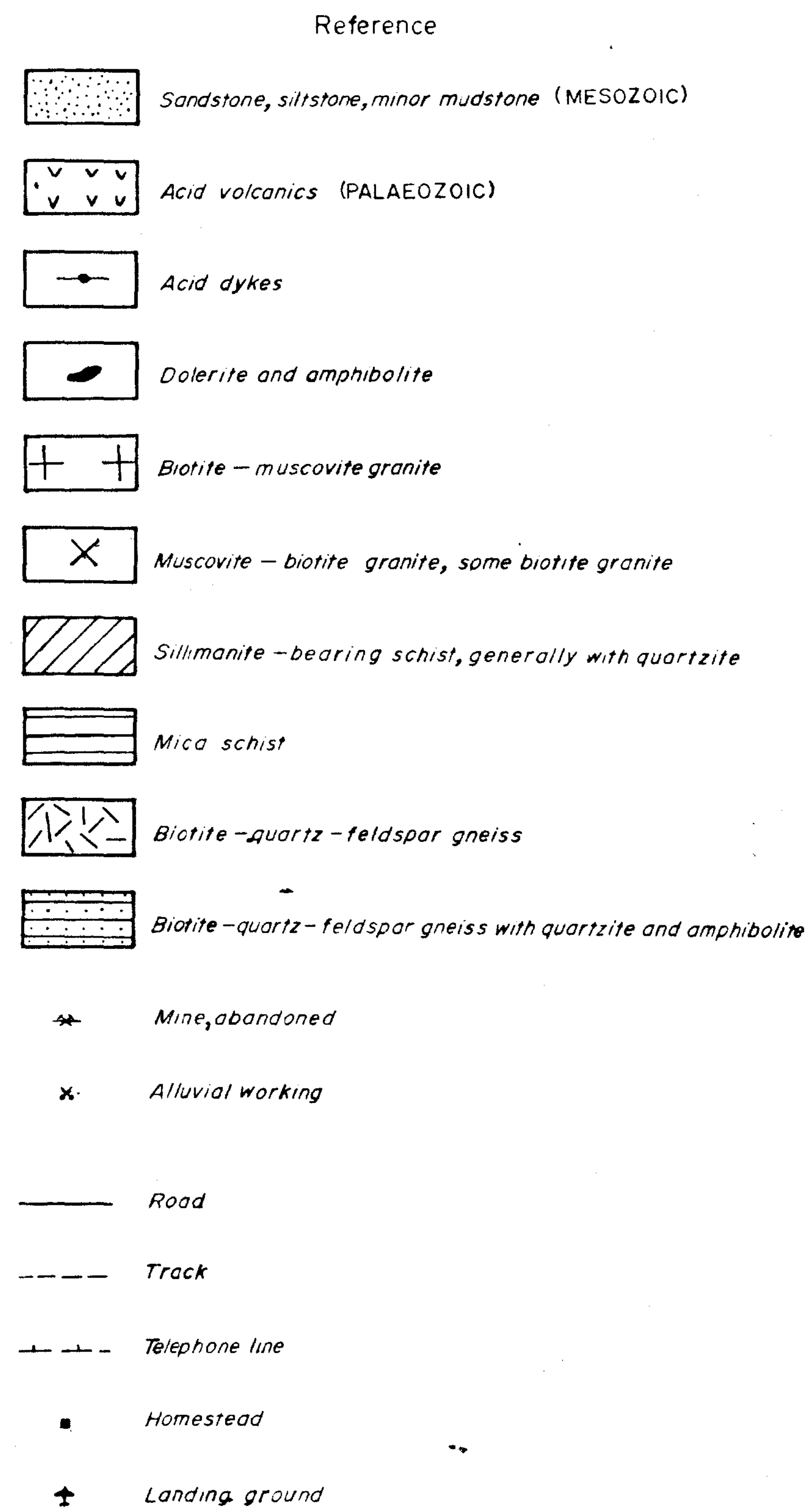
Small-scale folds are surprisingly scarce in all metamorphic rocks mapped. In the Yambo inlier sillimanite-bearing schist and dolerite appear to outline broad synforms with north-east trending axes, and the granites may occupy complementary antiforms. Tight, large-scale folds in schists on the boundary between the Hann River and Ebagoola 1:250,000 Sheet areas have axial planes which parallel the regional trend of schistosity. Broad folds south of these appear to be related to bodies of intrusive granite, and deform the schistosity.

Few major or minor faults have been mapped. Faults partly outline some bodies of sillimanite-bearing schist in the Yambo inlier, and other faults disrupt folded schists near the boundary of the Hann River and Ebagoola 1:250,000 Sheet areas. North-west-trending shear-zones are prominent in granite in the north-eastern part of the northern belt.



Distribution of metamorphic and igneous rocks in the Walsh, Hann River, and Ebagoola 1:250,000 Sheet areas, Queensland

Scale 1:1,000,000



ECONOMIC GEOLOGY

Alluvial gold was formerly produced from the Palmer River, which roughly bisects the Yambo inlier, and reefs were worked for gold at the Alice goldfield and the Hamilton goldfield, in the Hann River and Ebagoola 1:250,000 Sheet areas, respectively. The source of the alluvial gold in the Palmer River is probably located on the adjoining Mossman 1:250,000 Sheet area. The gold-producing lodes in the Alice goldfield are quartz reefs in muscovite-biotite granite or in schists adjacent to the granite. The producing lodes of the Hamilton goldfield are quartz reefs or veins associated with acid dykes, or quartz reefs in schists near their contact with the main granite body.

Traces of arsenopyrite, pyrite, stibnite, and galena have been found mainly in mullock dumps in the goldfields.

Iron oxide minerals form a large proportion of some weathered sillimanite-bearing schists in the Yambo inlier, and lateritic ironstone deposits range up to several feet in thickness in the schists in the central western part of the northern belt.

Graphite is abundant in fine-grained schists in many places in the south-western part of the northern belt. Kaolinite forms the matrix of many fine-grained sandstones and siltstones overlying the schists of the south-western part of the northern belt.

Underground water is obtained from only a few shallow bores, mainly in weathered granite, in the igneous and metamorphic rocks mapped. Mesozoic sandstones between the Yambo inlier and the northern belt feed a few perennially flowing streams and numerous springs. A few small perennial springs occur in the escarpment along the eastern edge of the main granite body of the northern belt.

REFERENCE

DE KEYSER, F., and LUCAS, K.G., 1965 - Geological map, Hodgkinson and Laura Basins, Qld., Bur. Min. Resour. Aust., preliminary edition.

NORTH BOWEN PARTY (1965), QUEENSLAND

A.G.L. Paine, D.E. Clarke (G.S.Q.)

Paine and Clarke spent from 17th June until 10th July in the Proserpine 1:250,000 Sheet area. The purpose of the trip was twofold: to re-examine parts of the mainland area of the Proserpine Sheet in an attempt to solve stratigraphic problems associated with the different volcanic units, and to map systematically the islands of the Cumberland Group in the southern part of the Sheet area.

From 17th to 28th June A.R. Jensen accompanied Paine and Clarke on traverse in the southern half of the Proserpine Sheet area. The individual characteristics of the Devono-Carboniferous, Lower Permian, and Tertiary volcanic-sedimentary rocks were critically examined, and their boundaries and relationships were established in sufficient detail to enable a 1:250,000 scale map to be compiled.

From 2nd to 7th July Paine and Clarke chartered the launch "Ebb Tide" for geological work in the Cumberland Islands. The first full day was spent sampling around the coast of Pentecost Island in the Lindeman Group. Pentecost Island consists mainly of a massive body of grey, hydrothermally altered quartz-feldspar porphyry which is presumed to be intrusive. Attention had been drawn to the possible economic value of this body of rock by the discovery of abundant alunite ((K, Na) Al_3 $(OH)_6$ $(SO_4)_2$) in thin section, and the discovery, by mineragraphic and spectrographic methods, of copper (in digenite) in a specimen collected in 1965; this specimen was found to contain 0.13% Cu. Disseminated pyrite is abundant (3% in the specimen analysed for copper). Iron staining is ubiquitous, and minor copper staining is persistent around the entire coastline of the island, which measures about 0.8 mile by 0.5 mile. Twenty eight specimens were collected, and were later submitted to the BMR Laboratory for analysis for extractable K_2O/Na_2O (in alunite), Cu, Pb, Zn, Au, Ag, and Mo.

The rest of the trip was devoted to systematic mapping of the Cumberland Islands. These islands had been mapped by Ampol Exploration Ltd. in 1962. They are a group of small, steep islands (averaging about 2 miles across) forming an ill-defined north-west-trending chain, and consisting of volcanics and granite. Ampol concluded that they constitute a double chain of probably Tertiary volcanic centres and comagmatic granite. We differ from this view, and believe instead that the islands represent summits of a drowned and faulted mountain range whose geology is essentially the same as that of part of the nearby mainland, i.e., mainly Lower Permian, but possibly including some Mesozoic rocks. We can see no justification for regarding the separate islands as individual volcanic centres, a theory inherent in Ampol's interpretation.

That Mesozoic rocks exist in this region has not yet been proved, but is strongly supported by some recent isotopic dates, and also by the existence in places of rocks derived from a provenance of granite and of coal measures which are Lower Permian or younger. There can be little doubt that Mesozoic rocks exist in the region. Some preliminary isotopic age-determination results reveal that they are probably Lower Cretaceous. Without detailed and painstaking mapping it is possible for the most part only to guess at the extent of these probable Mesozoic rocks. This is due to the dense cover of vegetation, absence of mappable structures, similarity between rock-units, and strong faulting. It is hoped that isotopic dating and plant fossil determinations will be available before a decision has to be taken on the extent of the post-Permian rocks.

GEOCHEMICAL SAMPLING, BOWEN 1:250,000 SHEET AREA, QUEENSLAND

M.J. Kelly, A. Busuttil, A.R. McDonnell, and
W. Potts

This party, consisting entirely of wages hands, collected soil, rock, and stream-sediment samples in the eastern half of the Bowen 1:250,000 Sheet area, which adjoins the Ayr Sheet area, sampled in 1965. Severe early storms forced the party to break camp before sampling was completed, but only two rugged areas where access is extremely poor were left unsampled (Fig. 8). A chartered launch was used for collecting in coastal areas and adjacent islands. Two thousand nine hundred and ninety seven samples were collected; these comprised 2140 soil samples, 721 rock samples, and 136 stream sediment samples. These ~~have been~~ were sent to Amdel for analysis at intervals during the season; to date the results for the first batch only have been received.

All sample-localities were plotted on 1:85,000-scale aerial photographs, and later transferred to 1:93,000-scale compilations. Complete lists of all samples, together with grid references and comprehensive data on location, sample site, type of sample, etc., were sent to Canberra at regular intervals. On receipt in Canberra, these data were recorded on punched cards.

GEOCHEMICAL SAMPLING-CANBERRA 1:250,000 SHEET AREA

The Canberra Party collected geochemical samples from three areas - one immediately west of Brindabella, and the others 13 miles west, and 15 miles west-south-west of Brindabella. Twenty three rock samples, thirty four stream sediments, and three heavy mineral concentrates were collected. No anomalous areas were discovered.

Vacation students employed by the Branch were shown techniques of geochemical sampling. Three members of the Bowen Geochemical team were also trained in sampling methods.

REPORT WRITING

KATHERINE-DARWIN REGION - BULLETIN 82

P.R. Dunn, P.W. Crohn (B.P. Walpole, M.A. Randal)

The economic geology section of Bulletin 82, 'The geology of the Katherine-Darwin Region', was completed, checked, and issued separately as a record. The chapter on granites was rewritten, and the manuscript of the whole bulletin was passed through the editors hands, corrected, and typed. By the end of October the manuscript was ready for the printers.

The second edition of the Katherine-Darwin 1:500,000-scale map was edited, the topographic base has been fair drawn, and the geological plate was ready for fair drawing by the beginning of October.

CARPENTARIA PROJECT, N.T.

P.R. Dunn, H.G. Roberts, K.A. Plumb

The publication programme for the Carpentaria area of the Northern Territory is nearing completion. During the year the explanatory notes for Milingimbi, Mount Marumba, and Walhallow were issued. The only outstanding explanatory notes are Arnhem Bay-Gove and Blue Mud Bay-Port Langdon; their publication is held up because of delays in printing the coloured editions of the maps.

The 1:500,000 sheet of the Roper River area was published, and the paper proofs of the McArthur River Sheet were received. The Arnhem Land 1:500,000 Sheet has been fair-drawn, and is almost ready for the printer.

Of the two bulletins being prepared on the Carpentaria area, Part 2 on Arnhem Land is now the most advanced, and should be completed by December, 1966. Part 1, Roper River to the Queensland border, is only about two-thirds completed, and it is expected to be ready for the editors by the end of February, 1967.

BOUGAINVILLE, NEW GUINEA

D.H. Blake and Y. Miezitis

Bougainville and Buka Islands, the northernmost islands of the Solomon Group, were mapped in 1965. During 1966 a 1:250,000 geological map of the area was compiled, and the preliminary edition was published; the standard edition is now in press. The explanatory notes to accompany the map are with the editor.

A bulletin entitled 'Geology of Bougainville and Buka Islands, Territory of New Guinea' has been written, and will be ready for press before the end of the year. A Record of the same title was issued in June.

CHARTERS TOWERS - BOWEN AREA, QUEENSLAND

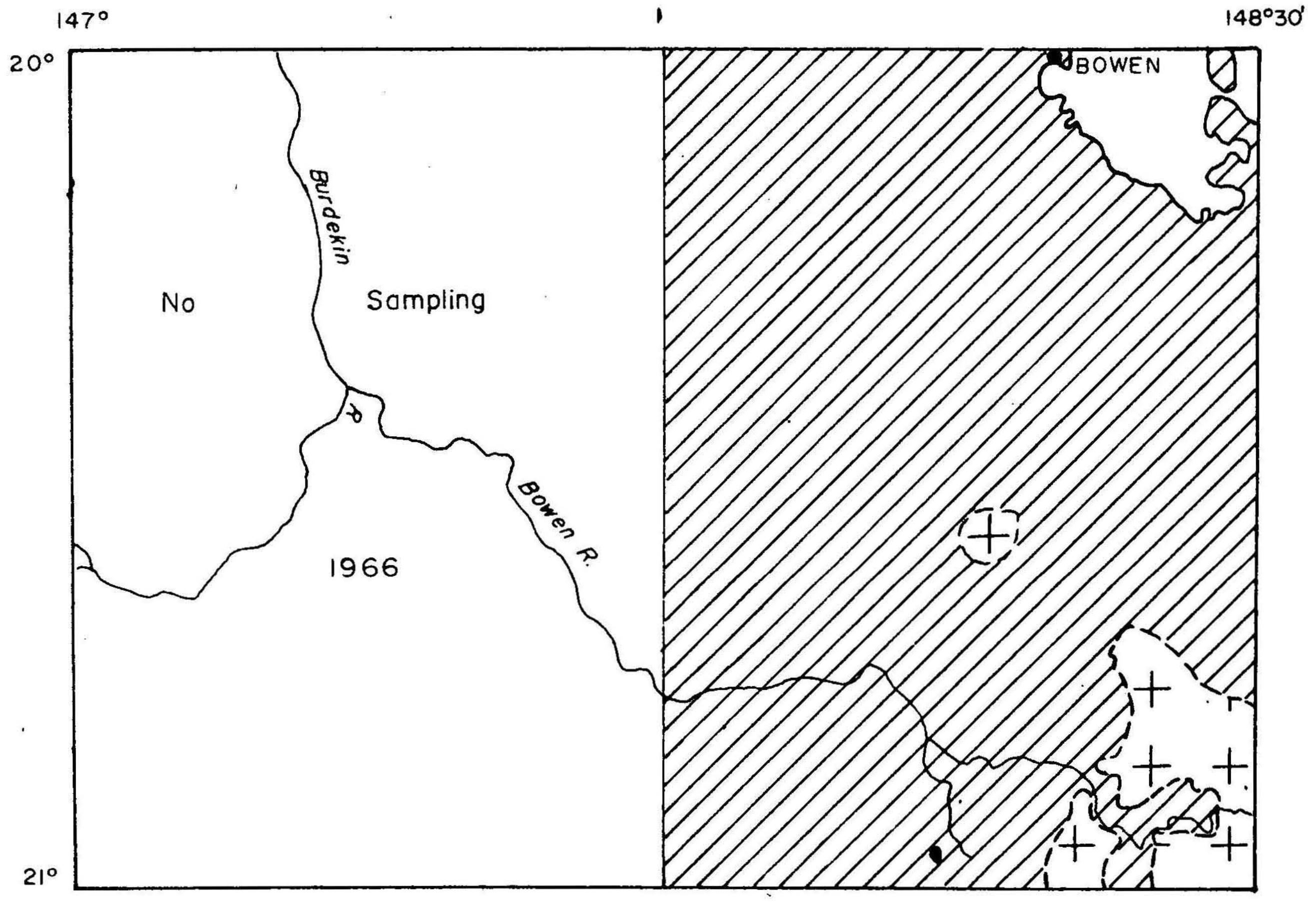
A.G.L. Paine, D.E. Clarke (G.S.Q.), and C.M. Gregory

Work proceeded during 1966 on the compilation of maps and reports, as follows (see Fig. 9):

HUGHENDEN 1:250,000 Sheet area:

The north-eastern part of the sheet (mainly igneous and metamorphic rocks) was mapped in 1963. The Preliminary Edition of the map (including part of the Eromanga Basin, mapped by R.R. Vine and party) was printed in August, 1964. Vine does not expect to be ready to prepare his part of the Sheet for Standard Edition or to write the Explanatory Notes until February, 1967; our part of the work is shelved until then. Record 1965/93, 'The geology of the N.E. part of the Hughenden 1:250,000 Sheet area', was issued in Dec., 1965, and is now being edited for the Report Series.

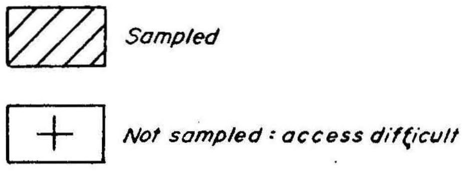
FIG. 8



GEOCHEMICAL SAMPLING —— 1966

BOWEN 1:250,000 SHEET AREA

Scale 1:1,000,000



TOWNSVILLE 1:250,000 Sheet area:

Mapping completed in 1963. Preliminary Edition printed 25/5/66. Explanatory Notes written by D.H. Wyatt (G.S.Q.). Both map and notes have been submitted to the editor for preparation for Standard Edition. Prints have been sent to the Queensland Chief Government Geologist for approval. Record 1965/159, "The Geology of the Townsville 1:250,000 Sheet area" was issued in July, 1966, and is being edited for the Report Series.

CHARTERS TOWERS 1:250,000 Sheet area:

Mapping completed in 1964. Preliminary Edition printed 19/7/66. Explanatory Notes written by D.E. Clarke (G.S.Q.). Preparation of map and explanatory notes for Standard Edition has been postponed until F. Olgers completes his Drummond Basin project in 1967. Results of 1966 work by D.E. Clarke in the Ravenswood area will also be incorporated. A record on the geology of the Sheet area has been prepared, and the draft is with the Supervisor.

AYR 1:250,000 Sheet area:

Mapping completed in 1964. Preliminary Edition (incorporating some changes arising out of field work in the Bowen and Proserpine Sheet areas in 1965) printed 3/5/66. Explanatory Notes written by C.M. Gregory. Map and notes handed to editor for Standard Edition 2/6/66. Record 1966/68, "The geology of the Ayr 1:250,000 Sheet area" was issued in August, 1966, and is now being edited for the Report Series.

BOWEN 1:250,000 Sheet area:

Sedimentary Section mapped the southern half of the Sheet area in 1961. Mapping of the northern half and re-examination of parts of the southern half were completed in 1965. Compilation of the northern half of the map and re-compilation of the southern half are well advanced, and it is hoped that the map can be submitted for Preliminary Edition printing before the end of the year. A record on the geology of the northern half of the Sheet area is being prepared. This record will incorporate an account of some amendments to the geology of the southern half of the sheet as mapped in 1961.

PROSERPINE 1:250,000 Sheet area:

Sedimentary Section (A.R. Jensen) mapped the southern half of the Sheet area in 1962. Mapping of the northern half of the Sheet area (and some re-examination of the southern half) was carried out by the North Bowen Party in 1965. However by the end of the field season some important problems still remained to be solved, the major ones being the relationship between the Devono-Carboniferous and Permian volcanics, between the Permian volcanics and the Permian coal measures, and whether or not the area of outcrop of the Permian volcanics contains any Mesozoic or Tertiary volcanics. Accordingly Paine and Clarke revisited the area in June and July, 1966.

Isotopic age-determinations (carried out by A.W. Webb at A.N.U.) are steadily coming to hand, and are almost invariably of great value and interest. The limits of a Lower Cretaceous adamellite batholith, mapped at present as part of the Urannah Complex, have been extended by a sixth 123-125 million years age to cover an area of 25 x 15 miles in the ranges west of Proserpine. There is some evidence to suggest that there may have been two distinct periods of igneous intrusion in the Lower Cretaceous: an earlier period of perhaps mesozonal emplacement of relatively large bodies of normal granitic to granodioritic composition, followed by a period (at approximately 115-110 million years) characterised by the emplacement of epizonal sub-alkaline complexes, one of which is associated with volcanics and cone-sheets.

Rhyolitic plugs hitherto mapped as a late component of the Lower Permian Lizzie Creek Volcanics have been shown to be Upper Permian (230 or 245 million years, depending on which of the two half-lives of rubidium is used).

GEOCHEMICAL SAMPLING, AYR 1:250,000 SHEET AREA, QUEENSLAND

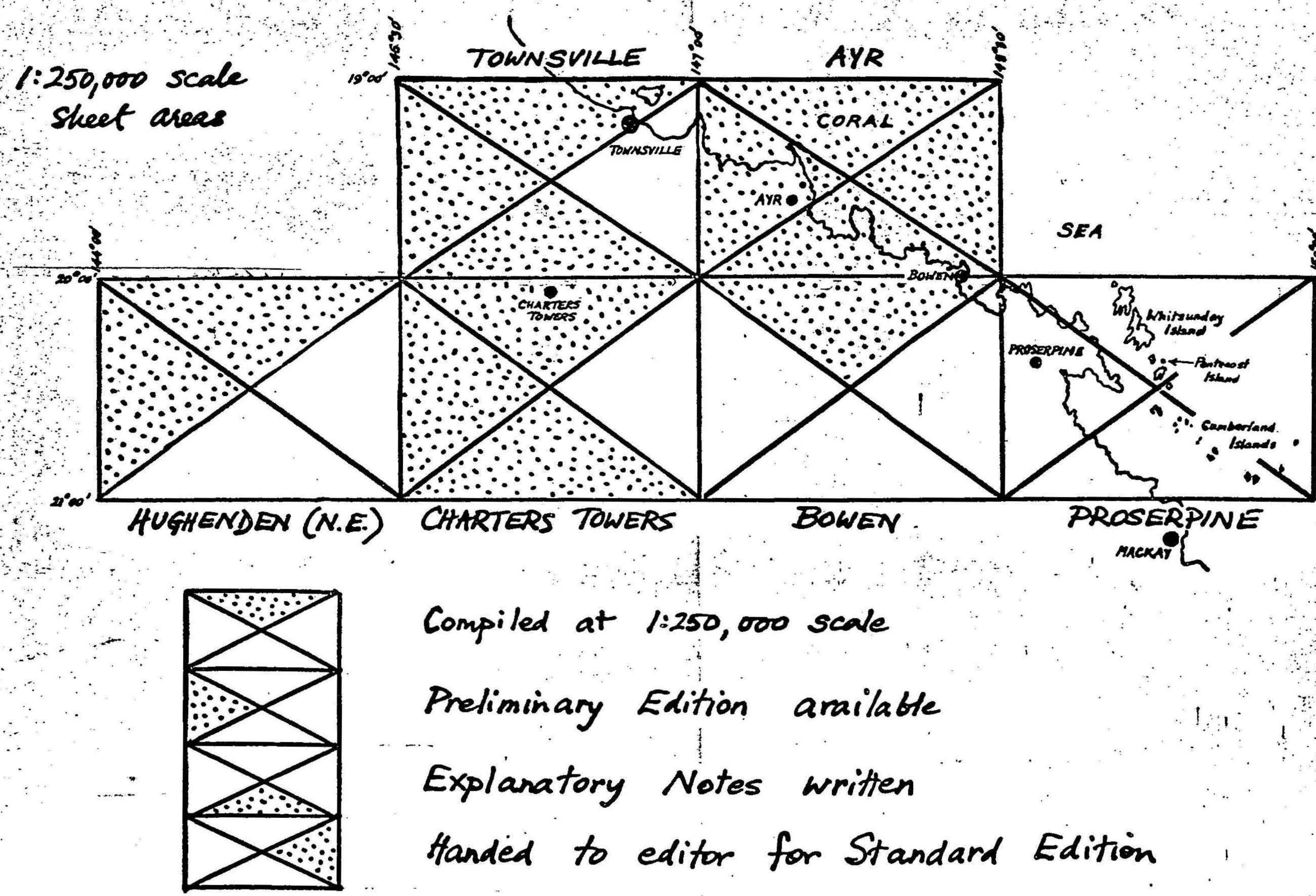
N.J. Marshall

The report on this work is at present in draft form, and is being edited within the Section. It will first be produced as a Record, and later as a Report. The maps are with the drafting office at present. Marshall has taken a position as geochemist with Australian Selection Pty Ltd, which is at present drilling in an area where samples containing anomalously high Mo were collected by our 1965 party.

FIG. 9

CHARTERS TOWERS REGION, QUEENSLAND

PROGRESS OF MAP COMPILATION



A.G.L. Paine
13th October, 1966

DETAILED PROJECTS

FIELD WORK

DARWIN URANIUM GROUP

C.E. Prichard, D.O. Shatwell, Y. Miezitis, D. Semple
W. Wahlan (Colombo Plan Student, J. Eftekharnejad (United Nations Fellow)

During 1966 prospecting for uranium and basemetal deposits by the Darwin Uranium Group continued in the Rum Jungle District. Compilation and assessment of existing geological and geochemical data were continued.

Geochemical prospecting by auger drilling (37, 133 feet to 30th September, 1966) was carried out in the Gould and Woodcutters areas to cover in more detail and extend the areas surveyed in 1965.

In the Gould area copper, nickel, cobalt, and radiometric anomalies were delineated at Waterhouse No 2 prospect. They are localised in carbonaceous shale close to its contact with hematitic quartzite breccia. Copper ranges up to 3000 ppm, and radiometric anomalies up to .03 mR/Hr in weathered rock. Several minor geochemical anomalies were also found.

At Woodcutters detailed auger drilling is in progress to examine radiometric and geochemical anomalies discovered in 1965. Auger cuttings are being analysed for copper, lead, zinc, cobalt, and nickel; to date no results have been received.

Exploratory diamond drilling is being carried out at Woodcutters - three holes have been completed, and five are in progress. One diamond drill hole was completed at Mount Minza, and another at Coomalie Gap West.

A summary of diamond drilling results is given in Table 2.

Compilation of Data on the Rum Jungle Area

Two geologists and one draftsman have been engaged during most of 1966 on compilation and synthesis of geological, geochemical, and radiometric data from the Hundred of Goyder. This information is being plotted on standardised sheets at a scale of 1" to 400 feet and, in areas of interest, at 1" to 100 feet.

The progress of compilation on the various sheets is as follows:

Sheets E31-32, E41-42, E51-52

These comprise the Mt. Fitch area, investigated in 1963 by Pritchard and French. All available geological, geochemical, and radiometric data from this survey have been compiled. In addition, geological (auger and diamond drilling, surface mapping) information from T.E.P. Ltd, have been plotted, but geochemical and radiometric data from this source have not yet been plotted.

Some detailed plans at 100 ft to 1 inch have been drawn showing geology and mineralization at the Mt. Fitch Prospect itself (Tamblyn's Shaft area). There is some suggestion that uranium mineralization may be controlled by ENE trending fold axes.

Sheets E62, E72

Compilation of data on E62 and E72 is about 80 percent complete. These sheets comprise the Dolerite Ridge-West Finniss Area (E62), and "Area 55" (E72). The sources of data were chiefly BMR auger drilling and TEP diamond drilling. The significance of a pyrrhotite lens at Dolerite Ridge will be evaluated.

Sheets E53, E54, E63 and E73 (The Embayment Area)

Because of known mineralization in the Embayment Area, compilation of data on these sheets (especially E63) involved much more work than on most of the other sheets. As well as plotting and interpreting existing data, some field investigations have been made in areas where the geology is in doubt.

Two longitudinal projections through the Embayment Area (showing geology and mineralization) have been compiled to facilitate interpretation of the various maps. About one hundred diamond drill sections have been drawn.

Compilation in the Embayment area has confirmed mineralization in depth between Whites' Open Cut and Brown's Orebody. Sub-ore grade mineralization is known to exist beneath and west of Whites' Open Cut. Sporadic uranium mineralization has been encountered in T.E.P. diamond drill holes at the Acacia Gap Tongue - Coomalie Dolomite contact.

Typing

To date, 592 T.E.P. diamond drill logs, 55 A.M.& S.diamond drill logs, and 321 drill hole assays have been typed.

All handwritten T.E.P. and A.M. & S logs have been typed, leaving 209 typed logs to be zeroxed later.

About 40 percent of T.E.P. & A.M. & S.diamond drill assays have been typed. About 327 churn drill logs remain to be typed.

TABLE 2

DIAMOND DRILLING RESULTS, RUM JUNGLE EAST AND MOUNT MINZA AREAS

Hole No.	Collar	Direction	Depression	Area	Grid	Depth	Target	Stratigraphic Summary
65/2	412S 16E	Grid W	-50°	Coomalie Gap West	Rum Jungle East	424 ft	Coomalie Dolomite	0-198' Golden Dyke Formation 198'-324' Transition 324'-424' Coomalie Dolomite
66/1	208S 42E	Grid W	-50°	Woodcutters	Rum Jungle East	474 ft	Gossan at 208S, 40E	Golden Dyke Formation throughout; lode 404'-440; From 422'-437' lode averages 0.22%Pb, 7.9%Zn, 0.9oz. Ag.
66/2	204S 38E	Grid E	-60°	Woodcutters	Rum Jungle East	352 ft	Quartz vein at 204S, 40E	Golden Dyke Formation throughout; pyritic lode 280'-299'; weathered; 277'-283', 5.15% Pb, and 0.77% Zn.
66/3	220S 33E	Grid E	-60°	Woodcutters	Rum Jungle East	646½ ft	Geochemical peak at 220S, 38E	Golden Dyke Formation throughout; Ag-Pb-Zn-pyrite lode 508'10" - 587'6" averages over 78'8" - 7.7% Pb, 20.9% Zn, 7.7 oz. Ag.
66/4	237S 460E	Grid E	-60°	Mt. Minza	T.E.P. Mine	422'	Slingram anomaly at 237S, 462E	Golden Dyke Formation throughout; no anomalous radioactivity.
66/5	192S 37E	Grid E	-60°	Woodcutters	Rum Jungle East	In progress	Northern extension of lead anomaly	Ausdrill Pty Ltd. 26/10/66 at 425 ft; chalcopyrite-sphalerite-pyrite-dolomite lode from 373-420 ft.
66/6	216S 35E	Grid E	-60°	Woodcutters	Rum Jungle East	In progress	Northern extension of mineralization intersected by 66/3	Mines Branch. 26/10/66 at 490 ft.
66/7	220S 33E	Grid E	-60°	Woodcutters	Rum Jungle East	In progress	Southern extension of mineralization intersected by 66/3	Mines Branch. 26/10/66 at 452 ft.
66/8	168S 35E	Grid E	-60°	Woodcutters	Rum Jungle East	In progress	Copper anomaly at 168S 38E	Ausdrill Pty Ltd. 26/10/66 at 219 ft.
66/9	120S 32E	Grid E	-60°	Woodcutters	Rum Jungle East	In progress	Uranium, lead, and zinc anomaly	Ausdrill Pty Ltd. 26/10/66 at 120 ft.

TABLE 3

Progress of Compilation, Hundred of Goyder

Sheet No	Geology	Geochemistry	Radiometric
E31	80%	60%	60%
E32	80%	60%	60%
E41	80%	60%	60%
E42	80%	60%	80%
E51	80%	60%	60%
E52	80%	60%	60%
E62	80%	80%	80%
E63	90%	80%	80%
E63 - 3	80%	-	-
4	80%	-	-
5	80%	-	-
6	80%	-	-
7	80%	-	-
8	80%	-	-
9	80%	-	-
10	80%	-	-
E53	70%	90%	90%
E54	70%	90%	90%
E72	90%	100%	100%
E73	30%	90%	90%
E81	10%	10%	10%
E82	15%	15%	15%
E83	50%	100%	100%
E93	20%	20%	-
E94	20%	50%	-

HERBERTON-MOUNT GARNET AREA, QUEENSLAND

D.H. Blake (B.M.R.), R.M. Tucker (G.S.Q.)

During the 1966 field season the mapping of the Herberton One Mile Sheet area was completed, and the southerly-adjacent Mount Garnet one-mile area was briefly examined in order to correlate the geology of both areas. Particular attention was paid to field relationships of the different rock units. This work was a continuation of the detailed mapping carried out in the area in 1962 (D.O. Zimmerman and party), 1963 (K.R. Yates), and 1964 (J.W. Smith and party).

TABLE 4

SUMMARY OF GEOLOGY, HERBERTON-MOUNT GARNET AREA

Cainozoic	(Alluvium and laterite (Atherton Basalt (with Herberton and Bradlaugh Deep leads)
	UNCONFORMITY
Middle to Upper Permian (?)	(Intrusion of leucogranite and hornblende-biotite granodiorite (Intrusion of biotite granite (Intrusion of diorite, dolerite, and granophyre
Lower Permian (?)	Walsh Bluff Volcanics
	UNCONFORMITY
Upper Carboniferous to Lower Permian	Intrusion of Elizabeth Creek Granite
Upper Carboniferous (?)	(Featherbed Volcanics (Nanyeta Volcanics (Glen Gordon Volcanics
	(UNCONFORMITY ?)
Middle Carboniferous	Silver Valley Conglomerate
	UNCONFORMITY
Silurian to	(Hodgkinson Formation (Mount Garnet Formation
	UNCONFORMITY
Precambrian	Schist

The approximate distribution of the rock units is as shown on the Atherton 1:250,000 Sheet.

Precambrian rocks crop out over a small area at Mount Garnet. They consist principally of albite-muscovite-quartz schist, but also include some amphibolite and gneissic albite granite. On the west side of the outcrop schist is faulted against sediments of the Mount Garnet Formation, but other contacts are hidden beneath a cover of Cainozoic alluvium.

The Hodgkinson and Mount Garnet Formations are made up of similar rock types, and are thought to be of comparable age. The boundary between the two formations is therefore necessarily arbitrary. The Hodgkinson Formation crops out in the Herberton Sheet area and in the northern part of the Mount Garnet Sheet area, whereas the Mount Garnet Formation is restricted to the southern part of the Mount Garnet Sheet area.

The Hodgkinson Formation consists of alternating greywacke, shale and siltstone, massive sandstone, chert, conglomerate, and limestone. The Montalbion Sandstone and Ringrose Formation shown on the Atherton 1:250,000 map are not unconformable on the Hodgkinson Formation, as stated in the Atherton Explanatory Notes, but are conformably interbedded within the Hodgkinson Formation, and probably represent facies variations. The names 'Montalbion Sandstone' and 'Ringrose Formation' have therefore been discarded as formation names within the Herberton-Mount Garnet area. The Mount Garnet Formation, although essentially similar to the Hodgkinson Formation, contains a higher proportion of limestone and chert, and also includes some interbedded basalt lavas. The Hodgkinson and Mount Garnet Formations are intruded by the Elizabeth Creek Granite and other granites, and are unconformably overlain by late Palaeozoic acid volcanics. Both formations are extensively mineralized.

The Silver Valley Conglomerate consists of boulder and pebble conglomerate, purple and green tuffaceous sandstone, welded tuff, buff sandstone and siltstone, and carbonaceous beds: the latter contain Middle Carboniferous plant fossils. The formation, which is generally flat-lying, lies with strong unconformity on steeply dipping Hodgkinson beds, and is overlain, possibly conformably, by Glen Gordon Volcanics. It is intruded by an irregular body of porphyritic microdiorite. There is no mineralization associated with the Silver Valley Conglomerate.

The late Palaeozoic Featherbed, Nanyeta, and Glen Gordon Volcanics consist of pink and grey acid welded tuffs, lavas, and bedded tuffs. The Featherbed Volcanics are intruded by Elizabeth Creek Granite in the westerly adjacent Almaden One Mile Sheet area, and are the host rocks for the Pb and Ag mineralization near Stannary Hills in the Herberton Sheet area. Both the Nanyeta Volcanics and Glen Gordon Volcanics are intruded by Elizabeth Creek Granite, but neither formation is mineralized.

The Elizabeth Creek Granite, of Upper Carboniferous to Lower Permian age, is the source of the Sn, Cu, Pb, Ag, W, Zn, and Sb mineralization in the area. The granite is typically a pale pink leucocratic medium-grained rock containing less than 5% biotite, but coarser and finer varieties also occur. The finer-grained varieties contain feldspar and rounded quartz phenocrysts. Pegmatitic patches occur locally, and aplite veins are common. Greisens are widespread, and in many areas, as near Herberton and Watsonville, the granite is sericitised and chloritised; the mineralization within the granite is restricted to the areas of secondary alteration. The Elizabeth Creek Granite intrudes the Hodgkinson and Mount Garnet Formations and the Featherbed, Nanyeta, and Glen Gordon Volcanics. It is itself intruded by acid porphyries related to the Walsh Bluff Volcanics and by granodiorite and biotite granite near Bakerville and Stannary Hills.

The Walsh Bluff Volcanics crop out in two areas, one near Herberton (labelled as Glen Gordon Volcanics on the Atherton Map), and a larger area west of Atherton. The formation consists of grey porphyritic acid lavas, welded tuffs, bedded tuffs, and high level intrusive porphyries. The porphyries occur as dykes and more irregular intrusions cutting Elizabeth Creek Granite and Hodgkinson sediments near Watsonville and Herberton. The formation, which is unmineralized, unconformably overlies Hodgkinson sediments and weathered Elizabeth Creek Granite, and is intruded by granodiorite and biotite granite.

A number of relatively small bodies of diorite, dolerite, and granophyre occur in the area. Their contact relationships are generally obscure, but they are thought to be younger than the Elizabeth Creek Granite.

Cropping out north of Bakerville and Watsonville is a large mass of biotite granite ('Pgh' on the Atherton Map), intruding Elizabeth Creek Granite, Walsh Bluff Volcanics, and Hodgkinson sediments. This granite is a grey or, less commonly, pink, medium-grained rock in which the feldspar tends to be slightly porphyritic. Xenoliths are common locally; no gneissen or pegmatite have been found associated with this granite. The biotite granite is intruded near Bakerville by a hornblende-biotite granodiorite. Bodies of similar granodiorite crop out near Herberton and Mount Garnet, but their contact relationships are less clear. Exposures of the biotite granite and the hornblende biotite granodiorite, unlike those of Elizabeth Creek Granite, are characterised by spheroidal weathering.

A small body of leucogranite crops out west of Bakerville. It appears to intrude the hornblende-biotite granite.

The Cainozoic Atherton Basalt unconformably overlies the older rocks. Basalt flows of this formation have infilled many of the old river valleys on the eastern side of both sheets, and near Herberton have buried rich alluvial tin deposits (the Herberton and Bradlaugh Deep Leads). The only eruptive centre known in the area is Hypipamee crater, a diatreme from which only very minor amounts of basalt lapilli were explosively erupted; all the basalt flows appear to have been derived from shield volcanoes situated outside the mapped area.

Extensive areas of alluvium occur in the ~~southern part of the~~ Mount Garnet Sheet area, where most of the laterite also occurs. Scattered patches of alluvium occur elsewhere in the area. Much of the alluvium is stanniferous.

Structure

The Hodgkinson and Mount Garnet Formations have been tightly folded, and mostly dip at angles greater than 45°. The Silver Valley Conglomerate and the late Palaeozoic acid volcanics, on the other hand, are generally flat-lying or gently dipping. Faults are abundant, but few show large displacements.

A number of volcano-tectonic structures have been recognised in the area by C.D. Branch: these include the Garrumba volcanic complex and the Featherbed, Glen Gordon, and Nanyeta cauldron subsidence areas. The Gurrumba Volcanic complex, situated south-west of Emuford, was mapped in detail. It consists of a composite 'net-veined' ring dyke intruded into Elizabeth Creek Granite and enclosing Hodgkinson sediments, a mass of autobrecciated rhyolite, and a small body of diorite near the centre of the complex. The composite ring dyke is made up of granophyre, diorite, and a variety of hybrid rocks of intermediate compositions: the diorite mostly occurs as pillow-like masses enclosed in and veined by granophyre. The textures within the ring dyke indicate that the diorite and granophyre magmas were intruded more or less simultaneously.

Economic Geology

Over 2000 lode mines occur in the Mount Garnet and Herberton Sheet areas. Most of these are tin mines, but there are also many copper, wolfram, and silver-lead mines. The vast majority of the mines are small, and only a few have produced more than 1000 tons of concentrates. The mineralization appears to be entirely associated with the Elizabeth Creek Granite, and no mineralization has been found in rocks younger than this granite. The ore minerals show a broad zonal arrangement around the granite, an inner zone of tin passing outwards into successive zones of copper, lead and zinc, antimony, and calcite.

Many of the creek beds in the area have been worked for alluvial tin and wolfram, but extensive deposits have been found only near Mount Garnet, Innot Hot Springs, Stannary Hills, and Glenlinedale.

RAVENSWOOD 1-MILE AREA, QUEENSLAND

D.E. Clarke (G.S.Q.)

D.E. Clarke, of the Geological Survey of Queensland, spent three weeks with A.G.L. Paine, of the Bureau of Mineral Resources, in mid-June to mid-July completing the regional mapping of the Proserpine 1:250,000 Sheet area. From late July to September, with a field assistant and equipment provided by the Bureau of Mineral Resources, he carried out detailed mapping of two thirds of the Ravenswood One Mile Sheet area. The remaining third comprises areas of low economic potential; previous regional mapping of these areas in 1963/64 is considered adequate.

The sketch map (Fig. 10) shows the distribution of the major geological units; the geology is summarized in the stratigraphic table. Compilation is at 1:24,000 scale, and the final map will be at one-mile scale.

The Upper Silurian-Lower Devonian Ravenswood Granodiorite forms a complex batholith extending over 3500 square miles in the Townsville Hinterland. Wyatt, Paine, Clarke, and Harding (1965)[1] in defining the Ravenswood Granodiorite, considered that it was typically developed in the Ravenswood One Mile Sheet area.

During the present survey it has been possible to delineate six major and several minor sub-units within the Ravenswood Batholith. The oldest and most widespread sub-unit is a poorly exposed complex of similar granodiorite phases which has been mapped as Undivided Ravenswood Granodiorite. Each of the other five major sub-units corresponds to a distinct phase of the Batholith, and has been given a separate stratigraphic name in the sketch map.

Results of the mapping may be summarized as:-

(1) Considerable amendment to the 1:250,000 geological sheet.

(2) Establishment of a broad geological control for most of the mineralization.

(3) Accurate plotting and examination of the many mines and prospects within the area.

(4) The delineation of a belt of shearing trending east-west along the northern side of the Mosgardies Granite which contains gold mineralization in the Rochford area.

1. Wyatt, D.H., Paine, A.G.L., Clarke, D.E., and Harding, R.R., (1965): The Geology of the Townsville 1:250,000 sheet area, Queensland. Bur. Min. Resour. Aust. Rec. 1965/159 (unpubl.)

FIG.10

RAVENSWOOD 1 MILE

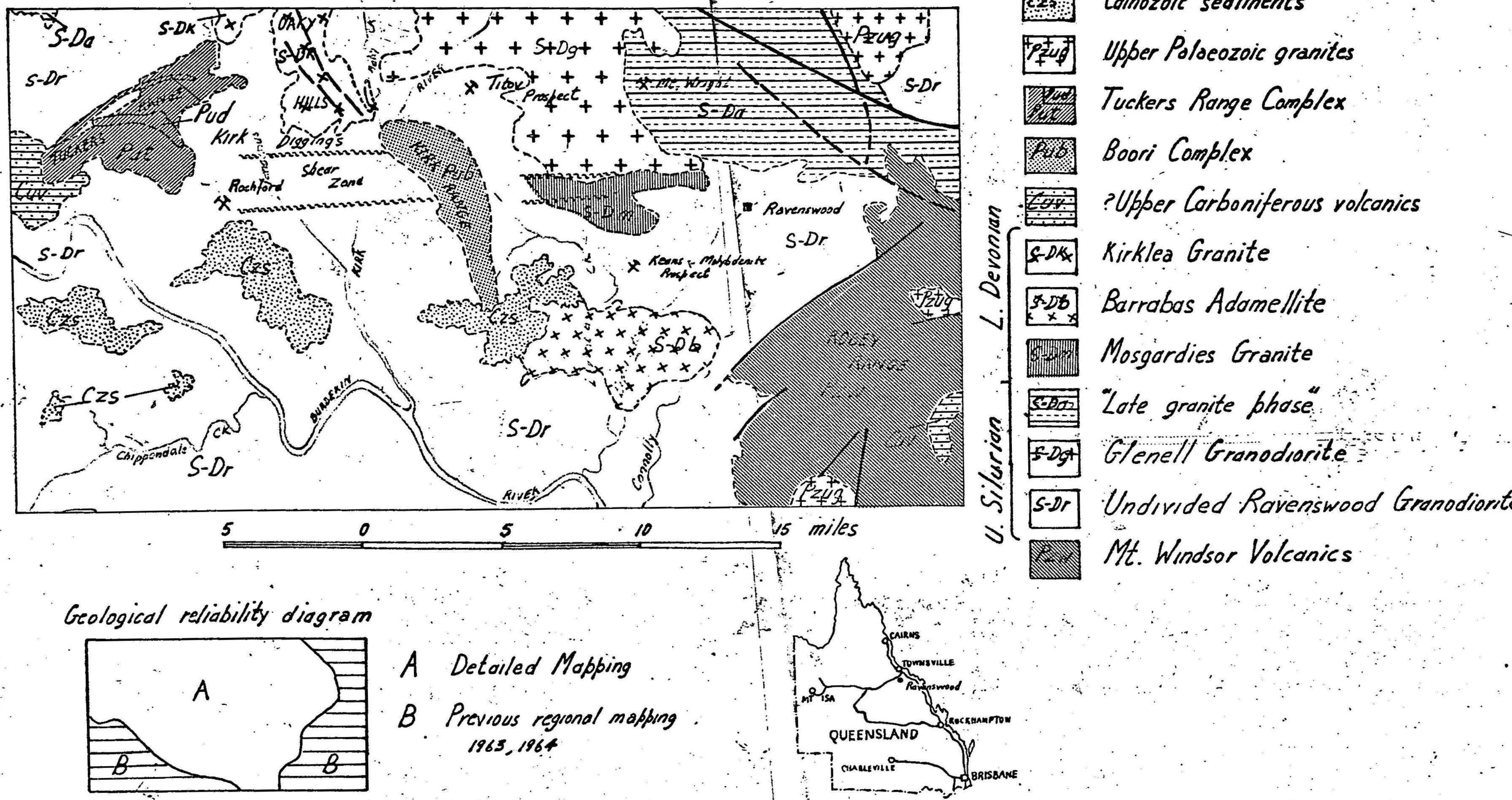


TABLE 5

STRATIGRAPHIC TABLE, RAVENSWOOD 1-MILE SHEET AREA

Symbol	Unit		Rock Type	Remarks
Czs	Cainozoic sediments		Sandstone, laterite	Includes Early Tertiary and Pliocene-Pleistocene sediments. Minor alluvial gold.
Pzug	Late Palaeozoic granites		Granodiorite, adamellite	Epizonal stocks; previously mapped 1963/64. No associated mineralization.
Put, Pud	Tuckers Range Complex		Granodiorite, quartz diorite, diorite (Put); diorite; gabbro, quartz diorite (Pud)	An igneous complex which intrudes (?)Upper Carboniferous volcanics; minor associated mineralization.
Pub	Boori Complex		Granodiorite, quartz diorite, monzonite, diorite.	Igneous complex similar to Tuckers Range Complex; no obviously associated mineralization.
Cuv	(?) Upper Carboniferous volcanics		Andesite, rhyolite, acid pyroclastics	Intrude and overlie Ravenswood Granodiorite; minor mineralization.
S-Dk	U. Silurian - L. Devonian Ravenswood Granodiorite	Kirklea Granite	Biotite granite	Au, Cu mineralization at margins.
S-Db		Barrabas Adamellite	Biotite adamellite granodiorite.	Associated Mo, Cu, Au mineralization.
S-Dm		Mosgardies Granite	Biotite granite, adamellite	Associated minor Au, Cu, (?)Mo mineralization.
S-Dg		Glenell Granodiorite	Granodiorite	Possible source of Mo, Cu, Au mineralization at Titov Prospect
S-Da		"Late granite phase"	Biotite granite, granophyre	Associated Au, Cu, Ag, Pb, Zn, Sb mineralization about Ravenswood.
S-Dr		Undivided Ravenswood Granodiorite	Granodiorite, some tonalite.	A complex of similar granodiorite phases and minor tonalite. Host of virtually all mineralization.
Pzw	Mt. Windsor Volcanics		Acid volcanics	Country rock of Ravenswood Batholith; minor mineralization near contacts.

(5) A better understanding of the complexity of the Ravenswood Batholith and its mineralization.

(6) Delineation of two Late Palaeozoic igneous complexes previously mapped as part of the Lower Palaeozoic Ravenswood Granodiorite.

(7) Collection of age determination samples from the various phases of the batholith and the late Palaeozoic complexes.

Mineralization within the Ravenswood Granodiorite can usually be directly related to one of the younger phases of the Granodiorite. The "corridor" between the Mosgardies Granite, the "late granite phase", the Barrabas Adamellite, and the Kirk Range is potentially the most heavily mineralized area.

The gold mineralization about Ravenswood with its complex sulphide ores is related to the "late granite phase" of the Ravenswood Granodiorite. At the Kirk diggings the Kirklea Granite is the probable source of mineralization.

A second episode of mineralization characterized by a simple molybdenum-copper-gold association is associated with the intrusion of the Barrabas adamellite. Most molybdenum mineralization appears to be restricted to the Ravenswood Granodiorite on the northern and eastern sides of the Barrabas Adamellite.

The copper-molybdenum mineralization at the Titov Prospect is not necessarily related to the Barrabas Adamellite. Here chalcopyrite and minor molybdenite are disseminated throughout the Undivided Ravenswood Granodiorite; reserves of subeconomic grade copper (0.25%) are considerable. A recent induced polarization survey has indicated an anomaly nearby, and drilling will be carried out in the Undivided Ravenswood Granodiorite adjacent to its contact with the younger Glenell Granodiorite; a geochemical anomaly corresponds with the I.P. anomaly.

The area mapped is currently being investigated by New Consolidated Gold Fields (A/sia) Pty. Ltd. and Anaconda Australia Inc., who hold current Authorities to Prospect over most of eastern and northern parts.

DIAMOND DRILLING, MOUNT GARNET AREA, QUEENSLAND

The joint B.M.R. - G.S.Q. diamond drilling programme in the Herberton-Mount Garnet area was completed on 16th April. One hole was drilled at the Extended Mine, Coolgarra, two at the Smith's Creek Mine, Nymbool, and one at the adjacent Adelaide Blocks Mine; the last two mines are held by Clutha Development. Total footage drilled was 1665 feet, the deepest hole being nearly 905 feet, at the Smith's Creek Mine. Tin assay values for all these holes were extremely low, generally less than 0.02 percent. In the deep hole at the Smith's Creek Mine a mineralized zone containing pyrrhotite, pyrite, and a trace of chalcopyrite was intersected from 828'3" to 856'10". However, this offers very little encouragement for further exploration, as the highest tin value was less than 0.1 percent.

All cores were logged and sampled by K.R. Levingston, District Geologist, Charters Towers.

DIAMOND DRILLING, DOBBYN, QUEENSLAND

W.B. Dallwitz made two brief visits to Dobbyn to log diamond drill core and to examine core logged by Australian Selection Pty Ltd and Ausminda. The diamond drilling was designed to test I.P. anomalies delineated by J.E.F. Gardener's party in 1964.

REPORT WRITING

HERBERTON-MOUNT GARNET AREA, QUEENSLAND

D.H. Blake, L.G. Cuttler (G.S.Q.)

After completing the Bougainville Bulletin and spending about two months in the Herberton-Mount Garnet area D.H. Blake began checking the Herberton and Mount Garnet 1-mile maps and making modifications and additions resulting from 1966 field work. Revision and expansion of the text of the preliminary draft of the Bulletin, written early in 1965, are also under way. L.G. Cuttler is preparing the sections on the Herberton and Bradlaugh Deep Leads.

LABORATORIES

CHEMISTRY

A.D. Haldane, J.R. Beevers, (N.W. Le Roux, N.J. Marshall)

Owing to an acute shortage of staff in the chemical laboratory and the policy of using AMDEL for routine chemical analysis the analytical work of the chemical laboratory has been reduced compared with that of previous years. The greater part of the work is now concerned with specific projects arising from other work in the Geological Branch and from analytical problems encountered in the laboratory. The following summary covers the main activities for the year.

Geochemical investigations - Because of initial difficulties encountered in setting up the direct-reading spectrograph part of the Mt. Isa geochemical investigations initiated by D.O. Zimmerman in 1963, and originally programmed for this instrument, was undertaken by the chemical laboratory. This involved some 900 auger samples from the Northern Leases (Pb/Zn type) and the Dawn/Bernborough area (Cu type) which were sampled to serve as orientation or type surveys for the remainder of approximately 1100 auger samples taken on traverses between the Northern Leases and Mt. Novitt. In addition 45 samples of ore, concentrates, and tailings were examined to determine the trace element assemblage associated with the ore. Comprehensive spectrochemical analyses of the Northern Leases, Dawn/Bernborough, and ore samples showed a trace element assemblage for Mt. Isa similar to that found in other sulphide deposits. The only elements showing anomalous distributions of any note were copper, lead, zinc, and silver in some of the auger samples. The results obtained for the Northern Leases confirm the geochemical work carried out by Debnam in 1953. Other results are as expected from the known mineralogy of the area.

Following completion of stage 1 of the Kalgoorlie geochemical survey a further 240 samples from underground workings were examined. Of the elements determined arsenic, possibly, silver, and molybdenum can be considered as indicators of gold mineralization. During the course of this investigation a method for the determination of trace amounts of gold in geological materials was developed using solvent extraction prior to the determination of the gold by atomic absorption spectrophotometry. Possible new methods for selenium and tellurium using atomic absorption techniques were also investigated, but proved unsuccessful. No further geochemical investigations are planned for the Kalgoorlie Goldfield.

A regional geochemical stream sediment sampling programme was carried out in the Hale River-Chewings Range area near Alice Springs N.T. concurrently with geological mapping of the north-eastern margin of the Amadeus Basin. A total of 470 samples, mainly stream sediments, were collected from minor drainage basins and valleys bordering major streams draining the Arunta Complex and Heavitree Quartzite. Analysis for trace metals was carried out spectrochemically. No significant anomalies were detected. Trace metal values, however, closely reflect the underlying rock type.

A series of hornfels samples were examined for the Baas Becking Geobiological Research Group, to determine whether or not any redistribution of trace elements occurred as a result of metamorphism. Lead and copper were found to be concentrated adjacent to the contact, and strontium was depleted. Cobalt, nickel, molybdenum, and vanadium showed little or no variation.

Selected sulphide samples (not strictly monomineralic) were also examined comprehensively for trace elements to assist in the study of sulphide migration during deformation being carried out by the Geobiological Research Group. Direct assistance given to this group is steadily increasing.

The chemistry of the phosphate deposits on Christmas Island was discussed with the Phosphate Group, and samples of as many types of phosphate rock from all localities from which samples were available were selected for analysis for trace elements; in all about 130 samples, including samples of recent bird droppings, were analysed. Full appraisal of the results has not yet been completed, however, anomalous contents of zinc and cadmium are clearly evident. Further work is proposed to extend the range of localities and types of phosphate rocks.

About 70 soil and rock samples were analysed spectrochemically for trace elements to assist with an orientation geochemical survey of a gold-bearing area near Wau, T.P.N.G.. The results show a clear relation between arsenic and gold, in keeping with experience in other gold-bearing areas, and also a strong correlation between silver and gold which could be of practical value.

Analytical - Analytical serivces occupied a relatively minor portion of the year's activities. Supervision of chemical work for the Phosphate Group continued. About 1000 samples from the Ayr 1:250,000 sheet Geochemical Survey were analysed for molybdenum. A group of samples alleged to contain ore-grade quantities of platinum, palladium, and gold were received from Anaconda Australia Inc. for check analysis. No platinum, palladium, or gold was detected. Other miscellaneous analyses included alkali metal, calcium, magnesium, iron, manganese, and nickel determinations on various rock samples. The chemistry section continued to monitor the level of zinc contamination in the Molonglo River for the Department of the Interior.

Research - Considerable attention has been paid to the theory and practical application of solvent extraction and atomic absorption spectrophotometry, both individually and jointly, as rapid, simple, and accurate methods of trace element analysis for a wide range of elements of geological ~~interest~~. A paper on the theory of solvent extraction and its application to the ~~analysis~~ of silicate rocks was presented to the Geological Society of Austral~~ia's~~ ~~Speci~~alists' Symposium held in Adelaide. The results of this work will appear in the BMR Records series, and is now being compiled. Errors due to aluminium, phosphate, and sulphate in the determination of calcium and magnesium by atomic absorption spectrophotometry were investigated, and satisfactory methods to overcome these interferences have been developed.

DIRECT-READING OPTICAL SPECTROGRAPH

Staff K.R. Walker and S.E. Smith

Field Hands R.E. Moon (commenced 2/12/65)
Z. Roksandic (commenced 30/5/66)

Very difficult conditions were experienced during the first half of the year under review owing to unsatisfactory air conditioning in the new laboratory, but from April on, when this problem was overcome, much progress was made. Operation of the direct reader and the performance of ancillary laboratory activities have been integrated to provide a fully functional laboratory, and the installation of equipment and arrangement of the sample preparation laboratories are nearing completion.

Though the direct reader was ready for final calibration at the beginning of October last year, the complete failure of the air conditioning system during the summer months delayed final mechanical adjustment and calibration until April and May of this year. The Department of Works and the contractor responsible for installing the air conditioning worked continuously on the system for 6 months, progressively modifying it until it operated according to specifications. When this stage was reached at the end of March the system had been completely rebuilt. Whether the modifications made are completely successful will not be known fully until the 1966-67 summer season. Most of the difficulties encountered resulted from inadequate capacity of the cooling system. Except for minor breakdowns it has operated satisfactorily during the winter and spring.

The delay in bringing the air conditioning into operation severely hampered laboratory activity on geological projects. During the delay S. Smith returned to the Acton laboratory for 6 weeks and R. Moon for 2 months until the air conditioning problems were solved. Every effort has been made during the last 6 months to reduce the backlog of work, though S. Smith had a further interruption to his work during May while he assisted the geochemical party with sampling in the Bowen area, Queensland.

During the first 6 months much preparatory work was done for geological projects to be undertaken later. This involved sample preparation, preparation of analytical mixtures, and electrode preparation. Climatic conditions sometimes permitted useful experiments to be run for investigations into analytical methods. Initial petrographic work and drill-hole profiles required for projects were completed. A draft paper was prepared on the requirements for and design of a direct reader for the analysis of geological materials.

Since the calibration of the direct reader in May, good progress has been made on the following projects.

(i) During instrument calibration and subsequently a detailed study of the involatile group of elements has been made to establish sound analytical controlfor the analysis of trace elements. Much information has been obtained on the behaviour of elements in the arc for a complete range of matrix types and a range of element concentrations. While establishing a reliable set of working curves for the analysis of geological materials and for the Mt. Isa project (see below), element values were obtained for available rock standards. From these measurements the accuracy of the instrument, the reproducibility of the results, and a method for the determination of involatile elements have been established. Interlaboratory checks with ANU also confirmed the reliability of results and the stability of the instrument. The results of these investigations are the subjects of two further papers in preparation. Some results of these investigation were presented to the symposium on "Modern Methods of rock analysis for constituent elements" at a special meeting of the Geological Society of Australia in August in a paper entitled "The application of the direct reading optical spectrograph to the analysis of geological materials".

(ii) For the Mt. Isa geochemical project, which is essentially a study of primary element dispersions in the Urquhart Shale, particularly in relation to mineralization at Mt. Isa, 950 samples have been analysed for 18 elements (17,100 determinations), viz., Cu, Ge, Ga, Fe, Mn, Cr, Co, Vi, Ni, Mo, Ca, Sr, Ba, Ti, Sc, Y, La, and Zr, and it is proposed to do Ag, Pb, and Zn by atomic absorption. A study on the distribution of elements along and across the strike of the Urquhart Shale is in progress. A comparison of the elemental composition of the Urquhart Shale and Spear Siltstone has not revealed any chemical distinctions between these two formations. Preliminary study of variation diagrams shows the distribution of some elements with respect to mineralization at Mt. Isa, and indicates that they appear to obey established geochemical laws for their distribution.

(iii) Good progress has been made with the petrological and chemical study of the Precambrian Hart Dolerite which crops out as a series of sills over a distance of 450 miles in the Kimberley region, N.W. Western Australia.

The region is currently being mapped by the Bureau and the Geological Survey of W.A.. Variation diagrams of element distribution with fractionation show that it is a tholeiitic intrusion whose fractionation-trend closely parallels that of the Skaergaard. It shows extreme fractionation towards silica, iron, and alkali enrichment, and is poor in Cr, and rich in Ba, Y, and Zr. It is similar in form and magma type to the widespread intrusions of the Mesozoic in Tasmania, Antarctica, etc., but because of its antiquity the distinction between it and the younger intrusions is important in terms of upper mantle studies. The distribution of Cr, Ni, V, and many of the major elements has been effected by multiple intrusion, whereas Ba and the involatile elements Sc, Zr, Y, etc., which concentrate in late fractions, were unaffected.

Various analytical determinations were done for ad hoc projects on request. This involved about 100 analyses for 16 elements, and included preliminary analyses for trace elements in clinoenstatite-bearing rocks from Cape Vogel, Papua.

The laboratory receivednumerous visitors during the year from government, industry, and research organizations, as well as group visits from school and technical college students.

PETROLOGY, MINERALOGY, AND X-RAY

PETROLOGY

C.D. Branch

Suites of rocks from the following areas were examined:

Western N.S.W. (submitted for age determination by N.S.W. Lands Dept) - Laboratory Report No. 7;

Misima Island - Laboratory Report No. 8;

Bougainville - Laboratory Report No. 16.

A heavy mineral concentrate from the Tonga Islands was examined for the Department of Anthropology, A.N.U.. A minute was written dealing with 'Pyroclastic Flows' over the signature of the Assistant Director (Geology) and distributed to all geologists; as a result, many rocksbrought in by field parties were recognised as welded tuffs for the first time.

The following were edited:

Report 105 - Geology and mineral deposits of the Port Moresby/Kemp Welch River area; Yates and de Ferranti.

Bulletin - Bougainville; Blake and Miezitis

Bulletin - Tertiary volcanic rocks of the Peak Range, Central Queensland; Mollan

Map - Ayr 1:250,000 Sheet area; Paine et al.

Map - Townsville 1:250,000 Sheet area; Wyatt et al.

The following lectures were given:

'Granite', to the second year adult education class, A.N.U., April 7.

'Volcanology in New Guinea', to East Canberra Rotary Club, July 26.

'Earthquakes and Volcanoes', on A.B.C. Schools Broadcast, August 8.

All new equipment for the thin section laboratory has been purchased, and, apart from some minor modifications being made now, is ready to be installed in the new laboratory on the third floor. However, because of the fire on the fourth floor it is unknown when the contractor will commence work in the laboratory, and until his work is completed it is impossible to occupy the laboratory. A long delay is expected, and some of the new thin section equipment will be set up temporarily in the Acton Laboratory.

X-RAY

C.D. Branch

Following the resignation of J.M. Rhodes from the Bureau in May, Branch was placed in charge of the X-ray laboratory. Since then the Metalliferous Section has been without a petrologist. During May the X-ray diffractometer and manual spectrograph, and the Philips 1210 automatic X-ray spectrograph were moved from the Acton Laboratory and installed in the new BMR building. A considerable time since then has been spent in lining-up the automatic spectrograph and designing modifications to make adjustments easier. In September a sheet of polypropylene 20 microns thick was obtained, and stretched to 1 micron thick. This will be used to replace the Mylar window in the flow counter on the spectrograph, and it will then be possible to determine sodium quantitatively, and to detect elements as light as carbon: the spectrograph will be recallibrated using the polypropylene window during October, and silicate analyses of rocks will commence in November.

The Rb/Sr ratios in 34 samples were determined for the Geochronology Group, and U/Th ratios in 12 samples were determined for the Department of Geophysics and Geochemistry, A.N.U.; Fourteen minerals were determined by X-ray diffraction. Two Records by Rhodes were edited: 'Trace element analysis by X-ray spectroscopy with emphasis on the determination of Barium, Lead, Nickel, and Zinc' (Record 1966/143); and 'Silicate analysis by X-ray fluorescent spectroscopy' (draft).

About 400 granite samples from north Queensland have been selected from the age determination collection for the 'Geochemistry of Australian Granites' programme. Analyses for the major elements will begin in November, and trace element analyses about mid-1967. The Bureau's programme will be enhanced by a detailed geochemical study of a high-level granite in north Queensland just started by a Ph.D student in the Department of Geology, A.N.U., of whom Branch has been appointed an honorary supervisor.

Symposia on Feldspars and Methods of Rock Analysis, arranged by the Geological Society of Australia in Adelaide, were attended from 22nd to 26th August, and, as time permitted, practical experience was grained in the X-ray laboratory run by Dr. K. Norrish in the Division of Soils, C.S.I.R.O., Adelaide.

MINERALOGY AND MINERAGRAPHY

I.R. Pontifex (October, 1965, to May, 1966.)

Sixteen minor "ore-mineralogy" reports were completed on various mineragraphic and petrographic investigations of ores, rocks associated with ores, heavy mineral and beach sands, phosphate rocks, and geochemical samples.

Twenty five miscellaneous minerals were identified by X-ray diffraction and/or microscopic examination.

The following suites of specimens are worthy of some comment:

1. In drill core from the Watsonville tin-field (N.Q.) eleven ore minerals and eight gangue minerals were identified, and their relationships enabled their paragenesis to be established. The ore minerals, in approximate decreasing order of abundance, are: arsenopyrite, pyrrhotite, chalcopyrite, cassiterite, stannite, pyrite, magnetite, sphalerite, galena, wolfram, bismuthinite.

2. A petrological and X-ray examination of bauxite samples from the Ashton 1:250,000 Sheet, Kimberley area, W.A., indicated that gibbsite is the main constituent forming the pisolites and matrix of most of the specimens. Hydrated iron-oxide is present in most samples, and cryptocrystalline silica occurs in the interstices of some. One sample was found to consist almost entirely of kaolinite. The textures in some samples suggest that the bauxite has been brecciated and recemented by secondary bauxitic material and silica.

3. Opaque minerals in andesitic rocks from Bougainville Island generally make up about 2% of each rock.

   Titaniferous magnetite is the main opaque mineral, and this is generally associated with lesser amounts of hematite. Minor amounts of maghemite, ilmenite, spinel, rutile, pyrite, and chalcopyrite were found in some specimens.

   Various textural features indicate primary exsolution of hematite and magnetite and also of the iron and titanium oxides.

A paper entitled "The Mineralogy and Genesis of Ores in the Astrolobe Mineral Field, Papua", together with accompanying photographs and maps, was prepared for presentation to the Scientific Meeting of the Geological Society of Australia, held in Adelaide during August.

Between July 19th and August 9th eighteen working mines in the Herberton area, Queensland, were visited. At each mine the ores, associated gangue, zones of alteration, and the country rock were examined.

The ores and some of the associated rocks were sampled from mines in granite and in sedimentary rocks; preference was given to those containing complex mineral assemblages.

The mineralogy of these ores is to be examined with the aim of correlating the mineral associations with the field geology, and investigating theories of ore genesis and mineral zoning in the area.

GEOCHRONOLOGY (Fig. 11)

A.W. Webb, V.M. Bofinger, R.R. Harding

During 1966, 190 isotopic age determinations were made on mineral and whole-rock samples in the Geochronology Laboratory of the Department of Geophysics and Geochemistry, A.N.U.. The bulk of the analyses were carried out on rocks from the East Kimberleys and Bowen Basin. The areas of the Australian mainland from which samples were dated are shown on the accompanying map. Samples from Malaysia, Antarctica, and T.P.N.G. were also analysed. In addition to these analyses, numerous calibration runs were made on Ar, Rb, and Sr spikes.

The Geochronology Laboratory was moved to a new building during the period November, 1965, to January, 1966, and most of the equipment was out of operation for almost three months.

The construction of a new solid-source mass spectrometer (MS-X) is almost completed.

Harding was the only member of the section to go on field work this year. During August and September he collected 38 samples for dating from the Wau, Kainantu, Chimbu, and Mt. Hagen areas of T.P.N.G.

The Bowen Basin and East Kimberley projects should be completed in 1967, and the compilation of this work is expected to take up several months of the year.

The progress in each survey is detailed below.

Bowen Basin

Sixty-three mineral concentrates from fifty-three samples of igneous rocks were dated by the potassium-argon method. In addition, twenty-one rubidium-strontium analyses were completed.

All samples which can be dated by the K/Ar method, from the area south of $20\frac{1}{2}^{\circ}$ S. lat, have now been analysed, as well as a considerable number from the northern parts of the Bowen and Proserpine 1:250,000 Sheet areas. The main discovery was that the Mount Morgan granite, which has always been regarded as of Permo-Triassic age, is at least 360 m.y. old (Upper Devonian). The remaining results have shown the wide extent of the plutonic activity in the Upper Permian (235 m.y.), from Marlborough to New England, and in the Lower Cretaceous (125 m.y.) in the Bowen-Proserpine area.

The Rb-Sr dating has a twofold purpose -- to date the volcanic rocks which are not suitable for K/Ar dating, and as a check, to date samples which have already been dated by the K/Ar method. A major problem in isotopic dating is the frequent discordance between K/Ar and Rb/Sr ages determined on the same sample. This problem is increased by the fact that two values for the decay constant of ^{87}Rb, which differ by 6%, are in common use, but neither constant will give ages which agree consistently with K/Ar ages. In general, Rb/Sr ages are either equal to, or greater than K/Ar ages. Consequently, it is not justifiable to compare Rb/Sr ages with the radiometric time scales of Kulp or those adopted by the Phanerozoic Time Scale Symposium, which are largely based upon K/Ar ages.

Samples which appear not to have been reheated or metamorphosed (and are therefore least likely to have lost radiogenic daughter products) are being dated by both K/Ar and Rb/Sr methods. The first group of granites studied was from the Maryborough Basin, where the average K/Ar mineral age is 217 m.y. and the total - rock Rb/Sr age is 218 m.y. (using $^{87}Rb = 1.47 \times 10^{-11} yr^{-1}$). Rocks from other areas are now being analysed to see if this relationship is consistent.

Another objective is to date by the Rb/Sr method, rocks which are suspected to have given low K/Ar ages; e.g., in the Urannah Complex, ages of 300 m.y. and 270 m.y. are fairly well established by the K/Ar method, but a number of results fall around 285 m.y. These ages may represent a partial argon loss from a 300 m.y. old granite due to heating by the 270 m.y. old granites, or may indicate a distinct phase of intrusion. The success of this attempt to determine the significance of this 5% difference will depend upon whether a general agreement between K/Ar and Rb/Sr ages can be achieved elsewhere.

Preliminary Rb/Sr analyses have been carried out on three volcanic units on the Bowen and Proserpine 1:250,000 Sheet areas.

East Kimberleys

Seventy-six analyses of total-rock and mineral samples were made, the majority of the total-rock samples being shales. Certain modifications to the preliminary results reported in 1965 are now possible.

The age of the oldest exposed rocks, the Halls Creek Group, is still in doubt, but could be older than 2650 m.y. Direct measurements on shales from the Group give ages much too young to be consistent with the known stratigraphy.

Within the Halls Creek Mobile Zone, intrusion of granitic rocks (Mabel Downs Granodiorite) accompanied the high grade metamorphism of the Halls Creek Group (Tickalara Metamorphics). This event has been dated at 1961 ± 27 m.y. A further period of granitic intrusion, unaccompanied by metamorphism, occurred 1854 ± 14 m.y. ago (Bow River Granite). This latter period of granitic intrusion was associated with the outpouring of vast quantities of the Whitewater Volcanics, which have an age of 1823 ± 17 m.y.

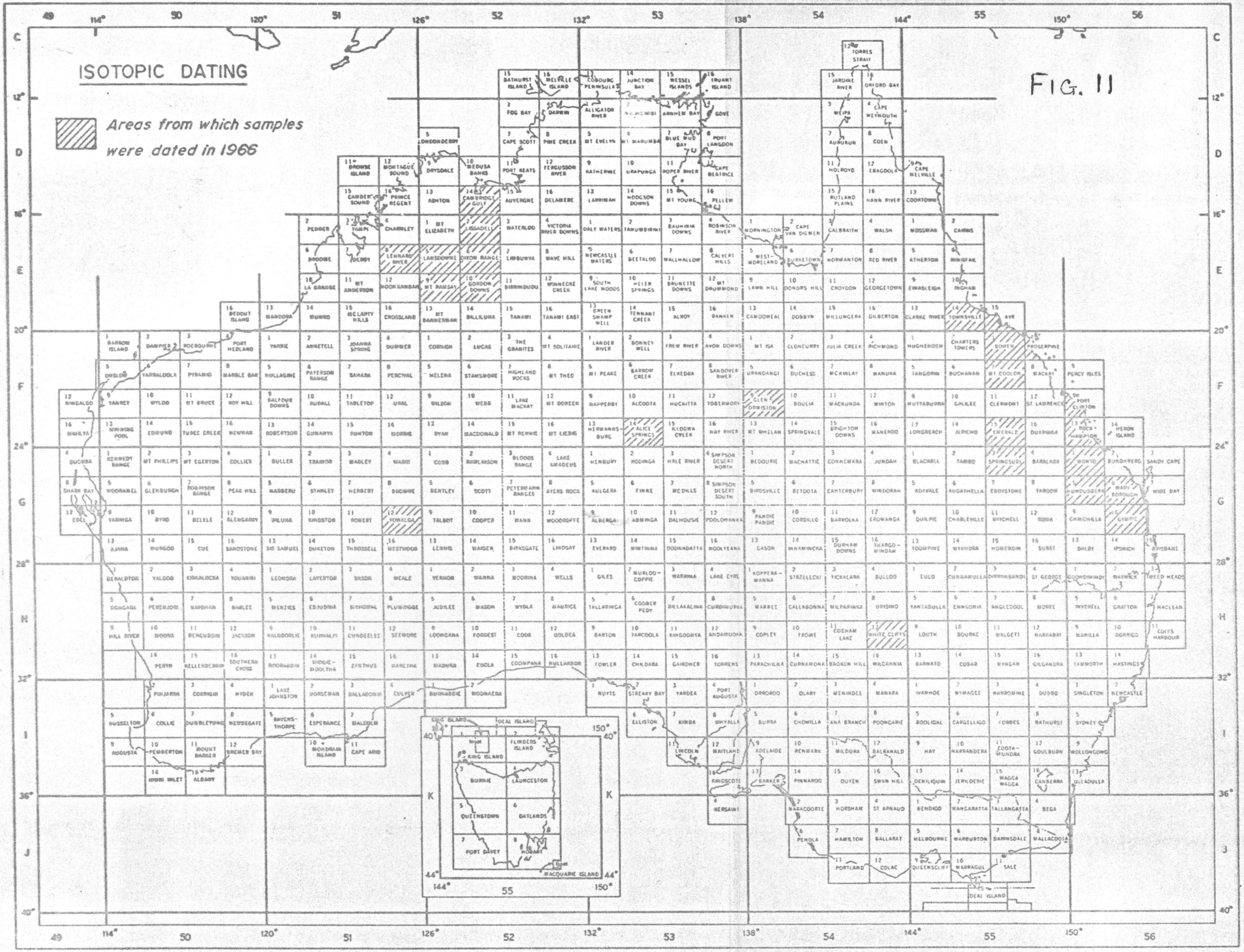
This period of major igneous activity had been concluded by the time of emplacement of the Hart Dolerite, dated at 1800 ± 25 m.y. The Kimberley Group was emplaced in the period between emplacement of the Whitewater Volcanics and the Hart Dolerite, and the Carson Volcanics from this Group have an indicated age of 1807 m.y.

Shale samples from the least disturbed sections in the northern part of the Halls Creek Mobile Zone give apparent ages of 1184 ± 123 m.y. for the Golden Gate Siltstone, 1080 ± 80 m.y. for the Glenhill Formation, and about 900 m.y. for the Pincombe Formation, indicating that the Carr Boyd Group is equivalent to units from the Kimberley and Sturt Blocks. A Palaeozoic event is reflected in some of the samples from the Glenhill Formation.

In the Kimberley Block, the Wyndham Shale has been accurately dated at 1707 ± 31 m.y. No unit of equivalent age has been found in the Sturt Block.

Correlation of units from the Kimberley and Sturt Blocks, across the Halls Creek Mobile Zone, is first possible at the Wade Creek Sandstone level. The Mount John Shale Member of the Wade Creek Sandstone has been dated at 1128 ± 110 m.y.. Tentative field correlations of this Member with parts of the Glidden Group has been confirmed. The Matheson and Maddox Formations from this Group have been accurately dated at 1031 ± 23 m.y. A 730 m.y. old event is also reflected in certain samples from these Formations.

Two periods of glaciation, each followed by marine sedimentation, occurred in the late Precambrian. The older period of glaciation has been determined as occurring 730 ± 30 m.y. ago. Interglacial shales have an indicated age of 685 m.y.. The Timperley and McAlly Shales are younger than the second glaciation, and have an age of 666 m.y.. This determines, within reasonable limits, the times of the Precambrian glaciations.



ISOTOPIC DATING
Areas from which samples were dated in 1966
FIG. 11

The results given above are based almost entirely on total-rock samples. Analyses of minerals extracted from the various rocks are in most instances unreliable, and give apparent ages much younger than the more reliable total-rock ages. For the Kimberley region, at least, all apparent ages determined on minerals must be regarded as minimum estimates. Biotite, in particular, has proved extremely unstable, and in most cases the apparent ages have no geological significance.

Use of shales in Rb/Sr Dating

The use of shales to determine the age of Precambrian sediments is becoming increasingly important. Age determinations on bore cores rely heavily on data from shales, and many of the results from the East Kimberleys are based entirely on total-rock analyses of shales.

Problems inherent in most samples are the normally low Rb/Sr ratio, and the small variation in the Rb/Sr ratio within a suite of samples. Experimental work, involving the leaching of samples with 0.1 N HCl, is being carried out. Promising results have been obtained, particularly with calcareous shales, as the effect of leaching is to remove carbonate material high in common strontium, thus enhancing the Rb/Sr ratio of the solid residue. Many shales which would have been rejected previously will now be useful for dating if the experimental work is successful.

One interesting aspect which has arisen from the dating of shales is that the initial $^{87}Sr/^{86}Sr$ ratio appears to be about 0.72. Previously it had been thought that equilibration with sea water should take place, and that the initial $^{87}Sr/^{86}Sr$ ratio of shales should be about 0.707 (sea water ratio). Analyses of present day samples of silt and clay material from the shelf area of the Sydney Basin and Gulf of Carpentaria (supplied by J. Kaulback) will be carried out to help in solving the problem of the initial $^{87}Sr/^{86}Sr$ value for shales.

Work on the significance of shale analyses will be continued on a 200 ft. core of the State Circle Shale. Samples have been taken at one foot intervals, and X-ray fluorescence analyses for Rb and Sr are being made by B.W. Chappell of the Geology Department, A.N.U.. It is hoped that a close study of this core will show what effect, if any, weathering has on the resultant date, and the significance of the data in terms of deposition, diagenesis, metamorphism, source material, etc.

Tertiary volcanics, eastern Queensland

It has been demonstrated by several investigators that completely fresh volcanic rocks give reliable whole-rock K/Ar ages. It has also been shown that badly altered rocks give K/Ar ages which are much too low. As fresh (unaltered) rocks are relatively rare, it is necessary to learn how much alteration can be tolerated before the effects of argon leakage become too great. The Tertiary volcanics of the Springsure area appeared to provide the opportunity to compare whole-rock ages with ages of sanidine in genetically related rocks. Sanidine has been considered to be highly suitable for K/Ar dating.

The project began in 1962, but when it was found that consistent results could not be obtained on the sanidines, the project lapsed until time became available to investigate this problem. No work was done during 1964 - 1965, but this year the difficulty was eventually overcome. Several samples from the area to the south-west of Brisbane were run in 1964 for the purpose of comparison with the Springsure samples.

The three conclusions from this study were:-

(1) There were unsuspected technical difficulties in the extraction of radiogenic argon from sanidine which were only overcome by heating the mineral to several hundred degrees C above its melting point.

(2) Whole-rock samples of middle Tertiary age, or older, may give acceptable dates when only slightly altered, because any argon loss is masked by the analytical error. However, the selection of samples for dating remains highly empirical.

(3) The volcanics in the Springsure area are of Oligocene age, and those in south-eastern Queensland are slightly younger (early Miocene).

<u>Bore Cores</u>

Five bore core samples were analysed. Biotite from granite basement in Netting Fence No. 1 was dated by the K/Ar method. Four samples of basalt from Yowalga No. 2 were dated by the Rb/Sr method, and an age of consolidation greater than 1000 m.y. measured. Two badly altered samples reflected a 446 m.y. event. Independent K/Ar analyses by Geochron and Isotopes Inc. measured only the Palaeozoic age.

<u>Miscellaneous</u>

Analyses unrealted to the major projects were carried out on samples from Malaysia (17), T.P.N.G. (5), Antarctica (12), the Amadeus Basin (4), western N.S.W.(1), and the Townsville-Charters Towers area (2).

The results of the work on the Malaysian, Amadeus Basin, and western N.S.W. samples have been reported.

The two granite samples from the Townsville 1:250,000 Sheet area were dated to supplement a palaeomagnetic investigation of sediments from this area by D.H. Wyatt (G.S.Q.) and Dr. F. Chamalaun (A.N.U.).

Dating of twelve samples from Antarctica, and three from T.P.N.G., is in progress.

BAAS BECKING GEOBIOLOGICAL RESEARCH GROUP, MINERALOGY SECTION

W.M.B. Roberts, A.S. Joyce, J.A. MacDonald (C.S.I.R.O.) (July-Oct.)

Dr. MacDonald is engaged in a study of a portion of the Mount Isa Orebody; taking the deposit as a tectonically deformed sequence in low grade metamorphic rocks he will examine the textural and chemical changes in some deformed sulphide-rich bands. Concurrently, he will examine , both from field evidence, and by laboratory experiments, the effect of metamorphism on the iron content of sphalerite. The object of this examination is to determine some of the measurable effects which result from the metamorphism of sulphides and their associated minerals.

A.S. Joyce carried out a statistical study of chemical analyses of regionally metamorphosed rocks in an attempt to recognise any possible migration of elements induced by metamorphism.

The results suggest that chemical reorganisation of the crust proceeds during the mineralogical reorganisation accompanying metamorphism. Pressure and temperature have opposing influences on the distribution of individual elements. The possible trends of major element redistribution recognised are as follows: FeO, total Fe, CaO, MgO, Na_2O, TiO_2, and MnO seem to increase in mean abundance with increasing pressure, and decrease with increasing temperature; SiO_2, Al_2O_3, Fe_2O_3, and K_2O, seem to decrease in mean abundance with increasing pressure, and increase with increasing temperature; H_2O appears to decrease with both increasing pressure and temperature.

These conclusions may be affected by bias resulting from emphasis on unusual rock types, and, by the possible effect of crustal evolution with time, because the exposed highly metamorphosed terrains are generally older than the low-grade terrains.

Insufficient usable data are available to examine the distribution of trace elements statistically but several published studies suggest that trace elements will undergo redistribution also. Therefore metamorphism theoretically could lead to generation of economically significant concentrations of trace elements under favourable localising conditions. If these elements encountered a source of sulphur during redistribution, their ultimate distribution would be modified drastically because of their high affinity for this element, and new mineral phases would appear. Such a mechanism is one possible explanation for the location of some sulphide deposits in metamorphosed sediments stratigraphically associated with greenstones.

Joyce also sampled four thermal aureoles adjacent to granitic intrusions in order to determine the behaviour of trace elements, in progressively metamorphosed, initially homogeneous, or nearly homogeneous rock units.

The preparatory petrographic examination of three of these suites of samples has been completed and some chemical results have been obtained. Silicate analyses completed for one suite of samples from the northern tip of the Jerangle Granite indicate no detectable change in major and minor element content with changing metamorphic grade, except for a decrease in H_2O with increasing grade and a decrease in Fe_2O_3. Trace element data are not yet available. Preliminary results on specimens from south of the Urialla Granite indicate mobility of Cu, Pb (both ten-fold regular variation) and B in the aureole, and suggest some mobility of other trace elements. Initial results on samples from adjacent to the Harrison Peak Granite also suggest significant variation in trace elements. Confident interpretation and evaluation of the study must await completion of the chemical analyses .

Starting from the early 1900's, W.M.B. Roberts is making a search of the literature for experimental work on sulphide synthesis. Much useful work has been done in the field, and a systematic compilation is essential.

Previous experimental work on the formation of chalcopyrite at low temperature had indicated that water was an essential component in the reaction. Even in the absence of water the reaction between CuS and FeS to give $CuFeS_2$ would possibly proceed by solid diffusion at low temperature if diffusion could be enhanced under these conditions by glide dislocations during the plastic deformation of the minerals.

To test the possibility, six experiments were set up; dry pellets of CuS and FeS were compressed together at temperatures ranging from 20°C to 150°C at 4,000 atmospheres for six weeks. Both sulphides had recrystallised in all experiments, but no reaction between them could be observed at the interface of the pellets when examined at 2,000 x magnification. At the same time stoichiometric proportions of CuS and FeS were mixed to a slurry with water and sealed in a teflon cylinder. This was compressed at 4,000 atmospheres and heated to 140°C for sixteen days. A complete conversion to coarsely crystalline chalcopyrite resulted. Under the conditions of the experiment, solid diffusion does not appear to be a possible reaction, and the mechanism is, therefore, an ionic one.

Work on the adsorption of metal ions to bentonitic clays was started, using copper and lead. At pH 10, 2 percent of copper was adsorbed from a solution containing 2 grams of copper per litre. This copper was converted to the sulphide by passing H_2S through the clay. A 1% solution of lead acetate was used to check the adsorption of lead. The chemical analysis has not yet been done, but H_2S was passed through portion of the clay, and the lead converted to lead sulphide.

Portions of these clays are being compressed at 4,000 atmospheres and at 140°C to check whether the dispersed sulphide will coalesce.

Some difficulties were experienced with the heating of the cylinders during the year, and a change from the wire-wound furnaces to oil-bath heating was made. However, the resistance used to heat the oil short-circuited during the experiments, and the oil baths had to be discarded.

New heating elements having a relatively low heat output per unit area are being made; it is hoped that these will not form carbon in the oil which caused the short circuit of the resistance heaters.

Equipment was designed to study quantitatively the effects of a pressure gradient on the movement of sulphides. However, this proved to be too difficult to construct, and a simpler approach will have to be considered.

Work will continue on the adsorption and desorption of metals on clays, and the study of their recrystallization behaviour under different temperatures and pressures and in different matrices.

Equipment has been partly made for the study of the solubility of sulphides in a variety of solutions, and to evaluate the solution mechanism as a factor in ore transport.

In early September, Roberts approached Professor Buchanan, at the Department of Physical Chemistry, University of Melbourne, and asked him whether he would advise the group on its physical chemistry programme. He agreed to do this, and also agreed that some of his research students would work on some of the group's problems.

Professor Buchanan is keenly interested in the physico-chemical aspects of mineral and ore formation, and with his help we should be able to develop a useful physical chemistry programme.

MISCELLANEOUS

PRECAMBRIAN TIME-STRATIGRAPHY

P.R. Dunn prepared a short paper for the Government Geologists' conference in Hobart on the Bureau's proposed subdivision of the Australian Proterozoic into three systems: Adelaidean, Carpentarian, and Lower Proterozoic. The proposals have been accepted, in principle, by the Queensland and South Australian Surveys, but not by the Western Australian Survey who prefer to adopt the Canadian subdivisions. The Bureau is using the new subdivisions on all its latest maps.

W. Compston, of the Australian National University, withdrew from authorship of the paper "A proposal for time-stratigraphic subdivision of the Australian Precambrian", and the paper has been submitted to the Journal of the Geological Society of Australia under the authorship of P.R. Dunn, K.A. Plumb, and H.G. Roberts.

P.R. Dunn has been appointed a member of the Subcommission on Precambrian Stratigraphy which operates as part of the Commission on Stratigraphy of the International Union of Geological Sciences. Professor Kalervo Rankama is president of the new Subcommission.

PETERMANN RANGES 1:250,000 SHEET AREA, N.T. (Fig. 12)

J.F. Ivanac

During the latter part of June and early July part of the south-western portion of the Petermann Ranges 1:250,000 Sheet area was investigated to determine whether or not ultramafic rocks extend across the South Australian-Northern Territory border, and to search for similar outcrops in the Mann Ranges. A number of gossans in the Petermann Ranges were also visited.

The nickel-bearing rocks - norite and pyroxenite - crop out in the Claude Hills in South Australia, and extend for about one mile into the Northern Territory. They are interlayered with acid, intermediate, and basic gneisses and granulites. Similar rocks extend westward into Western Australia. The ultramafic suite has been named the Giles Complex by the South Australian Geological Survey. Nickel occurs as a nickeliferous ochre formed by leaching of olivine-rich varieties of ultramafic rocks. Silica and magnesia have been leached from these rocks, which contained approximately 0.2% Ni. Average grade of the ochre is about 1.6% Ni.

The results (P.G. Miller pers. comm.) of four rotary-percussion drill holes put down by the South Australian Mines Dept. on a possible extension into the Northern Territory of the nickeliferous ochre deposits, suggest that they are very low grade. In the Northern Territory, five miles north of Claude Hills, two minor bodies of olivine gabbro(?) intrude coarse to fine-grained gneisses and granulites.

In the Petermann Ranges four prospects were briefly inspected; these are shown on the map as Butler Dome, Stevenson Peak, Katamala Cone, and Chirnside Creek. The prospects consist of manganiferous jasper lenses in carbonaceous and dolomitic shale and dolomite of the Pinyinna Beds (coloured black on Fig. 12).

At Butler Dome three groups of steeply dipping magnaniferous and siliceous gossans and collapse breccias extend over a strike length of about seven thousand feet. Each group is about 1000 feet long, and occurs in highly folded and contorted carbonaceous and dolomitic rocks of the Pinyinna Beds. The main gossan is 45 feet wide, and stands out as an impressive blue-black outcrop. A shaft about 40 feet deep has been put down in the footwall of the gossan to prospect quartz veins which cut the gossan. The gossans are similar to those at Mt. Isa, and contain boxworks and limonite derived from sulphides. The surrounding sediments have been sericitised, and contain substantial amounts of iron oxide (limonite and hematite). There is abundant evidence to suggest that the mineralization is bedded, and is possibly of syngenetic origin. Several chip samples of the gossans were collected, and these show anomalous lead, zinc, and cobalt values (see Table, Fig. 12).

Examination of the three other localities showed minor gossanous material, but no upstanding jasper bodies similar to those at Butler Dome. From the brief examination made, there appears to be a change from carbonaceous to dolomitic facies westwards from Butler Dome.

COLOUR AND INFRA-RED PHOTOGRAPHY

P.R. Dunn has discussed the possible future of colour and infra-red aerial photography with members of the photogeology group, and the airborne group of the Geophysical Branch. Mr. Sims, of the Forestry and Timber Bureau, and Mr. Chenhall Jones, of Aerial Photographs Pty Ltd, have also been consulted.

A tentative programme was devised for 1966 in which the Bureau Cessna would photograph in colour an area near the Daly River copper mine and an area near Tennant Creek during the course of aeromagnetic surveys in these regions. However, delay in the delivery of a 70mm. camera which was to be used for the project caused its cancellation. A similar project is proposed for 1967.

This initial programme will be used to assess the value of colour and infra-red photographs for detailed geological interpretation and mapping of possible metalliferous areas. They will also be assessed as a prospecting tool and as an aid to geobotanical work.

TRAINING PROGRAMME

In 1966 recruits to the Metalliferous Section were given a brief training course designed to show them most facets of the operations of the Section. The course consists of the following:

Reading of selected literature
Photogeology - 2 weeks
Laboratory - 2 weeks
Age Determination - 1 day
Rock Store - 1 day
Drafting - 2 days
Map Editing - 1 day
Groundwater A.C.T. - 1 day
Field Geochemical Sampling Techniques - 1 day
Petrology - 1 day
Equipment - 1 day
Other Branches - 4 days

FIG. 12

AUSTRALIA 1:500.000

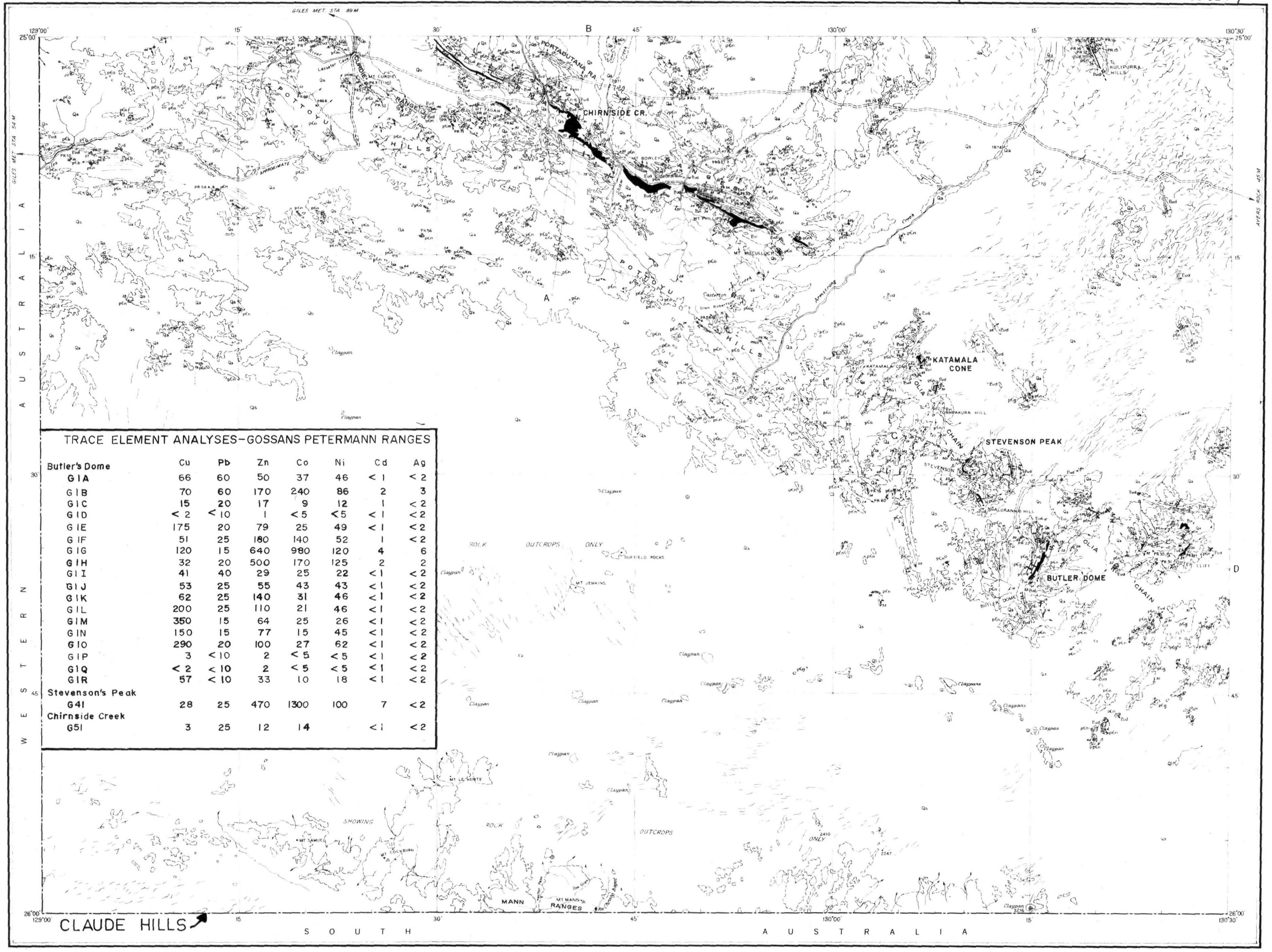
PETERMANN RANGES

NORTHERN TERRITORY

(1:250.000 GEOLOGICAL SERIES SHEET SG 52-7)

PRELIMINARY EDITION, 1964

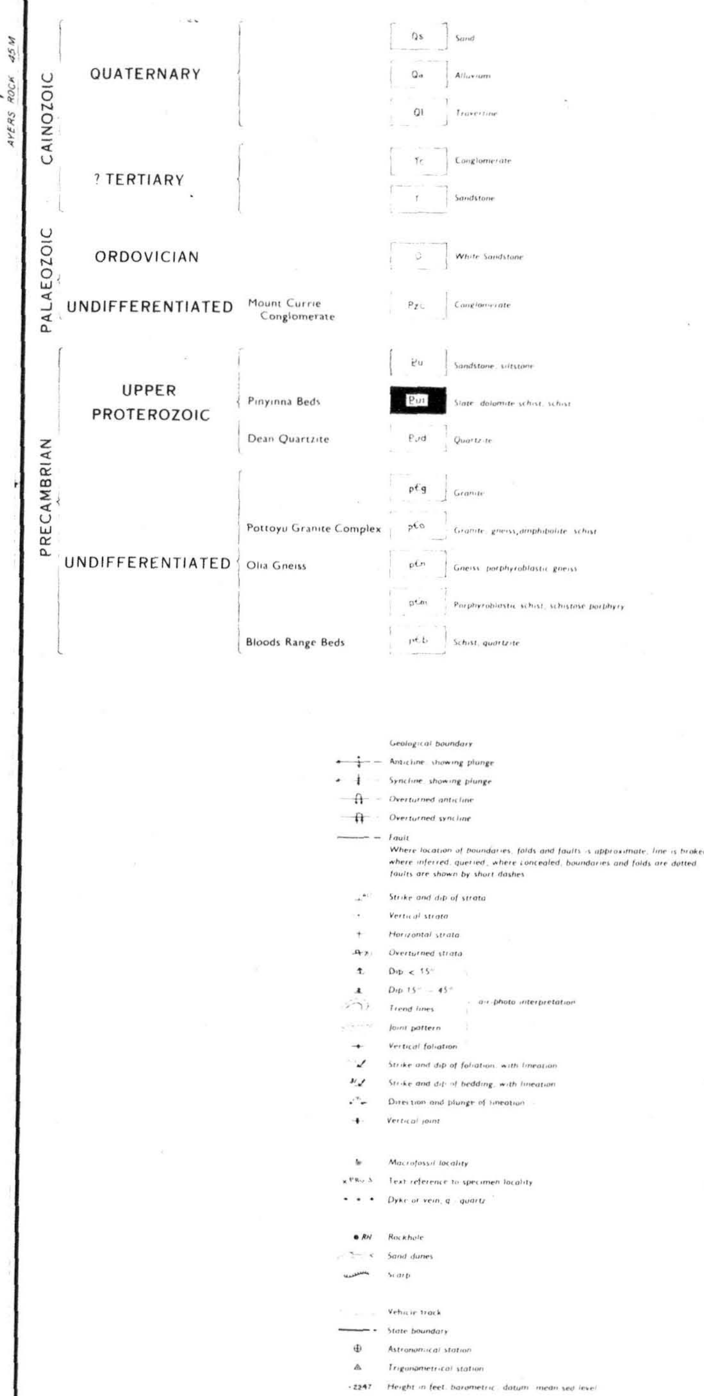
SUBJECT TO AMENDMENT



TRACE ELEMENT ANALYSES–GOSSANS PETERMANN RANGES

	Cu	Pb	Zn	Co	Ni	Cd	Ag
Butler's Dome							
G1A	66	60	50	37	46	< 1	< 2
G1B	70	60	170	240	86	2	3
G1C	15	20	17	9	12	1	< 2
G1D	< 2	< 10	1	< 5	< 5	< 1	< 2
G1E	175	20	79	25	49	< 1	< 2
G1F	51	25	180	140	52	1	< 2
G1G	120	15	640	980	120	4	6
G1H	32	20	500	170	125	2	2
G1I	41	40	29	25	22	< 1	< 2
G1J	53	25	55	43	43	< 1	< 2
G1K	62	25	140	31	46	< 1	< 2
G1L	200	25	110	21	46	< 1	< 2
G1M	350	15	64	25	26	< 1	< 2
G1N	150	15	77	15	45	< 1	< 2
G1O	290	20	100	27	62	< 1	< 2
G1P	3	< 10	2	< 5	< 5	< 1	< 2
G1Q	< 2	< 10	2	< 5	< 5	< 1	< 2
G1R	57	< 10	33	10	18	< 1	< 2
Stevenson's Peak							
G41	28	25	470	1300	100	7	< 2
Chirnside Creek							
G51	3	25	12	14		< 1	< 2

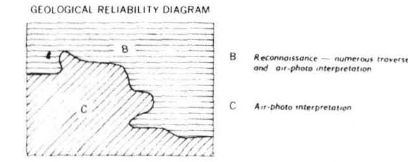
Reference



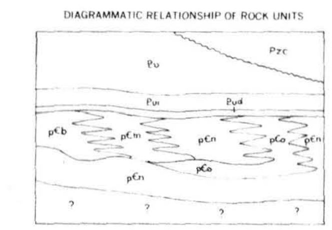
INDEX TO ADJOINING SHEETS

Scale 1:500.000

GEOLOGICAL RELIABILITY DIAGRAM

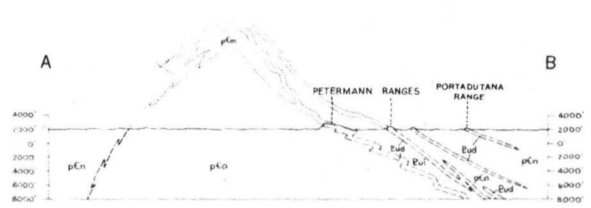


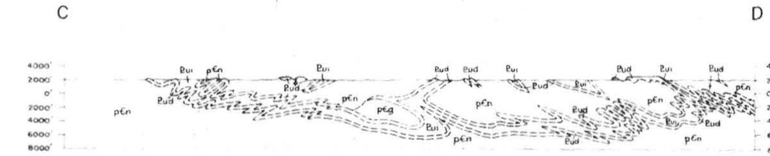
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity

Sections





PETERMANN RANGES

SHEET SG 52-7

The programme takes about six weeks to complete, and should provide the new geologist with an adequate background to the operations of the Section and its relationships to other Branches of the Bureau. The importance of cooperating with other Branches, and the need to understand and, where possible, to help with their work, are stressed.

EXCHANGE OF GEOLOGIST WITH GEOLOGICAL SURVEY OF CANADA

P.W. Crohn is attached to the Geological Survey of Canada on exchange with Dr. K.E. Eade. He is studying mineral deposits in various parts of Canada, concentrating principally in the central area of the Canadian Shield.

Dr. Eade arrived in Canberra on 25th March. Since then three months have been spent outside Canberra, as follows:

1. One month with the West Kimberley field party in the Lennard River area, Western Australia.

2. One month on a tour of the Kimberley region of Western Australia and the Carpentaria region of the Northern Territory, with H.G. Roberts. Brief visits were made to Rum Jungle, Mount Isa, and Tennant Creek.

3. Two weeks were spent in South Australia examining the Adelaidean System rocks in the vicinity of Adelaide and in the northern Flinders Range, and the older rocks of the Gawler Platform in northern Eyre Peninsula.

4. Three weeks were spent in Western Australia seeing the Lower Proterozoic section in the Hamersley Range, and the Archaean rocks in the Kalgoorlie and Nullagine-Marble Bar regions. Visits were made to Mt. Tom Price and the Wittenoom asbestos deposits.

This field work permitted examination of most of the important Precambrian sequences in Australia, and of some mineral deposits associated with them.

In Canberra, study of the literature and discussions with Bureau officers has assisted in appreciation of Australian Precambrian geology.

CLINOENSTATITE-BEARING ROCKS, CAPE VOGEL, PAPUA

W.B. Dallwitz

Fourteen chemical analyses of clinoenstatite-bearing rocks from Cape Vogel, Papua, are now available. These analyses, considered both individually and as a group, show certain unique and remarkable features which can not be explained in terms of differentiation processes inferred from detailed field, petrographic, and chemical studies, on the one hand, or from experimental studies in fractional melting of mantle-type rocks, on the other (Green and Ringwood, 1966). The special features of the chemical compositions of the rocks as a group are scarcely less remarkable than the occurrence of clinoenstatite itself, and may be summarized as follows:

(1) Magnesia contents range from 12.5 percent to 25.3 percent (concomitantly, the clinoenstatite contents range from a few percent to about 70 percent);

(2) Alumina and lime contents vary inversely with magnesia contents: Al_2O_3 ranges from 12 percent to 6 percent, and CaO from 6 percent to 3 percent;

(3) Iron oxides remain roughly constant at about 9.5 percent; and

(4) contrary to all expectations, silica remains constant, to within ± 1 percent, at about 57.5 percent.

As the chemistry of these rocks appears to defy explanation by any known processes of differentiation, it was decided to test by calculation the possibility that they are hybrids. For an origin by hybridization to be feasible, it was necessary to choose two rock-types with greatly different magnesia percentages, and with silica percentages of about 57, so that they could mingle in any proportions without appreciable change in the silica contents of the hybrids; the selected rocks would also have to be types likely to be found in the geological environment of Eastern Papua. The rocks most nearly satisfying the two principal requirements are enstatite pyroxenite (SiO_2 = 56%, MgO = 34.5%) and quartz dolerite (SiO_2 = 58.5%, MgO = 5.5%).

The proportions in which the enstatite pyroxenite and quartz dolerite magmas would have to mix to yield the different magnesia percentages found in the Cape Vogel rocks were calculated from the magnesia percentages of enstatite pyroxenite, quartz dolerite, and the fourteen analysed clinoenstatite-bearing rocks. On calculating the percentages of oxides (other than magnesia) which would result from mingling of enstatite pyroxenite and quartz dolerite magmas in the appropriate proportions, it was found that the percentages of these oxides fall remarkably close to those of the corresponding analysed rocks. This correspondence suggests that the different compositions of these rocks may be attributable directly to mixing of enstatite pyroxenite and quartz dolerite magmas in various proportions - i.e., each variant may be due to hybridization alone. Another hypothesis still to be tested by calculation involves derivation of the different compositions by formation of a single hybrid magma which might then have differentiated by fractional crystallization and gravitational settling of pyroxene phenocrysts. Still other calculations along the lines outlined above could be made by working out mixing-proportions for the two magmas from alumina and lime percentages instead of magnesia percentages.

Though origin by hybridization seems to be attractive, and even feasible, on paper, a great drawback to the acceptance of such a mode of origin lies in widespread doubt about, or even outright disbelief in, the existence of an enstatite pyroxenite magma. This doubt exists in spite of the numerous recorded examples of dykes of enstatite pyroxenite in alpine-type peridotite bodies. However, in view of the rather interesting results of the calculations carried out so far, the concept of the possible existence of an enstatite pyroxenite magma should be critically examined in the course of any study of the genesis of the clinoenstatite-bearing rocks. Quite extensive experimental work would probably be necessary for such an investigation.

The existence of clinoenstatite-bearing rocks or their analogues has already been established (in three separate areas of outcrop, each completely surrounded by Tertiary sediments) over a span of five miles or more on Cape Vogel. Topographic relief within the main area of outcrop is about 200 feet, and the rocks there are considered to be submarine lava flows at least as old as Upper Oligocene. Fresh specimens are quite difficult to obtain, and it is possible to walk several hundred yards without finding anything that could be called a rock. It is therefore quite impossible to do any systematic collecting in the area. The only solution, if we are to follow up the clinoenstatite problem constructively, is to carry out core drilling. As a beginning we might consider drilling three 500-foot holes or one 500-foot hole and one 1,000-foot hole. Reasons for drilling these holes would be:

(1) To obtain continuous cores of fresh rock for petrographic, chemical, and spectrographic study. (A very important consideration for understanding the conditions of formation and the stability-ranges of protoenstatite and clinoenstatite is to attempt to find out whether the high (6 to 7%) water content of the rocks reflects an original condition of the magma, or whether the water was introduced after the magma had solidified).

(2) To study compositional differences between successive lava flows, and to search for evidence of gravitational settling of pyroxene phenocrysts within them.

(3) To see whether or not individual flows are of uniform composition, after making allowances for possible differences attributable to gravitational settling of pyroxene crystals; if they are not uniform, a strong case for hybridization could be made out.

(4) To ascertain whether or not the lavas contain xenoliths (such as enstatite pyroxenite and peridotite) which might provide evidence as to their genesis.

(5) To find if rocks both more magnesian and less magnesian than the known extremes (12.5 and 25.3% MgO) exist. It would be quite fortuitous if the known extremes coincided with the actual extremes.

(6) To see whether or not the internal parts of flows differ in mineralogy and grainsize from the chilled margins: clinoenstatite may exist only in the chilled margins.

(7) To ascertain if any hypabyssal or plutonic equivalents of the clinoenstatite-bearing rocks exist (in the form of dykes or sills).

(8) To see whether or not different flows can be correlated in two or more drill-cores.

Information on any or all of the matters (1) to (6) would help to fill important gaps in our understanding of the genesis of the Cape Vogel rocks.

Detailed petrographic studies, numerous chemical analyses, trace-element determinations, micrometric analyses, and refractive index measurements, as well as microprobe analyses of phenocrysts, microlites, and groundmass materials would have to be made to test the validity, or otherwise, of theoretical calculations of the type discussed above, but the required checks could not be carried out with information obtainable only from the specimens already in hand. In fact, it has turned out that the main role of the new material collected in 1964 has been to point to additional and previously quite unsuspected gaps in our knowledge (see points (1) to (6) above); these gaps are serious barriers to progress towards elucidating the genesis of the rocks, and emphasize the necessity for obtaining material which may help to answer at least some of the important questions which have arisen. This material can be obtained only by drilling.

The discovery of rocks containing a petrogenetically important polymorph (clinoenstatite) of $Mg\,SiO_3$ not previously found in terrestrial rocks should provide sufficient encouragement to carry out further work at Cape Vogel, but when this mineral makes up about 70 percent of one of the specimens already examined, the stimulus is even greater. If the Bureau does not make a serious effort in the Cape Vogel area, some other organization may well step in.

Information obtained by drilling would undoubtedly also be of importance in interpreting the results of magnetic and gravity work to be undertaken in Papua, and would fit in with J.E. Thompson's proposals for geological mapping and other investigations in Eastern Papua. Both the regional work and the more detailed studies on Cape Vogel would complement the work of H.L. Davies, who is investigating an hypothesis that the Papuan Ultramafic Belt is an up-faulted segment of the mantle.

It is considered essential that explanation of the clinoenstatite occurrence be sought not only in terms of petrography and chemistry, but also in terms of the tectonic and volcanic processes which together have brought to the surface a unique magma rich in magnesia as well as silica. Any petrogenetic interpretation must, therefore, take into account the possibility of a direct connection between the clinoenstatite-bearing rocks and magma sources at rarely tapped depths within the mantle. Thus it is important that the thickness and composition of the crust, both in the immediate Cape Vogel area and in the Eastern Papuan region as a whole, be investigated by geophysical means, supported by field mapping and petrological studies, especially of the basic and ultramafic rocks of the region.

REFERENCE

GREEN, D.H., and RINGWOOD, A.E., 1966 - The genesis of basaltic magmas, _in_ Petrology of the upper mantle. Publ. No. 444, Dept. of Geophysics and Geochemistry, A.N.U., pp. 118-205.

APPENDIX I

PUBLICATIONS

BULLETINS

In press, in preparation, or projected

No 76	Branch, C.D.	The volcanic cauldrons, ring complexes, and associated granites of the Georgetown Inlier, Queensland	In press
No 82	Walpole, B.P., Dunn, P.R., Randal, M.A., Crohn, P.W.	The geology of the Katherine-Darwin Region, Northern Territory	Edited and ready for printer
No 84	de Keyser, F., Lucas, K.G.	The geology of the Hodgkinson Basin, Queensland	95% edited. Awaiting contribution by K.G. Lucas
No 88	Richards, J.R.,[+] White, D.A., Webb, A.W., Branch, C.D.	Isotopic ages of acid igneous rocks in the Cairns hinterland, north Queensland	In press
No 93	Blake, D.H., Miezitis, Y.	Geology of Bougainville and Buka Islands, Territory of Papua and New Guinea	Edited ready for printer
	Dunn, P.R., Roberts, H.G., Smith, J.W.	Geology of the Carpentaria Proterozoic Province, N.T. Part 1: Roper River to the Queensland border	Writing in progress
	Roberts, H.G., Plumb, K.A., Dunn, P.R.	Geology of the Carpentaria Proterozoic Province, N.T. Part 2: Arnhem Land	Writing in progress
	Dow, D.B., Gemuts, I.[@]	Precambrian geology of the Kimberley Region: East Kimberley	Writing in progress
	Plumb, K.A.	Precambrian geology of the Kimberley Region: The Kimberley Basin	Writing to begin in 1967.
	Gellatly, D.C., Sofoulis, J., Derrick, G.M.	Precambrian geology of the Kimberley Region: West Kimberley	Writing to start in 1967
	Blake, D.H., Smith, J.W., Yates, K.R.	Geology and mineral resources of the Herberton/Mount Garnet area Queensland	Writing in progress
	Paine, A.G.L.,[*] Wyatt, D.H.	The geology of the Charters Towers-Bowen Region, Queensland	Writing to start in 1967

Footnote: + Australian National University
@ Geological Survey of Western Australia
* Geological Survey of Queensland
x University of Queensland

REPORTS

In press, in preparation or projected

No 83	Crohn, P.W. Oldershaw, W.	The geology of the Tennant Creek one-mile Sheet area, N.T.	In press
No 101	Oldershaw, W.	Geological and geochemical survey of the Captains Flat area, New South Wales.	In press
No 105	Yates, K., de Ferranti, R.	The geology and mineral resources of the Port Moresby-Kemp Welch area, Papua.	In press
No 106	Beevers, J.R.	A chemical investigation of the potential role of sorption in ore genesis	In press
No 114	Dunnet, D., Harding, R.R.	Geology of the Mount Woodcock 1-mile Sheet area, Northern Territory	Editing completed.
No 115	Trail, D.S.	Mineralized Tertiary rocks of Woodlark Island, New Guinea	In press
No 117	Harding, R.R.	Catalogue of age determinations carried out by the K-Ar, Rb-Sr, Re-Os, and Pb-alpha methods on Australian rocks between June, 1962, and December, 1965	In press

No 126	Paine, A.G.L., Harding, R.R.*, Clarke, D.E.*	The geology of the north-eastern part of the Hughenden 1:250,000 Sheet area, Queensland	With the editor.
No 127	Wyatt, D.H.,* Paine, A.G.L., Harding, R.R.*, Clarke, D.E.*	The geology of the Townsville 1:250,000 Sheet area, Queensland	With the editor
No 128	Paine, A.G.L., Gregory, C.M.*, Clarke, D.E.*	The geology of the Ayr 1:250,000 Sheet area, Queensland	With the editor
	Wyatt, D.H.,* Paine, A.G.L.,* Clarke, D.E.,* Gregory, C.M., Harding, R.R.	The geology of the Charters Towers 1:250,000 Sheet area, Queensland	Being edited within Section
	Paine, A.G.L., Gregory, C.M.*, Clarke, D.E.*	The geology of the northern half of the Bowen 1:250,000 Sheet area, Queensland (with additions to the geology of the southern half).	Writing in progress
	Clarke, D.E.,* Jensen, A.R., Paine, A.G.L.	The geology of the Proserpine 1:250,000 Sheet area, Queensland	Writing to start in 1967
	Pontifex, I.R.	Mineragraphic investigations, 1964-1965.	With the editor
	White, D.A., Shields, J.W., Ivanac, J.F.	The Union Reefs Goldfield, N.T.	Final draft complete and edited
	Roberts, H.G., Gemuts, I., @ Halligan, R. @	Adelaidean and Cambrian stratigraphy of the Mount Ramsay 1:250,000 Sheet area, Kimberley Region, Western Australia	Writing complete-being edited within Section
	Dow, D.B.	Palaeozoic rocks of the East Kimberley Region, Western Australia.	Writing in progress

OUTSIDE PUBLICATIONS

PUBLISHED

Dow, D.B.	Evidence of a late Precambrian glaciation in the Kimberley Region of Western Australia	Geological Magazine 102, 407-14
Branch, C.D.	The structure and evolution of the volcanic cauldrons, ring complexes, and associated granites of the Georgetown Inlier, Queensland	Nature, 209, 606- 7

Richards, J.R.,[+] White, D.A., Webb, A.W., Branch, C.D.	Chronology of the acid igneous rocks of North Queensland, Australia	Earth and Planetary Science Letters 1, 107-9
Compston, W.,[+] Crawford, A.R.,[+] Bofinger, V.M.	A radiometric estimate of the duration of sedimentation in the Adelaide Geosyncline, South Australia.	Jour. Geol. Soc. Aust., 13, 229-76
McDougall, I.,[+] Leggo, P.J.	Isotopic age determinations on granitic rocks from Tasmania.	Jour. Geol. Soc. Aust. 12, 295-332
Richards, J.R.,[+] Berry, H.,[+] Rhodes, J.M.	Isotopic and lead-alpha ages of some Australian zircons	Jour. Geol. Soc. Aust., 13, 69-96.
Heier, K.S.,[+] Rhodes, J.M.	Thorium, uranium and potassium concentrations in granites and gneisses of the Rum Jungle Complex, N.T.	Economic Geology 61, 563-71
de Keyser, F.,	Arfvedsonite in granites of the Ingham district, North Queensland.	Contributions to Mineralogy & Petrology, 12, 315-24.
Dallwitz, W.B., Green, D.H.,[+] Thompson, J.E.	Clinoenstatite in a volcanic rock from the Cape Vogel area, Papua.	Jour. Petrology 7 (3)

OUTSIDE PUBLICATIONS

In press or in preparation

Branch, C.D.	The source of eruption for pyroclastic flows: cauldrons or calderas.	Bull.volc. v. 29(i) in press
Branch, C.D.	Genesis of magma for acid calc-alkaline volcano-plutonic formations.	Tectonophysics in press.
McDougall, I.,[+] Compston, W.,[+] Bofinger, V.M.	Isotopic age determinations on rocks from Victoria, Australia: a revised estimate of the age of the Devonian-Carboniferous boundary.	Bull. Geol. Soc. Amer. in press.
Arriens, P.A.,[+] Brooks, C.,[+] Compston, W.,[+] Bofinger, V.M.	The discordance of mineral ages in granitic rocks resulting from post-crystallization redistribution.	Jour. Geophys. Res. in press
Dunn, P.R., Plumb, K.A., Roberts, H.G.	A proposal for time-stratigraphic subdivision of the Australian Precambrian.	Jour. Geol. Soc. Aust. in press.
Roberts, H.G., Gemuts, I.,[o]	Evidence of two major late Precambrian glaciations in the Kimberley Region of Western Australia.	Jour. Geol. Soc. Aust. in prep.
Webb, A.W.	A comparison of mineral and whole-rock K/Ar ages of Tertiary volcanic rocks from central Queensland.	Jour. Geol.Soc. Aust. in prep.

Webb, A.W., Stevens, N.C.,[x] McDougall, I.[+]	Isotopic age determinations on Tertiary volcanic rocks in south-east Queensland.	Proc. Roy. Soc. Qld. in prep.

RECORDS

Completed and Issued 1966

1965/93	The geology of the N.E. part of the Hughenden 1:250,000 Sheet area, Qld.	A.G.L. Paine, R.R. Harding, D.E. Clarke*
1965/109	Petrography and petrology of rock specimens from the Port Moresby- Kemp Welch area, Papua.	A.S. Joyce
1965/112	Geological report on the Great Davenport Gold Prospect, Kurundi Goldfield	W.S.Yeaman
1965/117	A complete programme for the calculation of the Barth mesonorm	W.R. Morgan
1965/118	The igneous petrology of the Cooktown 1:250,000 Sheet area, North Queensland	W.R.Morgan
1965/127	Minor metalliferous investigations, N.T. Resident Geological Section.	A.Vanderplanck, P. Rix, P.W.Crohn, J. Barclay
1965/132	Mineralogical investigation of ore specimens from the Astrolabe Mineral Field, Papua	I.R. Pontifex
1965/156	Geology of the Mount Ramsay 1:250,000 Sheet area, W.A.	H.G.Roberts,@ R. Halligan I. Gemuts @
1965/158	Geochemical prospecting at McArthur River, N.T.	A.D. Haldane
1965/159	The geology of the Townsville 1:250,000 Sheet area, Queensland	D.H. Wyatt* A.G.L. Paine R.R. Harding D.E.Clarke*
1965/161	Geology and mineral deposits of the Port Moresby-Kemp Welch area, Papua	K.R. Yates R.Z. de Ferranti
1965/168	Geology of the Mount Woodcock one-mile Sheet, Tennant Creek area, Northern Territory.	D.Dunnet R.R. Harding
1965/172	Visit to Kalgoorlie and Norseman Goldfields	I.R. Pontifex N.W. Le Roux
1965/174	Explanatory notes on Cambridge Gulf 1:250,000 Geological Sheet, SD/52-14, Western Australia	K.A. Plumb J.J. Veevers

1965/201	The geology of the Union Reefs area, N.T.	D.A. White, J.W. Shields, J.F. Ivanac
1965/202	Percussion drilling in New Guinea during 1962 and 1963	R.G. Horne M.D. Plane
1965/204	Geochemical sampling, Michelago area, N.S.W.	J.F. Ivanac N.J. Marshall
1965/209	Miscellaneous chemical, petrographic, and mineragraphic investigations carried out in the Geological laboratory, January-December, 1965	compiled by E. Woodhead
1965/210	The geology of the Lansdowne 1:250,000 Sheet area, SE/52-5, W.A.	D.C. Gellatly, G.M. Derrick, K.A. Plumb
1965/214	Rum Jungle area, 1965. Summary of activites	C.E. Prichard, J.F. Ivanac
1965/217	Metalliferous Section, Geological Branch Summary of activities, 1965	-
1965/231	History of manganese development - Groote Eylandt	P.W. Crohn, P.R. Dunn
1965/234	Geochemical sampling at Tennant Creek, N.T., 1964-1965	W.S. Yeaman
1965/247	Notes on a field trip to the Northern Territory, 1965	P.R. Dunn
1965/252	Radiometric ages of acid igneous rocks in the Cairns Hinterland, northern Queensland	J.R. Richards,+ D.A. White, A.W. Webb, C.D. Branch
1965/254	Geochemical and radiometric survey, Rum Jungle, N.T. 1964	R.G. Dodson, D.O. Shatwell
1966/22	Catalogue of age determinations carried out by the K-Ar, Rb-Sr, Re-Os, and Pb-α methods on Australian rocks between June, 1962, and December, 1965	R.R. Harding
1966/34	Geochemical and radiometric investigations, Rum Jungle East area, 1965 (Coomalie Gap West and Woodcutters areas).	D.O. Shatwell
1966/55	Geology of the Drysdale-Londonderry 1:250,000 Sheet area, W.A.	D.C. Gellatly J. Sofoulis @
1966/62	The geology of Bougainville and Buka Islands, Territory of New Guinea.	D.H. Blake Y. Miezitis
1966/68	The geology of the Ayr 1:250,000 Sheet area, Queensland	A.G.L. Paine C.M. Gregory D.E. Clarke
1966/81	Geology of the Ashton 1:250,000 Geological Sheet area, SD52-13, Western Australia.	G.M. Derrick
1966/96	Geochemical investigations in the Kalgoorlie and Norseman area, Western Australia	N.W. Le Roux

1966/97	Geochemical investigations in the Kalgoorlie area, Western Australia - Progress report	N.W. Le Roux
1966/121	Miscellaneous chemical, petrographic, and mineragraphic investigations carried out in the Geological laboratory. Part 1 January-June, 1966	compiled by E. Woodhead
1966/128	Chemical investigations during the year 1958, January-December	compiled by E. Woodhead
1966/130	Kalgoorlie geochemical project report, 1966	J.R. Beevers
1966/135	Report on copper occurrences, Durack River - Salmond River district, Kimberley Division, W.A.	H.G. Roberts G.M. Derrick J.F. Ivanac
1966/143	Trace element analysis by X-ray spectroscopy with emphasis on the determination of barium, lead, nickel, and zinc.	J.M. Rhodes
1966/151	Chemical investigations during the year 1960	compiled by E. Woodhead
1966/154	Gould area geochemical and geophysical surveys, Rum Jungle area, Northern Territory 1965	D.O. Shatwell, K. Duckworth

RECORDS (In Preparation)

1965/150	Multi-element solvent extraction in Atomic Absorption Analysis	N.J. Marshall
1965/206	Report on Perth-Kalgoorlie visit May 31st to June 4th, 1965. Part 1. Perth Spectroscopy Conference. Part 2. Collection of samples for Tellurium and Selenium Analysis, Kalgoorlie	N.J. Marshall
1965/242	Metamorphism and igneous activity in the Lamboo Complex, East Kimberley area, Western Australia	I. Gemuts G
1966/18	Specialist assistance in atomic absorption techniques	C.S. Rann
1966/78	Celia Dolomite reconnaissance, Rum Jungle district, N.T., 1965	D.O. Shatwell
1966/136	Geology of the Mount Elizabeth 1:250,000 Sheet area, SE/52-1, Western Australia	H.G. Roberts W.J. Perry
1966/167	The mines and mineral deposits of the Katherine-Darwin area	P.W. Crohn
1966/172	A proposal for time-stratigraphic subdivision of the Australian Precambrian	P.R. Dunn K.A. Plumb H.G. Roberts
1966/179	The geology of southern New Ireland	D.J. French
	Geology of the Montague Sound 1:250,000 Sheet area, SD51-12, Western Australia	A.D. Allen G

Geology of the Medusa Banks 1:250,000 Sheet area, SD52-10, Western Australia	K.A. Plumb W.J. Perry
Geology of the Mount Elizabeth 1:250,000 Sheet area, SE52-1, Western Australia	H.G. Roberts W.J. Perry
Geology of the Prince Regent-Camden Sound 1:250,000 Sheet area, SD51-16, 15, Western Australia	I. Williams © J. Sofoulis ©
Geology of the Yampi 1:250,000 Sheet area, SE 51-3, Western Australia	J. Sofoulis © D.C. Gellatly G.M. Derrick C.M. Morgan R. Farbridge ©
Geology of parts of the Lennard River and Charnley 1:250,000 Sheet areas Western Australia	D.C. Gellatly© J. Sofoulis G.M. Derrick C.M. Morgan R. Farbridge ©
Explanatory notes to the Charnley 1:250,000 Sheet area, SE 51-4, Western Australia	R. Halligan © J. Sofoulis ©
The geology of the Charters Towers 1:250,000 Sheet area, Queensland	D.H. Wyatt* A.G.L. Paine D.E. Clarke* C.M. Gregory R.R. Harding
The geology of the northern half of the Bowen 1:250,000 Sheet area, Queensland (with additions to the geology of the southern half)	A.G.L. Paine, C.M. Gregory, D.E. Clarke *
The geology of the Proserpine 1:250,000 Sheet area, Queensland	D.E. Clarke,* A.R. Jensen, A.G.L. Paine
The economic geology of the Townsville 1:250,000 Sheet area, Queensland	K.R. Levingston*
The economic geology of the Charters Towers 1:250,000 Sheet area, Queensland	K.R. Levingston*
The geology of the Herberton and Mount Garnet 1-mile Sheet areas	D.H. Blake, J.W. Smith, K.R. Yates
Regional multi-element geochemical survey-Ayr 1:250,000 Sheet area, Queensland	N.J. Marshall
The use of jet-boats in New Guinea	D.B. Dow
The geology of the eastern part of the South Sepik area	D.B. Dow, J.A. Smit, P. McNab, J.H.C. Bain
Percussion and diamond core-drilling in New Guinea, 1964	R.G. Horne

Pre-Mesozoic geology of the Walsh, Hann River, and Ebagoola 1:250,000 Sheet areas, Queensland	D.S. Trail, I.R. Pontifex W. Willmott D. Palfreyman W. Whitaker*
Silicate analysis by X-ray fluorescent spectroscopy	J.M. Rhodes
A rapid method for the assaying of gold-bearing samples by solvent extraction and atomic absorption spectrophotometry	J.R. Beevers
Theory and practice of solvent extraction applied to atomic absorption spectrophotometry	J.R. Beevers
Regional geochemical survey, Hale River, Amadeus Basin, N.T.	A.S. Wiria Sumita W.O. Hibberson
Investigations of cold extractable copper, lead, and zinc in geochemical samples	J.R. Beevers
The application of the direct reading optical spectrograph to the analysis of geological materials	K.R. Walker
A study of element behaviour in the arc and of analytical control in silicate analysis optical emission spectroscopy	K.R. Walker
A comparison of optical emission spectrographic analytical methods and of values obtained by them for geochemical standards	K.R. Walker
Primary element dispersions in the Urguhart shale, particularly in relation to mineralization at Mt. Isa, N.W. Queensland	K.R. Walker S.E. Smith
Distributions of elements with progressive metamorphism	K.R. Walker A.S. Joyce
A petrological and chemical study of the Hart dolerite, N.W. Western Australia	K.R. Walker and others
A study of the basic igneous rocks of the Lower Proterozoic of N.W. Queensland	K.R. Walker

MAPS AND EXPLANATORY NOTES

(1966 progress indicated by underlining)

1:250,000 Sheet Area	Field Work	Map Prelim. Edit.	Coloured Edit.	Authors	Explanatory Notes Record	Publication
Cooktown	1962-63	1964	1966	(de Keyser, F. (Lucas, K.G.	1962/149	1966
Cape Melville	1962-63	1964	1966	(de Keyser, F. (Lucas, K.G.	1964/93	1966
Ingham	1962-63	1964	1966	de Keyser, F., Fardon, R.S.H., Cuttler, L.G.	1964/78	1966
Walhallow	1961-62	1963	1966	Plumb, K.A., Rhodes, J.M.	1963/116	1966
Milingimbi	1962	1963	1965	Rix, P.	1963/115	1966
Mount Marumba	1962	1964	1966	Roberts, H.G., Plumb, K.A.	1963/148	1966
Arnhem Bay-Gove	1962	1964	With printer	Dunnet, D.	1964/62	Printed, awaiting map
Blue Mud Bay-Port Langdon	1962	1964	With printer	Plumb, K.A., Roberts, H.G.	1964/67	Printed, awaiting map
Gordon Downs	1962	1963	Ready for fair drawing	Smith, J.W., (G) Gemuts, I.	1963/120	With editor
Dixon Range	1962-63	1964	Ready for fair drawing	Dow, D.B., Gemuts, I. (G)	1964/56	With editor
Lissadell	1963	1964	With editors	Dunnet D., Plumb, K.A.	1964/70	Draft complete
Cambridge Gulf	1963	1966	Corrections being made	Plumb, K.A., Veevers, J.J.	1965/174	In progress
Lansdowne	1964	1965	Ready for fair drawing	Gellatly, D.C., Derrick, G.M.	1965/210	With editor
Mount Ramsay	1964	1966	Ready for fair drawing	Roberts, H.G., Halligan, R. (G) Playford, P. (G)	1965/156	With editor

1:250,000 Sheet Area	Field Work	Prelim. Edit.	Coloured Edit.	Author	Record	Publication
Mount Elizabeth	1965	With printer	-	Roberts, H.G. Perry, W.J.	1966/136	-
Ashton	1965	With printer	-	Derrick, G.M.	1966/81	-
Drysdale-Londonderry	1965	1966	-	Gellatly, D.C., Θ Sofoulis, J.	1966/55	-
Medusa Banks	1965	Being compiled	-	Plumb, K.A., Perry, W.J.	April, 1967	-
Montague Sound	1965	With printer	-	Allen, A. Θ	Being edited	-
Prince Regent-Camden Sound	1965	With printer	-	Williams, I., Θ Sofoulis, J. Θ	In preparation	-
Charnley	1965/1966	Being compiled	-	Halligan, R., Θ Sofoulis, J. Θ	-	-
Lennard River	1965-1966	Being compiled	-	?	-	-
Yampi	1966	Being compiled	-	?	-	-
Townsville	1960-1963	1966	-	Wyatt, D.H.*	1965/159	Draft complete
Hughenden	1963	1964	-	Paine, A.G.L. Vine, R.R.	1965/93	Draft by February, 1967
Charters Towers	1963-1964	1966	-	Clarke, D.E.*	Being edited in Section	Draft written
Ayr	1964	1966	-	Gregory, C.M.	1966/68	With editor
Bowen	1961 and 1964-1965	Being compiled	-	Gregory, C.M.	Not started	-
Proserpine	1962 and 1965	Being compiled	-	Clarke, D.E.*	Not started	-
Bougainville	1965	1966	-	Blake, D.H., Miezitis, Y.	1966/62	
Walsh (part)	1966					
Hann River (part)	1966					
Ebagoola (part)	1966					

Other maps

1:500,000 scale

Katherine-Darwin	Being fair drawn
Roper River	Published 1966
McArthur River	Advance copies October, 1966
Arnhem Land	Fair drawing completed
East Kimberley	Compilation completed October, 1966
Kimberley Basin	Compilation to be ready December, 1967
Charters Towers - Bowen	Compilation to be ready December, 1967
Hodgkinson-Laura	With printer
Papuan Ultramafic belt	To be commenced in 1968

1 inch to 1 mile

Tennant Creek	Published, 1966
Mount Woodcock	Preliminary edition issued, 1966
Herberton)	Compilations ready by April, 1967
Mount Garnet)	