COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 123

Annual Summary of Activities Geological Branch 1969

ANNUAL SUMMARY OF ACTIVITIES

GEOLOGICAL BRANCH

1969

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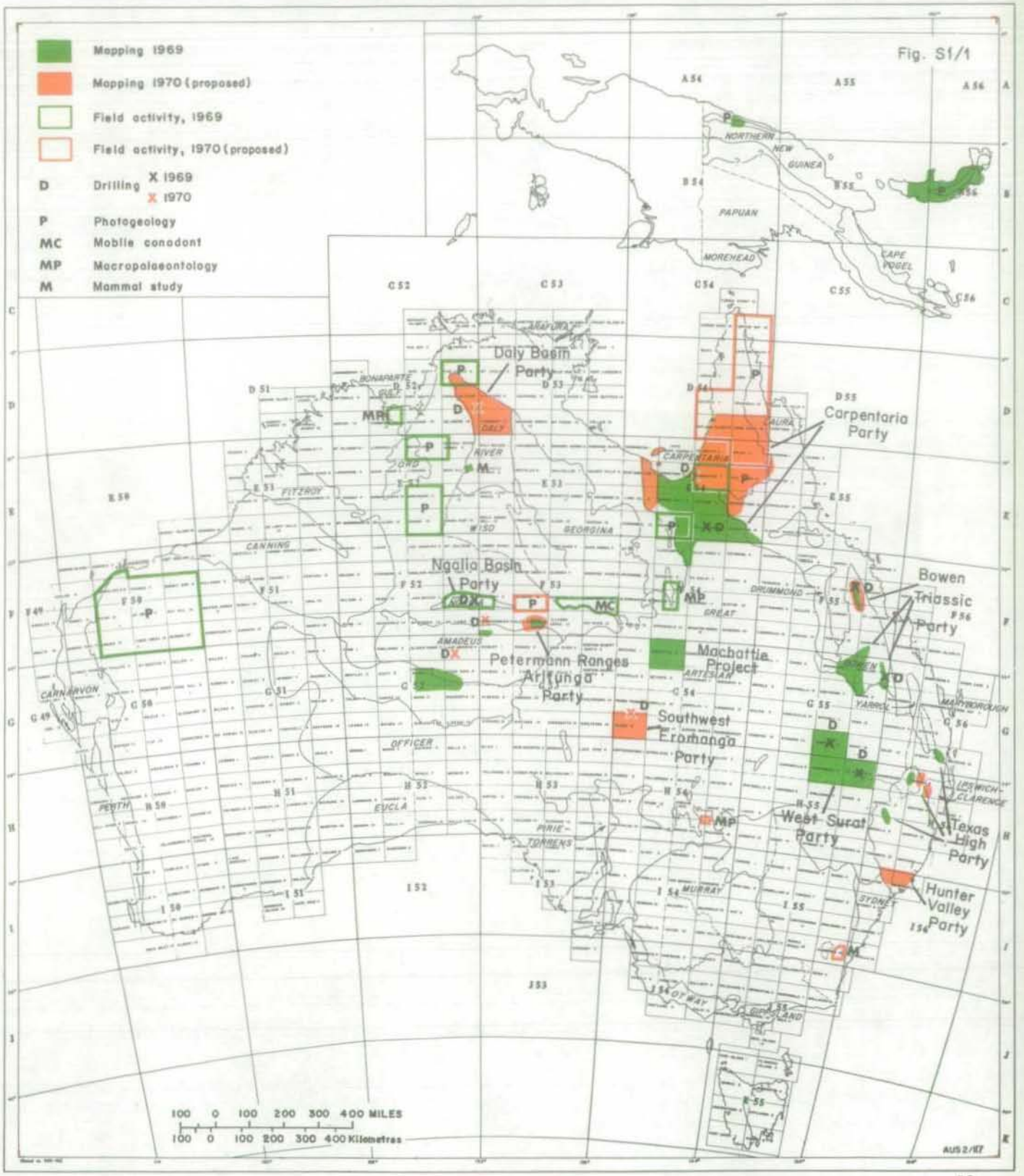


To accompany Record 1969/123

S.D.

S1 - SUMMARY (Fig. S1/1)

During 1969, field activities were conducted in areas ranging from the Bonaparte Gulf Basin in Western Australia to the Australian Capital Territory in eastern Australia.

Field surveys were continued in the West Surat Basin, Machattie and Bowen Basin Triassic of Queensland. The Bowen Triassic project was a continuation of the detailed sedimentological study of 1968. A major project, which will eventually cover the whole of the Carpentaria Basin in northern Queensland, was initiated. In general the stratigraphy of the northern part of the Eromanga Basin continues into the southern part of the Carpentaria Basin.

The Palaeozoic rocks of the Warwick-Drake area of south-east Queensland, particularly the Devonian-Permian sequence, were examined in detail by the Texas High party. A reconnaissance examination of Palaeozoic rocks flanking the Clarence-Moreton Basin in New South Wales was made to compare the section with the similar sequence of the Texas High.

The joint B.M.R.-U.S.G.S. study of the Gosses Bluff impact structure was completed during the year. The project is an excellent example of the advantages of an interdisciplinary approach to a complex problem. The project team consisted of geologists, geophysicists (magnetic, gravity and seismic) and petroleum technologists and the results are expected to provide the most complete evaluation of an impact structure available. The bulletin on the project should be published late in 1971.

The mapping of the southern Precambrian margin of the Amadeus Basin (Mann Ranges & Kelly Hills) was continued with particular attention devoted to metamorphic grades and mineralization. Detailed mapping of the nappe complexes along the north-eastern margin of the Amadeus Basin was continued. Folding and overthrusting of the order of 10-15 miles has been demonstrated. Analysis of the data obtained should provide a detailed structural history of this complex area.

Logging of water bores in the Eromanga and Surat Basins was continued during the year. Gamma-ray and temperature logs were run in 119 bores and flowmeter-caliper logs were recorded in 55 bores.

Stratigraphic drilling was continued in the west Surat Basin (1950'), Carpentaria Basin (2185'), Bowen Basin (3840') and Ngalia Basin (4397') and as in the past has provided valuable stratigraphic information in areas with restricted outcrop data.

Comprehensive palaeontological studies were continued embracing most of the sedimentary basins in Australia and Papua-New Guinea and utilizing material collected by both B.M.R. and company personnel. Of particular interest are the studies by Skwarko on the Cretaceous ammonites of Australia, the Tertiary vertebrate faunas by Plane, Australian trilobite faunas by Shergold and Strusz and conodonts and ostracods by Druce and Jones.

The systematic study of foraminifera, particularly from Papua-New Guinea and New Britain, and the Jurassic-Cretaceous palynology of Queensland have added considerably to stratigraphic information in these areas. The installation of a scanning electron microscope should prove to be a valuable addition to the study of microfossils.

The photogeology group continued the systematic interpretation of sheet areas for field party use. Several special and research projects were completed during the period.

The production of publications and reports remained at a satisfactory level with the publication of 5 bulletins, 3 reports, 15 explanatory notes and 9 external papers. Eighteen records were issued.

S2 - GREAT ARTESIAN BASIN

by

R.R. Vine

Personnel: R.R. Vine (part time)

General: Work during the year concentrated on preparing maps and reports for publication (listed in Chapter S17 under Eromanga Basin). Supervision of the contracts for wireline logging of water bores continued. Logging under the 1968 contract continued in November and December, 1968, and after a break for the wet season in January and February was completed in April 1969; operations were in the southeastern Eromanga Basin and western Surat Basin. Logging under the 1969 contract started in July and was continuing at the end of October; operations were in the Carpentaria Basin and coverage is nearly complete. Details of the logging are summarized in Table 1.

Table 1. Logging 1968-1969

	Month	Logs obtained			
		Gamma-ray	Temperature	Flowmeter/caliper	Electric
1968	November	19	19	14	1
	December	1	1	1	-
	January-February	-	-	-	-
	March	14	14	10	-
	April	8	8	7	-
	May-June	-	-	-	-
1969	July	16	16	9	-
	August	22	22	3	-
	September	24	24	5	-
	October	15	15	6	-
	Totals	119	119	55	1

S3 - EROMANGA BASIN PARTY

by

B.R. Senior

Personnel: B.R. Senior, J.A. Ingram, B.M. Thomas, Daniele A. Senior

General: Mapping of the Eromanga Basin in Queensland was completed in 1968. The early part of 1969 was spent compiling results and writing reports (listed in Chapter S17). These included a paper reporting the value of shallow rotary core drilling in prospecting for opal.

S4 - SURAT BASIN PARTY

by

R.R. Vine

Personnel: N.F. Exon (to August), A. Medvecky

General: Work was concentrated on compiling results and writing reports of mapping in 1968, and preparing for publication the results obtained during the whole of the Surat Basin project (listed in Chapter S17). This includes a summary of the geological evolution of the Surat Basin.

S5 - WEST SURAT BASIN PARTY

by

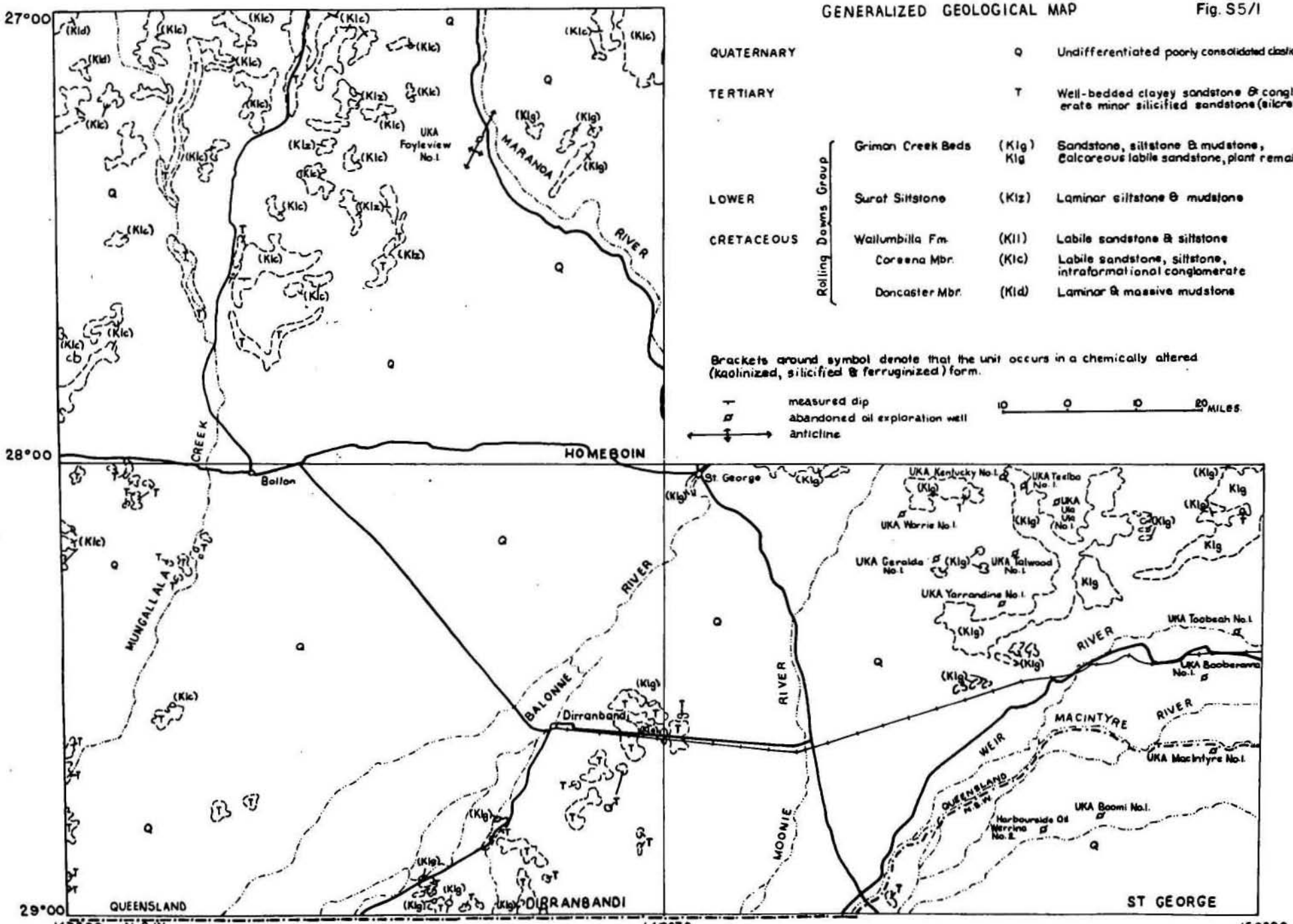
B.R. Senior

Personnel: B.R. Senior (Party Leader), Daniele Senior, Barbara K. Graham

Visitor: R.R. Vine, B.M.R. 18/6/69 - 20/9/69.

Area mapped: Homeboin, Dirranbandi and St. George 1:250,000 Sheet areas.

Aircraft survey: A Cessna 182 chartered from Union Air Pty Ltd was flown for a total of 15 hours in 3 days, excluding positioning time. It was used to plot positions of water bores, main roads and homesteads which post-date the aerial photography, and for geological reconnaissance. The aircraft saved several weeks of field time.



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Q/A306

Drilling: A programme of shallow stratigraphic drilling was started early in October. Progress at 31st October is summarized in Table 1.

Geology: Figure S5/1 is a generalized geological map which illustrates the major structural features and includes a generalized description of each rock unit.

The mapped area lies in the southwest part of the Surat Basin which is separated from the Eromanga Basin partly by the basement Nebine Ridge and partly by the Cunnamulla Shelf. Cretaceous and Jurassic sediments in this area of shallow basement have a combined thickness of approximately 2000 feet. The basement surface slopes gently to the east off the Cunnamulla Shelf and Nebine Ridge into the Surat Basin proper.

Practically all outcrops are strongly chemically altered, and identification of individual rock units is at times questionable. Future stratigraphic drilling will be designed to test the reliability of the mapping.

Cainozoic sediments are widespread, and occur mainly in two elongate depressions (Fig. S5/2) which extend into New South Wales.

Drillers' logs of water bores record the deposits as drift sand, gravel, conglomerate and clay. Stratigraphic drilling is planned to determine the nature and age of these deposits.

Hydrology: During the course of the field work 79 samples of water were collected from bores tapping aquifers in Jurassic and early Cretaceous sandstone. The head space gas in the sample bottles was analysed for hydrocarbon gas by the Petroleum Technology Section and A.M.D.E.L. The results were disappointing. Of 35 analyses available to date, only 11 indicate the presence of methane. Ethane was not detected in any of the samples. The results indicate that by improving the sampling technique a worthwhile study could be carried out in the future.

Conductivity measurements were made on all bores visited during the field work. The results have yet to be evaluated, but previous work in adjacent areas has shown that individual aquifers have characteristic conductivity values.

TABLE 1 DRILLING IN WEST SURAT AREA

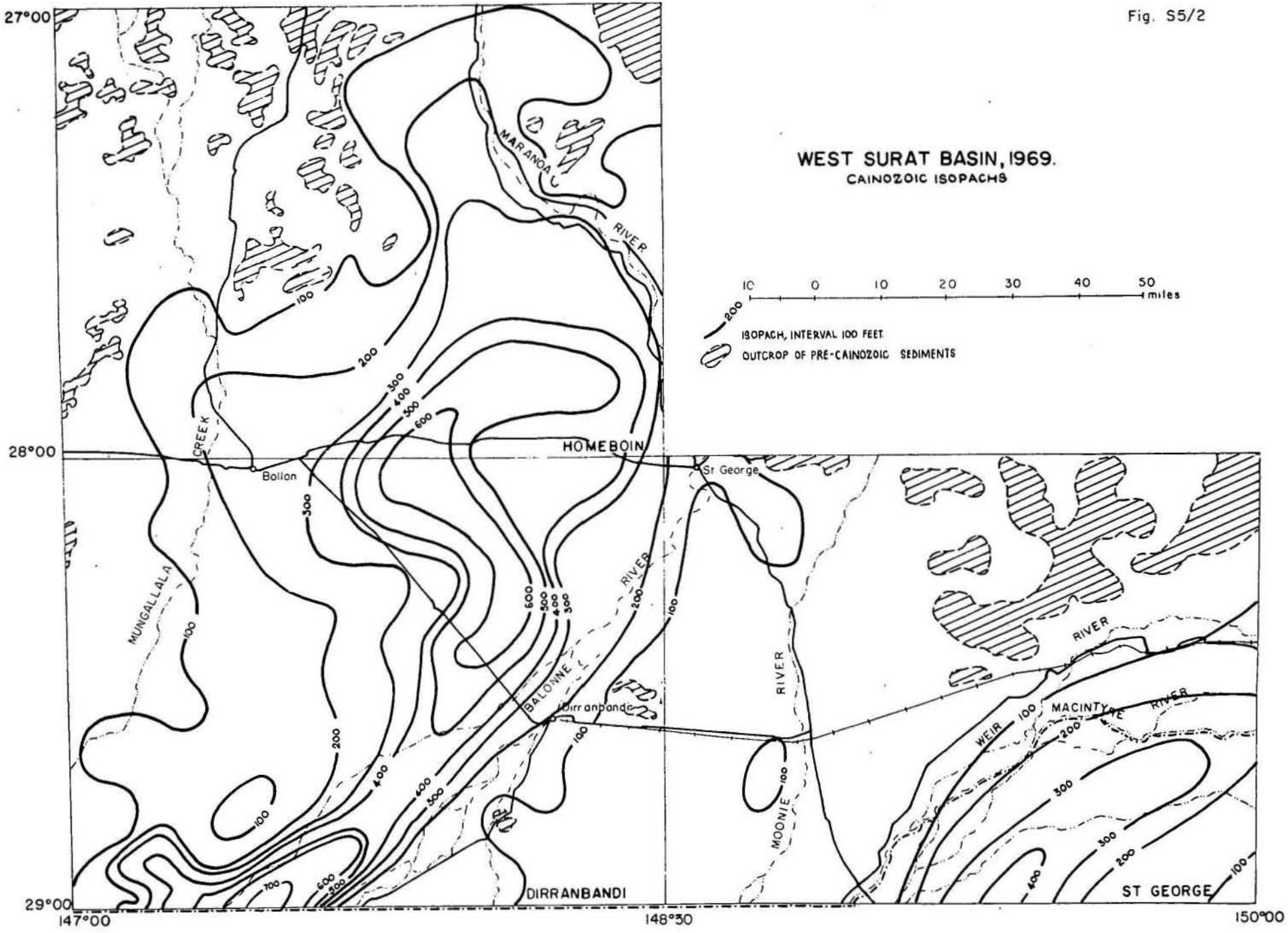
(1 to 31st October, 1969)

BMR Scout Hole	Drilled (feet)	Cored (feet)	Recovery (feet)	Results
Homeboin 1	450	29	24'5"	Obtained Coreena Member cores for palynology, disproved possible Coreena/Doncaster Member contact.
Homeboin 2	170	30	25'6"	Obtained Surat Siltstone core for palynology. Established Surat Siltstone/Coreena Member contact.
Homeboin 3	480	20	13'2"	Established that very thin Cainozoic sediments occur in the Maranoa River valley. Obtained cores of Griman Creek Formation for palynology.
St. George 1	240	20	18'4"	Proved presence of Griman Creek Formation below thin Quaternary sediments.
St. George 2	390	10	7'4"	Proved the presence of Griman Creek Formation below thick Quaternary sediments.
Dirranbandi 2	220	20	17'8"	Successfully recovered cores of fresh Cretaceous for palynology.
Totals	1950	129	106'6"	

Fig. S5/2

WEST SURAT BASIN, 1969.

CAINOZOIC ISOPACHS



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9/A307

S6 - MACHATTIE PROJECT

by

B.R. Senior

Personnel: B.R. Senior, B.K. Graham & D.A. Senior

Discussion: The Machattie 1:250,000 Sheet area was partly re-mapped during August 1969. Mapping of adjacent areas in 1966 made it obvious that the geology of the Machattie area was more complicated than the original interpretation; in particular the Winton Formation is much more extensive than originally shown. The boundary between the non-marine Winton Formation and marine Mackunda Formation was mapped. An abundant, though restricted, fauna of the pelecypod Inoceramus sp., rare belemnites and sharks' teeth were found at about 25 localities. Planimetric information on the sheet was up-dated. The basis for a second edition of the Machattie Geological Sheet is available, if required.

S7 - CARPENTARIA BASIN PARTY

by

H.F. Doutch

Organization and Activities

The Carpentaria Basin Party commenced preparations for its first field season in February 1969 and was in the field from the end of May until the end of September.

The Party mapped the 1:250,000 Sheet areas of Millungera, Donors Hill and Burketown, those parts of the Carpentaria Basin in Cloncurry, Dobbyn, Croydon and Gilberton Sheets, and began mapping in the Normanton and Georgetown Sheets.

Party personnel were:

B.M.R. - H.F. Doutch (Party Leader), J. Ingram, J. Smart
Geological Survey of Queensland - K. Grimes

As part of the project -

1. J. Ingram mapped Sweers and Bentinck Islands in the company of Dr. C. Phipps and others of the Geology Department of Sydney University, using a boat chartered for six days.

2. Forty hours were flown in 10 days in a chartered Cessna 182 for the purposes of bore spotting and reconnaissance.

3. A B.M.R. Fox rig drilled 2185 feet in five scout holes (2 on Dobbyn, 2 on Cloncurry and 1 on Richmond), including 315 feet of coring with 75% recovery.

4. The party worked closely with the Millungera Gravity Party (BMR), which carried out a detailed gravity survey around and between Mts Brown and Fort Bowen in the Millungera Sheet area.

Geology of the Carpentaria Basin (Fig. S7-1)

The stratigraphy of the northern part of the Eromanga Basin continues generally into the southern part of the Carpentaria Basin.

The oldest rocks in this part of the Carpentaria Basin are quartzose sandstone, siltstone and conglomerate which crop out along its eastern margin. A condensed and incomplete part of this succession, east of Croydon, was named the Gilbert River Formation by earlier workers, a name eventually applied to all the Mesozoic rocks in the Gregory Range and their equivalents elsewhere. Vine, in his Explanatory Notes for the Richmond Sheet area, divided the formation into a lower cross-bedded sandy unit, a middle silty unit, and a partly sub-labile upper unit for which he retained the name 'Gilbert River Formation'. However, the middle unit can be traced into the Croydon area where it is equivalent to most of the Gilbert River Formation as originally defined, and the top unit (Vine's 'Gilbert River Formation') was not deposited in the Croydon area. The middle unit, to which the name 'Gilbert River Formation' should eventually be restricted, contains pelecypods and brachiopods between Croydon and Glenora Homestead, but elsewhere is fluviatile in origin. The top and bottom units have not yet been formally named; they are both probably fluviatile. All three units were undivided on the accompanying map as a Gilbert River Formation sensu lato pending further detailed study of the measured sections. Total thickness varies from 500 feet for the three units in the Richmond area to less than 200 feet for the two lower units in the Croydon area.

The Wallumbilla Formation, which conformably overlies Vine's 'Gilbert River Formation' in the north of the Eromanga Basin, continues into the Carpentaria Basin. Here, most of the formation is concealed by soils and Cainozoic piedmont deposits and is known mainly from water bores and scout holes; in the Burketown and Karumba wells it has been called the Blackdown Formation, for which the type area is further north near Wrotham Park in Cape York Peninsula. The names are probably synonyms. Both units are predominantly grey shaly mudstone. In the Carpentaria Basin the Wallumbilla Formation is about 600 feet thick; it cannot be subdivided at this stage into the members recognized in the northern Eromanga Basin.

CARPENTARIA BASIN PARTY
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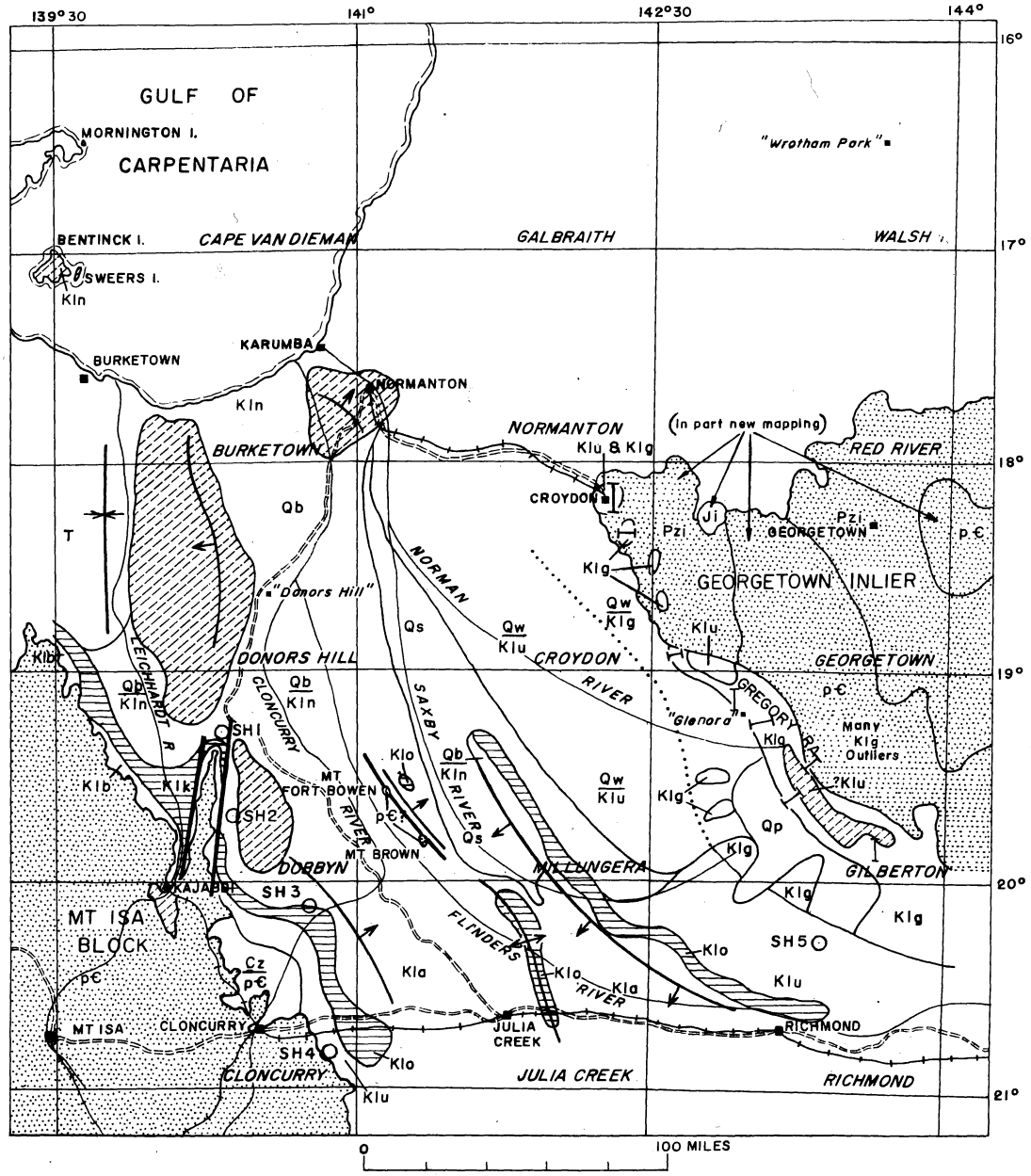

CAINOZOIC

QUATERNARY
- Cz Undifferentiated
- Qs Sand, partly aeolian
- Qb Black soil
- Qw Outwash sand, partly consolidated
- Qp Older red piedmont sand on ferricrete
- Duricrust

TERTIARY
- T Leichhardt River Beds — quartz-sandstone and conglomerate

MESOZOIC

LOWER CRETACEOUS
- Kln Normanton Formation — sandstone and mudstone
- Kla Allaru Mudstone
- Klk Kamileroi Limestone
- Klo Toolebuc Limestone
- Klb Blackdown Formation } Mudstone
- Klu Wallumbilla Formation }

UPPER JURASSIC? – LOWER CRET
- Klg Gilbert River Formation — conglomerate, sandstone, shale

TRIASSIC (OR JURASSIC?)
- Ji Inoruni Sandstone

PERMIAN
- Pzi Igneous rocks

PRECAMBRIAN
- p€ Undifferentiated

- Inferred boundary, concealed
- Regional dip
- Detailed section
- SH5 Scout hole
- Fault
- Road
- Railway
- "Glenora" Homestead

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However, conformably overlying the Gilbert River Formation sensu lato in the Gilberton, Georgetown and Croydon Sheet areas are scattered hilltop remnants of a weathered labile sandstone which originally contained few or no quartz grains and which is now leached to a granular clay rock. This unit can be interpreted as a local basal sandy member of the Wallumbilla Formation; marine pelecypods have been collected near Croydon.

The Toolebuc Limestone conformably overlies the Wallumbilla Formation in the Eromanga Basin and can be traced northwards into the Carpentaria Basin in the Millungera Sheet area. The Kamileroi Limestone in the Dobbyn Sheet area crops out sporadically north and south of the type area and appears to be the continuation of the Toolebuc Limestone of the northwest Eromanga Basin; gamma ray logging, currently in progress, is expected to confirm the identity of the two formations. The lithology of the composite unit varies from calcilutite and calcarenite to calcareous mudstone and sandstone. Fossils are plentiful - fish scales and pelecypods are common in the east and belemnites in the west. The thickness of the unit in water bores is between 20 feet and 60 feet.

Conformably overlying the Toolebuc Limestone in the Eromanga Basin is the Allaru Mudstone, a grey mudstone very similar to the Wallumbilla Formation. The Allaru Mudstone crops out poorly in the Carpentaria Basin, but its continuity from the Eromanga Basin can be demonstrated from water bores and scout holes northwards as far as Karumba and Burketown, where it is the lower part of the Normanton Formation.

The unit is also characterized by lenses of cone-in-cone calcareous siltstone, and by a northward increase in the proportion of sandstone. Some calcareous beds are fossiliferous. The thickness of the formation in the Karumba well is 650 feet.

Outcrops of the upper part of the Normanton Formation, the youngest Cretaceous unit in the Carpentaria Basin, are common between Donors Hill, Burketown and Normanton, but most have been affected by a deep weathering process ('duricrusting') associated with an old Cainozoic land surface. Labile sandstone and siltstone, locally calcareous, predominate in the formation, in which some beds contain Lower Cretaceous ammonites, pelecypods and belemnites. The upper Normanton Formation is 750 feet thick in the Karumba well. It is intended to restrict the name 'Normanton Formation' to this upper arenitic part. It is probably equivalent to the Mackunda Formation in the Eromanga Basin.

Cainozoic sediments in the Carpentaria Basin are rarely more than 100 feet thick. They can be classed into five groups, four characterized by particular depositional environments and a miscellaneous group which includes ferricrete, duricrust, travertine and alluvium. The four depositional groups are (1) Tertiary fluviatile sand and pebble beds, deposited in a downwarp in the Leichhardt River area. (2) Quaternary silt and clay, derived from

Cretaceous mudstone formations and deposited by an ancestral Flinders River and its tributaries between the Eromanga Basin and the Gulf of Carpentaria. (3) Quaternary quartzose sands, which spread out as a wide piedmont apron west and south of the Gregory Range, and which are the erosional product of the Gilbert River Formation (sensu lato) and older igneous and metamorphic rocks of the range. (4) Pleistocene and recent beach rock and sand, occurring as a well preserved series of successively abandoned strands parallel to the present shores of the Gulf of Carpentaria.

The structure of the southern part of the Carpentaria Basin is essentially an asymmetrical basin, probably fault controlled along its western margin in contrast to a regional dip west of $\frac{1}{2}^{o}$-1^{o} along its eastern margin. However, post-depositional uplift along the axis of the basin, between Julia Creek and the southeast corner of the Gulf of Carpentaria, produced the faulted basement inliers of Mts Brown and Fort Bowen in the Millungera Sheet, and an upwarp of the duricrust further north, to which the downwarp in the Leichhardt River area was complementary. Uplift of Cretaceous rocks and basement to form the Gregory Range probably occurred during the same tectonic episode.

Basement Rocks

Basement rocks cropping out along the western margin of the Basin were not systematically examined.

In the Millungera Sheet, along the axis of the Basin, the inliers of Mts Brown and Fort Bowen are east-tilted fault blocks on both geological and geophysical evidence. Mt. Brown is composed of schist and undoubtedly is part of the Carpentaria Basin basement - unmetamorphosed sandstone and conglomerate (at Mt. Fort Bowen) may be part of the sedimentary sequence in the basin rather than basement rocks.

Around the Basin's eastern margin, basement rocks were mapped in a number of places; in the Georgetown Sheet the Inoruni Sandstone was re-examined; no fossils were found, but on tectonic grounds its age is more likely to be Triassic than Jurassic. Basalt and dolerite occur as inliers in the Inoruni Sandstone; they appear to be part of a Permian (?) basic province not previously recognized. In the Gilberton Sheet area previously unmapped Precambrian rocks were found to belong to an older gneiss and almandine amphibolite suite and younger granite and upper greenschist suite. The younger suite resembles the Cape River Beds in the Hughenden and Charters Towers area; roof pendants in granite in Clarke River Sheet were mapped as similar units. The Burdekin River Fault Zone appears to separate the high and low grade metamorphic domains.

S8 - BOWEN TRIASSIC PARTY

by

P.J. Alcock & A.R. Jensen

Personnel: P.J. Alcock, A.R. Jensen (6/8/69 to 10/9/69)

Duration of Field Work: 24/5/69 to 24/9/69

Drilling: Thirteen holes were drilled with a B.M.R. Fox rig during the period 3/6/69 to 25/7/69. The drilling was undertaken to obtain cores and cuttings for palynology and sedimentology studies. Details of the holes and some preliminary results are shown in Table I.

Rewan-Clematis Study: Preliminary examination of all sandstone samples from measured stratigraphic sections in the Clematis Sandstone and Rewan Formation confirmed the basic three-fold subdivision (Rewan Formation, lower and upper Clematis Sandstone) made in the early part of the study. A re-examination of cross stratification measurements suggests that the provenance of the Rewan Formation and Clematis Sandstone varies from area to area, but it is the same for both units in any one area. On the basis of the combined results of field observations, preliminary petrographic study, and heavy mineral analysis, the Lower and Middle Triassic sequence can be divided into about fifteen lithological units each having a distinct mineralogical composition and provenance. It is hoped that this type of investigation will be carried to the subsurface in the near future.

As a part of a second, more detailed, phase of the study detailed drawings of good exposures of the Clematis Sandstone and Rewan Formation were made during a short field season in August and September. Most of the exposures were approximately 100 feet long and 100 feet high. Preliminary analysis of this work shows that in the Clematis Sandstone each of the 100 beds examined can be placed in one of seven categories based on grainsize, thickness, stratification type, and nature of lower boundary surface.

Moolayember Study: Preliminary results of heavy mineral studies indicate that stable varieties predominate in the northern and southwestern areas of outcrop while less stable minerals are common in the southeast. This pattern is reflected in the high proportion of volcanic lithic grains in sandstones of the southeastern area and supports the idea of derivation from a nearby volcanic source. Titaniferous heavy minerals make up a large proportion of the residues from all areas.

Molluscs of probable freshwater origin were collected from the upper part of the Moolayember Formation in the southeastern area of outcrop. This is the first known occurrence of a freshwater fauna in the unit.

Detailed work on outcrops in the southwestern part of the basin has shown that the upper and lower parts of the formation, distinguished in earlier work, exhibit distinct sedimentation patterns. Both units have features typical of fluvial sediments but the gross characteristics of each suggest that different fluvial systems or different parts of the same system were involved. The change in sedimentational pattern at the boundary between the lower and upper units is accompanied by a sharp increase in lithic content of the sandstone.

TABLE I DRILLING - BOWEN TRIASSIC PARTY

1:250,000 Sheet	Hole No.	Grid Ref.	Total depth (feet)	Footage Cored	Core rec. (feet)	Logs run	Formations	Water	Preliminary results & remarks
Baralaba SG55-4	1	28118930	330	40	29	Electric, gamma	Moolayember Fm.		Drilling across strike of Moolayember Formation supports division into lower sandy conglomeratic unit with minor mudstone and an upper unit of interbedded mudstone and lithic sandstone. The boundary is gradational but may be taken at the topmost conspicuous conglomerate bed.
Baralaba SG55-4	2	27988920	340	30	24½	Electric, gamma	Moolayember Fm.		
Taroom SG55-8	1	27798876	370	40	36	Electric, gamma	Moolayember Fm.		
Taroom SG55-8	2	27438842	360	40	37½	Electric, gamma	Moolayember Fm.		
Taroom SG55-8	3	27308832	410	55	53½	gamma	Precipice Sst., Moolayember Fm.		
Taroom SG55-8	4	27668864	350	40	38½	Electric, gamma	Moolayember Fm.		
Mt. Coolon SF55-7	2	63943588	370	40	38	Electric, gamma	Teviot Fm., Carborough Sst	700 gals/ hr. at 100'	Tuffaceous sandstone in Teviot Fm.
Mt. Coolon SF55-7	3	63763613	310	30	27	Gamma	Teviot Fm., Carborough Sst.	1000 gals/ hr. at 300'	Tuffaceous sandstone in Teviot Fm.
Mt. Coolon SF55-7	4	64983508	200	40	38	Electric, gamma	Rewan Fm.		Five holes drilled 100-200' apart in cross pattern to study size, shape and orientation of the sedimentary bodies.
Mt. Coolon SF55-7	5	64983508	200	40	38	Electric, gamma	Rewan Fm.		
Mt. Coolon SF55-7	6	64983508	200	30	28½	Electric, gamma	Rewan Fm.		
Mt. Coolon SF55-7	7	64983508	200	40	38	Electric, gamma	Rewan Fm.		
Mt. Coolon SF55-7	8	64983508	200	30	28	Gamma	Rewan Fm.		
	Total Drilled		3840	495	454½				

S9 - TEXAS HIGH PARTY

by

F. Olgers

Personnel: F. Olgers and P.G. Flood

Visitors: Dr. J.M. Dickins spent three weeks with the party collecting Permian fossils in the Drake region of New South Wales, at Glenmore and Alum Rock homesteads, and in the Warwick fault blocks. W.J. Perry accompanied the party on a reconnaissance trip through the Palaeozoic rocks of northeast New South Wales and southeast Queensland. Professor D. Hill and Dr. Chapman of the University of Queensland visited the party for two days. They were shown the Permian-Carboniferous unconformity east of Limevale and at Alum Rock homestead.

Duration of field work: 28/4/69 to 1/7/69

A seven week field trip was made in the Warwick-Drake region to examine, in some detail, the Devonian and Permian sedimentary sequences, and a ten-day reconnaissance traverse was made through the Palaeozoic rocks in southeast Queensland and flanking the Clarence-Moreton Basin in New South Wales to compare these rocks with the Palaeozoic strata of the Texas High.

Devonian rocks crop out south of Warwick on the northeast margin of the Texas High where the Mesozoic rocks of the Clarence-Moreton Basin onlap the basement rocks. The sequence is Lower Devonian and older and has been mapped as the "Silverwood Series" (Richards & Bryan, 1923) and Silverwood Group (Lucas, 1959). A twofold subdivision into a dominantly volcanic unit at the base followed by a sedimentary sequence was recognized but not mapped out by Richards and Bryan.

The Silverwood Group, which is estimated to be about 14,500 feet thick, is here subdivided into three formations which consist from the base upward, of 6000 feet of fine-grained andesitic tuffs and silicified fine-grained sediments (Risdon Stud Formation), 4,500 feet of coarse-grained andesitic pyroclastics and flows with some sediments, including fossiliferous limestone lenses, mainly near its top (Connolly Volcanics), and 4,000 feet of sediments including olive green mudstone, chert, lithic sandstone, limestone and intraformational conglomerate (Rosenthal Creek Formation). Neither the top nor the bottom of the Silverwood Group is exposed, and the thickness of 14,500 feet must be regarded as a rough estimate. Rich coral faunas in limestones near the top of the Connolly Volcanics and in the Rosenthal Creek Formation indicate a Lower Devonian age for the upper part of the group; the Risdon Stud Formation could at least partly range down into the Silurian. (Fig. S9/1).

Fig. S9/1

SILVERWOOD AREA
Queensland

Geology and Compilation 1969 by F. Olgers and P. G. Flood

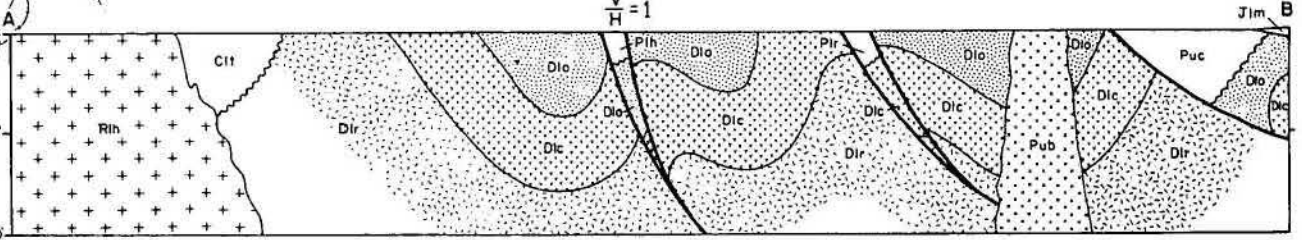
RECENT		Qa	Alluvium
LOWER JURASSIC	Marburg Sandstone	Jlm	Feldspathic to feldspatholithic sandstone; mudstone
LOWER TRIASSIC	Herries Adamellite	Rlh	Adamellite
	Stanthorpe Adamellite	Rls	Adamellite
PERMIAN OR TRIASSIC		Pub	Diorite
			Feldspar porphyry
PERMIAN	Condamine Beds	Puc	Mudstone, poorly sorted sandstone, conglomerate, tuff
LOWER PERMIAN	Rhyolite Range Beds		Spherulitic rhyolite
		Plh	Spherulitic rhyolite, andesite, agglomerate, tuff, minor sediments
	Eight Mile Creek Beds	Ple	Conglomerate, sandstone, mudstone; minor agglomerate
		Plr	Conglomerate, sandstone, mudstone; minor limestone
UPPER DEV.(?) TO UPPER(?) CARBONIFEROUS	Texas Beds	Clt	Interbedded sandstone and mudstone; chert, limestone
LOWER DEVONIAN	Silverwood Group — Rosenthal Creek Formation	Dlo	Interbedded sandstone and mudstone chert, conglomerate, limestone
	Silverwood Group — Connolly Volcanics	Dlc	Andesitic pyroclastics mainly; minor sandstone and limestone
	Silverwood Group — Risdon Stud Formation	Dlr	Silicified fine-grained pyroclastics and sedimentary rocks

Fault
Geological boundary
Strike and dip of strata
Overturned strata
Vertical strata
Dyke: a-aplite; d-diorite; p-porphyry; r-rhyolite
Cu Silverwood Coppermine
4/99 Photo-centre point
Limestone
Limestone pebbles
TH 408 Fossil locality with collection number
Railway
Road
Track
Homestead

0 1 2 MILES
0 1 2 KILOMETRES

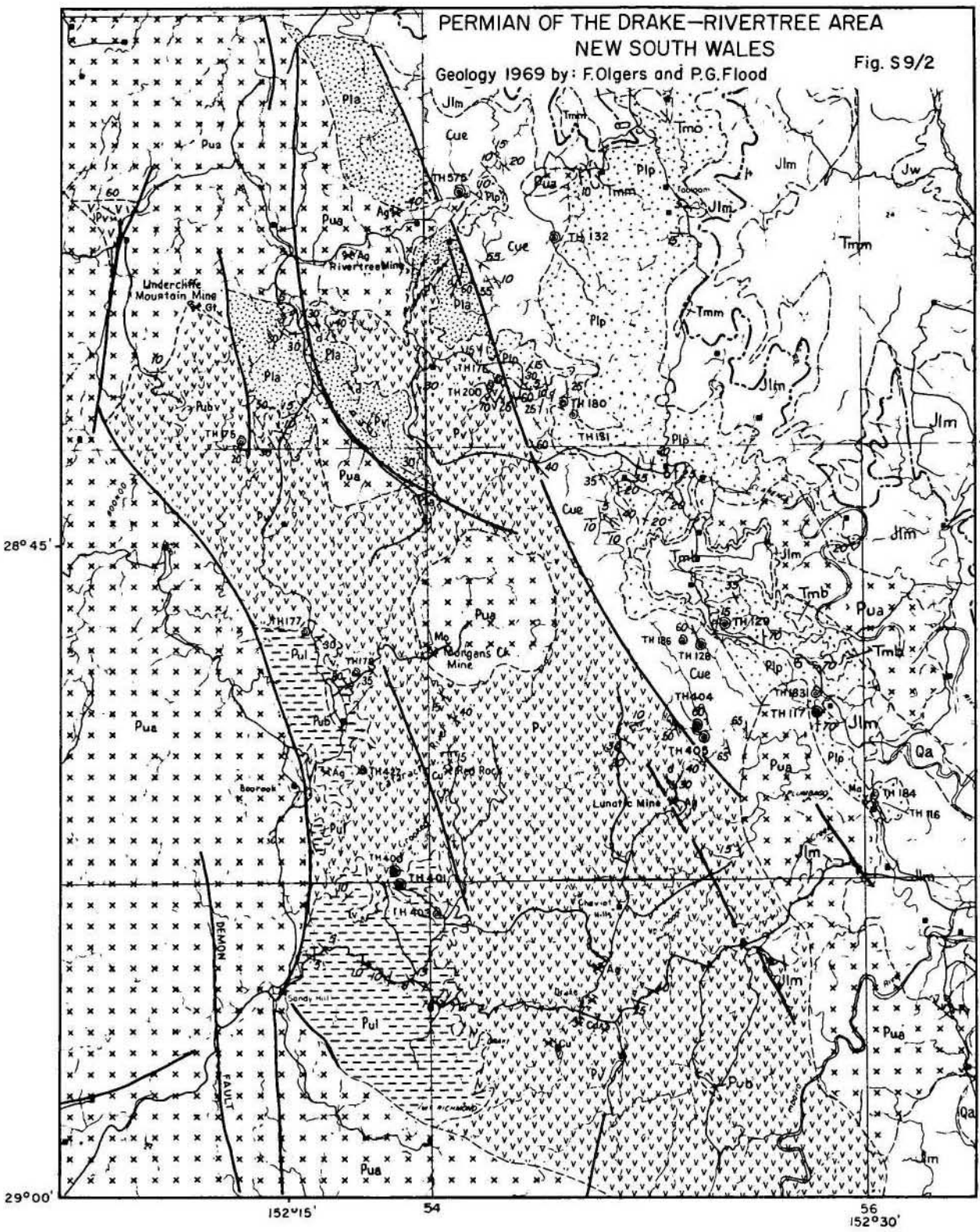
Section A-B

$\frac{V}{H} = 1$



To accompany Record 1969/123

H56/A2/15 EJ



To accompany Record 1969/123

H56/A2/14

The Carboniferous rocks of the Texas High, previously described by Olgers and Flood (BMR Rec. 1969/29), were not re-examined.

The Permian sequence between Rivertree and Drake in New South Wales was remapped and four units were recognized. They comprise, from the base upward: at least 2,000 feet of conglomerate, mudstone and sandstone (Paddys Flat Formation), 1000 feet of mudstone (Razorback Creek Mudstone), 1500 feet of coarse-grained pyroclastic rocks (Drake Volcanics) and 500 feet of mudstone (Gilgurry Mudstone). The Paddys Flat Formation unconformably overlies Carboniferous rocks and is unconformably overlain by Mesozoic strata. The unit is exposed only east of the Carboniferous sequence, and its relationship to the Razorback Creek Mudstone, the oldest unit exposed in the small graben west of the Carboniferous rocks, is not known. (Fig. S9/2).

A ten-day reconnaissance traverse was made through the Palaeozoic rocks of southeast Queensland and the margins of the Clarence-Moreton Basin in New South Wales to compare these rocks with the Devonian, Carboniferous and Permian strata of the Texas High in the Goondiwindi and Warwick Sheet areas. Four distinctive sequences can be recognized within the "Palaeozoics":

i) The oldest rocks in the region are the Rocksberg Greenstones and Bunya Phyllite near Brisbane and the Nambucca Beds on the north coast of New South Wales. They are of pre-Devonian age.

ii) A sequence of rocks dominated by interbedded greywacke and mudstone flanking the Clarence-Moreton Basin (Fitzroy Beds) and extending northward into the Brisbane area (Neranleigh-Fernvale Group). These rocks are very similar to the Lower Devonian and Carboniferous sediments of the Texas High. The Neranleigh-Fernvale Group unconformably overlies the Bunya Phyllite north of Brisbane, and the Fitzroy Beds are faulted against the Nambucca Beds.

iii) Probable Permian rocks in the D'Aguilar Range and environs north-west of Brisbane between Fernvale and Laceys Creek School.

iv) Mesozoic rocks at Burleigh Heads (below Tertiary basalt) and North Burleigh south of Southport.

S10 - NGALIA BASIN - STRATIGRAPHIC DRILLING

by

T. Nicholas

Personnel: T.G. Evans, T. Nicholas (22/7/69 to 3/9/69)

Visitors: W.J. Perry (16/9/69 to 20/9/69), A.T. Wells (16/9/69 to 20/9/69).

Duration of drilling: 20/7/69 to 20/9/69

Geological results: The regional geology of the Ngalia Basin has now been completed following the preparation late in the year of two preliminary maps and records (1969/85 and 1969/89) dealing with the Napperby and Lake Mackay Sheet areas respectively. A record summarizing the geology of the basin as a whole is being compiled by A.T. Wells.

Stratigraphic drilling: Because of lack of outcrop or very poor exposure in the centre of the Ngalia Basin, a programme of shallow stratigraphic drilling was undertaken during August and September to obtain a better understanding of the subsurface stratigraphy.

Eight stratigraphic holes were programmed under contract to the BMR by Intairdril (Aust.) Pty. Ltd using a Gardner Denver 15W rig and both mud and air drilling techniques. All drilling sites were located on the Mount Doreen Sheet area (see accompanying map). Holes Mount Doreen No. 7, 8B, 9, 10 and 13 were positioned on BMR and GAI seismic traverse lines with the object of identifying shallow seismic reflecting horizons. Holes Mount Doreen No. 11, 12 and 14 were either drilled to verify structural interpretations in certain areas or else to determine what formations were present at shallow depth.

Self potential, resistivity and gamma-ray logs of all holes were run with a WIDCO 2000' logger.

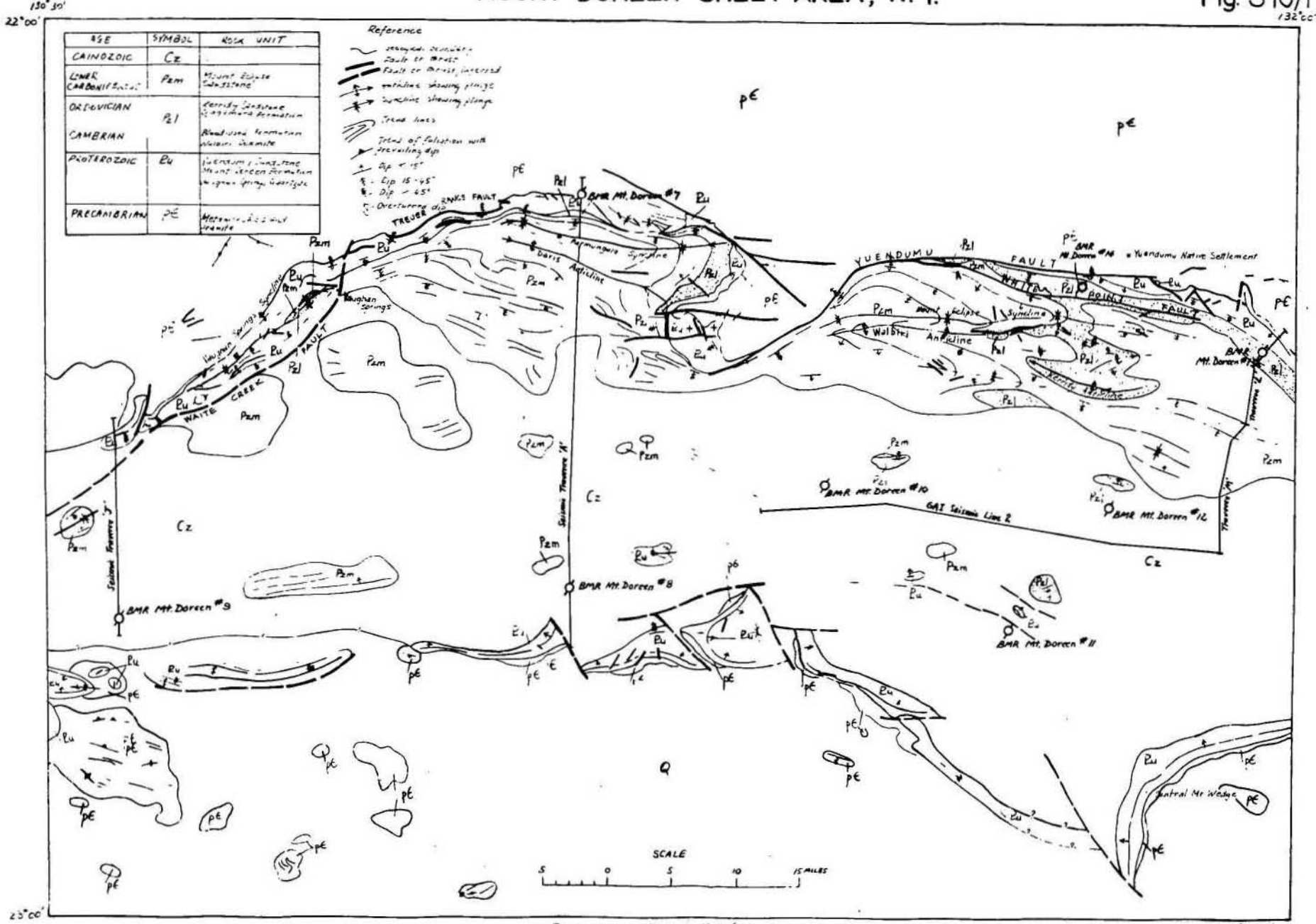
Total footage drilled was 4,397 feet; 72 feet of core were recovered and in all holes cuttings were taken at 5 foot intervals.

Drilling results:

Mount Doreen No. 7 - drilled to 375 feet at the northern end of BMR seismic traverse A between dolomite of uncertain age to the south and Precambrian basement rocks to the north. Hole intersected 190 feet of fine grained, thinly laminated, brown claystone and 185 feet of steeply dipping, very fine grained, waxy, greenish argillite tentatively correlated with the basal green shales of the Proterozoic Mount Doreen Formation, exposed a few miles to the east. The dolomite cropping out to the south of Mount Doreen No. 7 is now regarded as the upper part of the Mount Doreen Formation.

MOUNT DOREEN SHEET AREA, N. T.

Fig. S 10/1



To accompany Record 1969/123

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Mount Doreen No. 8 - two holes air drilled on the southern end of BMR seismic traverse A were abandoned at 130 feet and 235 feet respectively due to hole caving and partial collapse caused by excessive water flow, estimated as 20,000 to 30,000 gallons/hour. A third attempt at a new site slightly to the north was drilled using mud, and reached a total depth of 717 feet. The reflecting horizon indicated from seismic traverses was penetrated at 360 feet and is a fine grained, grey, oolitic in part, porcellanitic rock. The bottom hole core encountered a dark grey, laminated, pyritic sandstone with thin interbedded black plastic clays. Until laboratory studies are undertaken, no attempt at correlation with outcrops can be made.

Mount Doreen No. 9 - drilled to 800 feet using mud, cased to 348 feet. The hole was sited on the northern end of BMR seismic traverse J with the aim of identifying an intermediate reflecting horizon which projects to the surface near this point. This reflecting horizon, which consists of dolomitic limestone with thin silty interbeds, was intersected at 695 feet after passing through 125 feet of Tertiary-Quaternary? sandstone and silcrete and 570 feet of red and purple micaceous, sandy siltstone. The hole bottomed at 800 feet in a slumped and brecciated red-brown siltstone with interbedded coarse, greenish sandstone. It has not so far been possible to relate the sequence found in Mount Doreen No. 9 to outcropping formations in the Ngalia Basin.

Mount Doreen No. 10 - drilled to a depth of 530 feet on the western end of GAI seismic traverse line 2 in the area of an aeromagnetic high. Encountered arkosic, pebbly sandstone with green shale interbeds containing fragmentary carbonaceous material. It is hoped that palynological examination of this core will verify the Carboniferous age assigned to this formation. Tentatively correlated on the basis of similar lithology with the Carboniferous Mount Eclipse Sandstone.

Mount Doreen No. 11 - drilled to a depth of 590 feet to the south of an outcrop of Proterozoic Vaughan Springs Quartzite with the aim of penetrating Proterozoic sediments or Precambrian basement rocks. Sediments encountered were calcareous, gypsiferous green and grey clay, believed to be Tertiary-Quaternary? in age.

Mount Doreen No. 12 - site situated south of an outcrop of Ordovician? Kerridy Sandstone. The hole terminated at 610 feet after passing through ?Tertiary sandstone, Kerridy Sandstone and an arkosic conglomeratic sandstone with green siltstone pebbles which is probably part of the Kerridy Sandstone.

Mount Eclipse No. 13 - drilled at the end of BMR seismic line 2 with the object of determining the nature of the concealed formation lying between outcrops of Proterozoic Vaughan Springs Quartzite and Ordovician? Kerridy Sandstone. Hole terminated at 594 feet after passing through dark grey, possibly carbonaceous siltstone and fine grained, pale grey sandstone. No rocks of similar lithology occur in outcrop in the Ngalia Basin, and hence no attempt at correlation has been made at this stage.

Mount Doreen No. 14 - drilled to intersect a known fossiliferous horizon within a sequence of Cambrian dolomite and siltstone. Hole terminated at 180 feet after encountering a continuous sequence of red-brown, micaceous, dolomitic siltstone. Core recovery was unfortunately very poor and as the hole was dry only a gamma-ray log was obtained.

S11 - GOSSES BLUFF IMPACT STRUCTURE

by

D.J. Milton (U.S.G.S.)

This joint B.M.R.-U.S.G.S. project commenced in 1967 and has included detailed geological studies, core drilling, and magnetic, gravity and seismic surveys - the latter surveys by the Geophysical Branch of the Bureau. The field work was completed during 1969 and the results are being evaluated for publication by B.M.R. in a joint U.S.G.S.-B.M.R. bulletin.

A brief field season in 1969 by D.J. Milton was devoted to geologic study of the outer zones of the Gosses Bluff structure and to liaison with the geophysical parties. Geologic mapping and the seismic data together indicate a bowl of disruption somewhat smaller than had been envisioned previously. The area of more or less uniformly vertical outward-facing strata occupies a circular area about 16 kilometers in diameter, which presumably approximates the area within the rim crest of the former crater. Severely disturbed strata are found beyond this limit for three or four kilometers in some sectors, but these are in sharply limited patches and from seismic evidence do not extend to great depth. These are apparently remnants of the rim of the crater, where shallow outward thrusting dominates.

Additional occurrences of thermally metamorphosed breccia were found around the Bluff. These are commonly obscure on the ground but clearly marked by aeromagnetic anomalies. Their distribution suggests that the plain around the Bluff is a stripped surface approximating the base of the shocked breccia. One particularly significant outcrop lies at the very base of the outer Bluff wall, which indicates that the present Bluff is not merely an erosional feature but was a central peak, buried to an unknown depth by melt breccia.

Computer analysis of the shatter cone data collected in 1968 (with a few additional measurements in 1969) is in progress. If the beds are restored to horizontal at elevations appropriate to their stratigraphic position, the cone axes point to a focal zone above the center of the Bluff. The foci of cones in different stratigraphic units are spread vertically within this zone. The simplest interpretation of the spread is that it is a result of the increasing inward as well as upward displacement of the rocks from the outside of the structure to the center.

It appears that the pre-erosion form of the crater can be recovered more closely than was expected. The geologic mapping with the seismic and gravity data on the subsurface, and particularly the shatter cone data, should also allow the displacement vectors throughout the structure to be determined to a degree considerably better than in any comparable structure yet studied.

Two independent dating methods indicate a Lower Cretaceous age for the Gosses Bluff event. A K/Ar date of 133 ± 3 m.y. was measured on a specimen of sanidine-rich pumice that forms one of the minor rock types in the Mt. Pyroclast melt breccia (R. Marvin, USGS Branch of Isotope Geology). Fission track dating annealing of zircon and apatite from baked breccia recovered from drill holes beneath the melt breccia is still in progress, but a preliminary date of about 120 m.y. is currently indicated (C.W. Naeser and D.J. Milton, USGS). Aside from the significance for Gosses Bluff itself, this provides one of the few reference points, either absolute or stratigraphic, in the Mesozoic history of central Australia. In particular it places an upper limit on the age of the summit surface of the Macdonnell and James Ranges, with which the summit surface of Gosses Bluff may be correlated.

Petrographic study of the Mt. Pyroclast breccia indicates transformation to noncrystalline phases (probably including both truly melted rocks and glasses produced by shock at subsolidus temperatures) followed by a period of recrystallization at high temperatures, as might be expected at the base of the melt breccia zone. Much of the free silica crystallized as tridymite (since inverted back to quartz), and high-temperature sanidine and several zeolites (heulandite, chabazite, and stilbite) also formed. Processes during the stage of recrystallization were not isochemical. For example, most of the 12.6 percent of K_2O in the material used for dating must have been acquired from aqueous solutions rather than been present in the shale(?) precursor.

S12 - PETERMANN RANGES - ARLTUNGA PARTY

by

D.J. Forman, R.D. Shaw, and M. Kahn

Personnel: D.J. Forman, R.D. Shaw, G. Bradley (A.N.U. 3/6/69-13/6/69), M. Kahn (A.N.U. 17/7/69 - 28/8/69), B. Hobbs (A.N.U. 17/7/69 - 22/7/69), W.B. Dallwitz (B.M.R., 19/8/69 - 23/8/69), J.N. Casey and E.C. Druce (B.M.R. 22/8/69 - 23/8/69).

Duration of field work: 1st June 1969 to 28th August, 1969.

Projects:

(a) Regional mapping of Mann Ranges in southeast corner of Petermann Ranges Sheet area and Kelly Hills in Ayers Rock Sheet area. (b) Detailed mapping of Arltunga Nappe Complex: Ruby Gap - Atnarpa area; White Range area; Arltunga Gold Fields area and part of Winnecke Gold Field area. (c) Metamorphic mineral reconnaissance on parts of Hermannsburg, Alice Springs and Ayers Rock Sheet areas. M. Kahn of the Australian National University worked with the field party and mapped an area of the Arltunga Nappe Complex near Atnarpa.

Geology:

Mann Ranges - Kelly Hills: The Mann Ranges consist of gneiss and granite intruded by mafic dykes. The gneiss, granite and mafic dykes have all been metamorphosed and now typically contain hornblende, diopside, garnet, feldspar, with or without quartz. A thrust marked by mylonite occurs along the northeast part of the range. A thrust fault marked by mylonite and pseudotachylite was mapped cutting the granite, gneiss, and mafic dykes of the Kelly Hills.

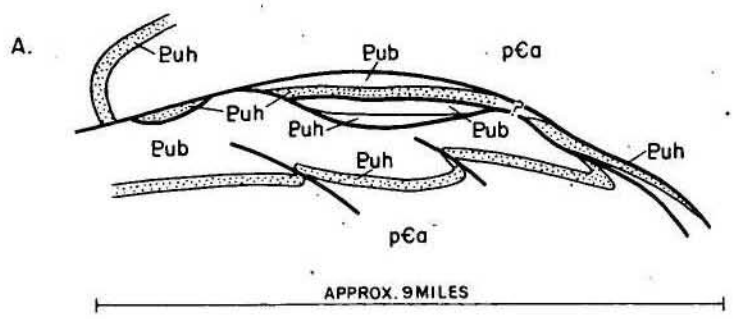
Ruby Gap area: The Heavitree Quartzite and Bitter Springs Formation of the Ruby Gap area were mapped at a scale of 1:24,000 by Forman and Shaw. The mapping reveals a structure (Fig. S12/1) that probably resulted by thrusting from north to south. The autochthonous Heavitree Quartzite and Bitter Springs Formation are folded about east-west axes that dip steeply north. The movement of these east-west trending folds is consistently north to south. The autochthonous rocks are overlain by several thrust sheets of allochthonous Heavitree Quartzite and Bitter Springs Formation and these have in turn been overthrust by allochthonous Arunta Complex. The strata in each thrust sheet face upwards. All the allochthonous rock has a strong lineation trending north-south. A reconstruction of the thrusting sequence by which such a structure may form is given in figure S12/1 (B-E).

Ruby Gap - Atnarpa Area

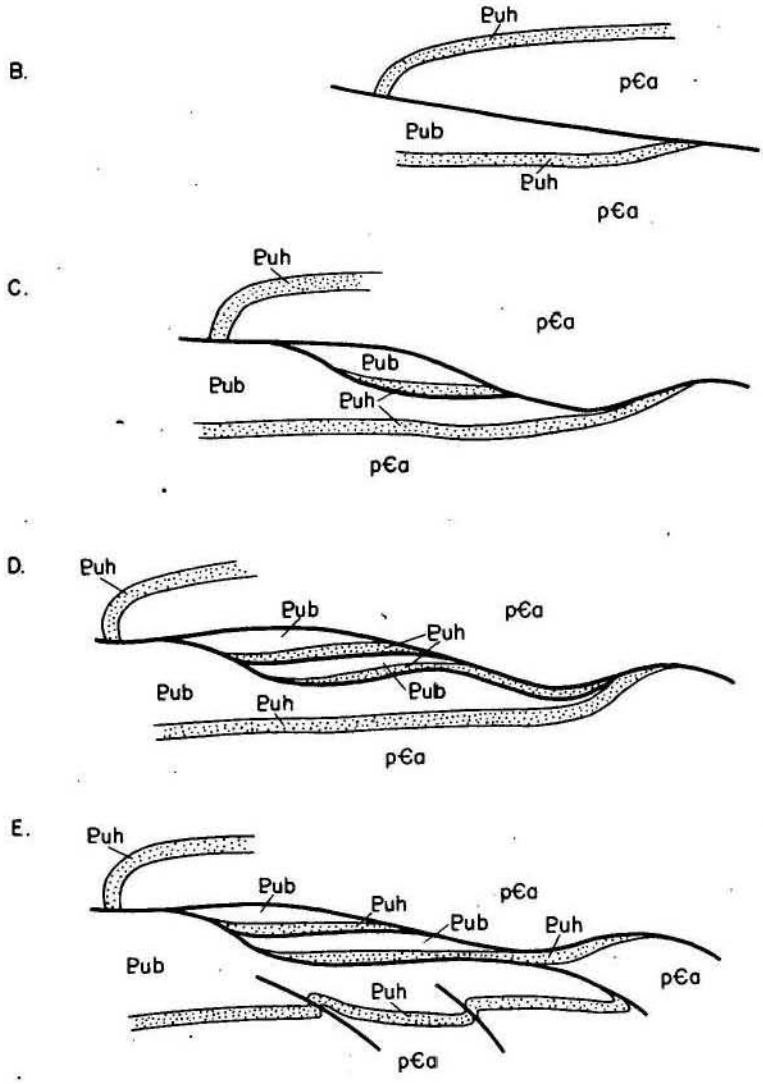
The area was mapped by M. Kahn between the middle of July and the end of August. The area forms part of the Atnarpa Antiform structure and extends eastwards for 8 miles from a point about 2 miles east of Atnarpa homestead.

The oldest rocks are the Arunta Complex, an assemblage of metamorphic and intrusive igneous rocks of many lithologies. The Arunta Complex is overlain by the Heavitree Quartzite, with about 40 to 50 feet of arkosic, coarse-grained and pebbly quartzite at the base. Stretched quartz pebbles as much as 1½ inches long occur within the basal beds about 3 miles east of Atnarpa homestead on the northern flank of an east-west range. The lower part of the Heavitree Quartzite is massive to thick bedded and appears lighter-toned on aerial photographs. The upper part is predominantly thin bedded and appears darker toned on the photographs. It is possible to map them as separate units in most parts of the area. Bitter Springs Formation which is essentially a dolomite in the area overlies the Heavitree Quartzite, but its total thickness is not exposed.

Fig. S 12/1



DIAGRAMMATIC SKETCH OF CROSS-SECTION
RUBY GAP AREA

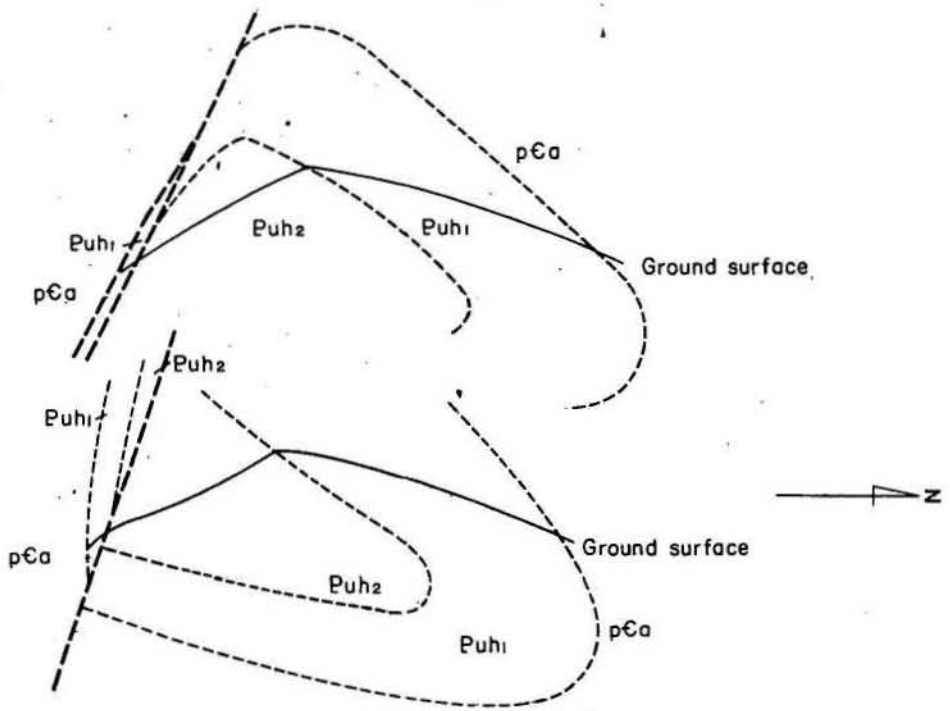


DIAGRAMMATIC EXPLANATION OF DEVELOPMENT OF RUBY GAP NAPPE BY THRUSTING
(without showing anticlinal warping)

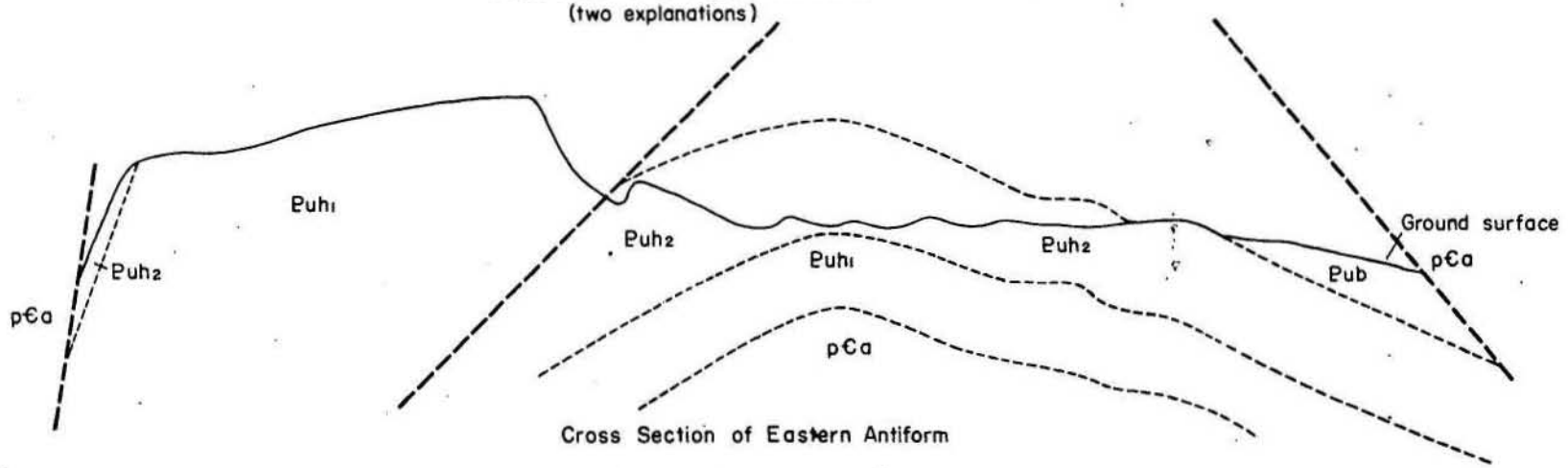
To accompany Record 1969/123

F 53/A14/110

Fig. S12/2



Cross Sections of Western Antiform
(two explanations)



Cross Section of Eastern Antiform

To accompany Record 1969/123

F 53/A14/III

The layering in the rocks is parallel to the bedding. A second cleavage has developed at a few localities especially in the hinges of folds. Lineation in most cases is defined by the folds axes or by the linear arrangement of quartz grains in the Heavitree Quartzite.

The most prominent structures in the area appear to be two antiforms (Fig. S12/2) separated by a folded thrust fault. The axes of these antiforms and associated small folds plunge westward at angles generally varying from 15 to 25 degrees. A few small folds (exposed in a valley) are doubly plunging. The northern limb of the western antiform is overturned as the Heavitree Quartzite underlies the Arunta with basal pebbly beds in between (Fig. S12/2). The structure in the western antiform is further complicated by the presence of the upper part of the Heavitree in its core at the western end. Later folds have developed about north-south axes.

Most of the contacts are faulted. The older faults are thrusts parallel to contacts; the thrust separating the two antiforms continues around the eastern antiform. The younger faults cut across the east-west structures and can be termed strike-slip faults.

White Range - Arltunga Goldfield area:

The Heavitree Quartzite was mapped in detail by D.J. Forman. It is predominantly a white, medium-grained quartzite but the following units have been mapped within it: (1) A basal conglomerate 0 - 20 feet thick containing elongate pebbles, cobbles and boulders of quartzite in a coarse-grained quartzite matrix, separated by white quartzite from (2) a thin-sericite-quartz schist associated with a thin sequence of platy quartzite and a thin sequence of coarse-grained quartzite with very fine pebbles of vein quartz; separated by white, medium-grained quartzite from (3) 100 feet or more of yellow-brown coarse-grained, cross-bedded pebbly quartzite. The pebbles are of elongate vein quartz, separated by white medium-grained quartzite from (4) platy quartzite with some interbedded slate and sericite quartz schist which are overlain directly by slate and carbonate of the Bitter Springs Formation.

The lineation shown by elongation of quartz grains and of pebbles is almost entirely north-south. The elongation of the pebbles is due to stretching; they can be observed in places, in various stages of necking and probably rupturing. The pebbles lie flattened in the plane of schistosity. The schistosity and elongate pebbles are in turn re-folded by strain-slip folds whose axes have several orientations and form conjugate sets at several localities.

The detailed map pattern within the Heavitree Quartzite is complex and has not been analysed yet. However, the Heavitree Quartzite dips at shallow angles beneath the Arunta Complex over most of the area mapped and within about 20% of this area the quartzite can be proven by stratigraphy to be overturned. The Arunta Complex at the contact with the Heavitree Quartzite is also overturned at a number of localities as the Arunta Complex directly

overlies the basal conglomerate member of the Heavitree Quartzite, which in turn overlies a white quartzite. At other localities units of the Heavitree Quartzite dip beneath the Arunta Complex and these can also be shown to face downwards, on stratigraphic evidence, at a number of localities. Where units of the Heavitree Quartzite can be proven to face upwards they generally overlie the Arunta Complex in the overturned limbs of downward facing antiforms. These downward facing antiforms present a strong case for regional overturning in the area and suggests the Arunta Complex - Heavitree Quartzite contact lies on the lower limb of a recumbent anticline of large dimensions (15 miles across the strike).

Important Conclusions:

1. The nappe at Ruby Gap is the result of over-thrusting from north to south (10 miles).

2. The nappe in the White Range - Arltunga areas is probably due to a combination of recumbent folding and overthrusting from the north to the south (15 miles).

3. The White Range Nappe and the Winnecke Nappe are the same nappe (and not separate nappes as reported in B.M.R. Report 103). This nappe overlies the nappe exposed at Ruby Gap.

Arltunga Structural Study

by

A.J. Stewart (Yale University)

Duration of field work: 1st November 1968 - 14th January 1969

Area mapped: Western part of Arltunga Nappe Complex.

Geology

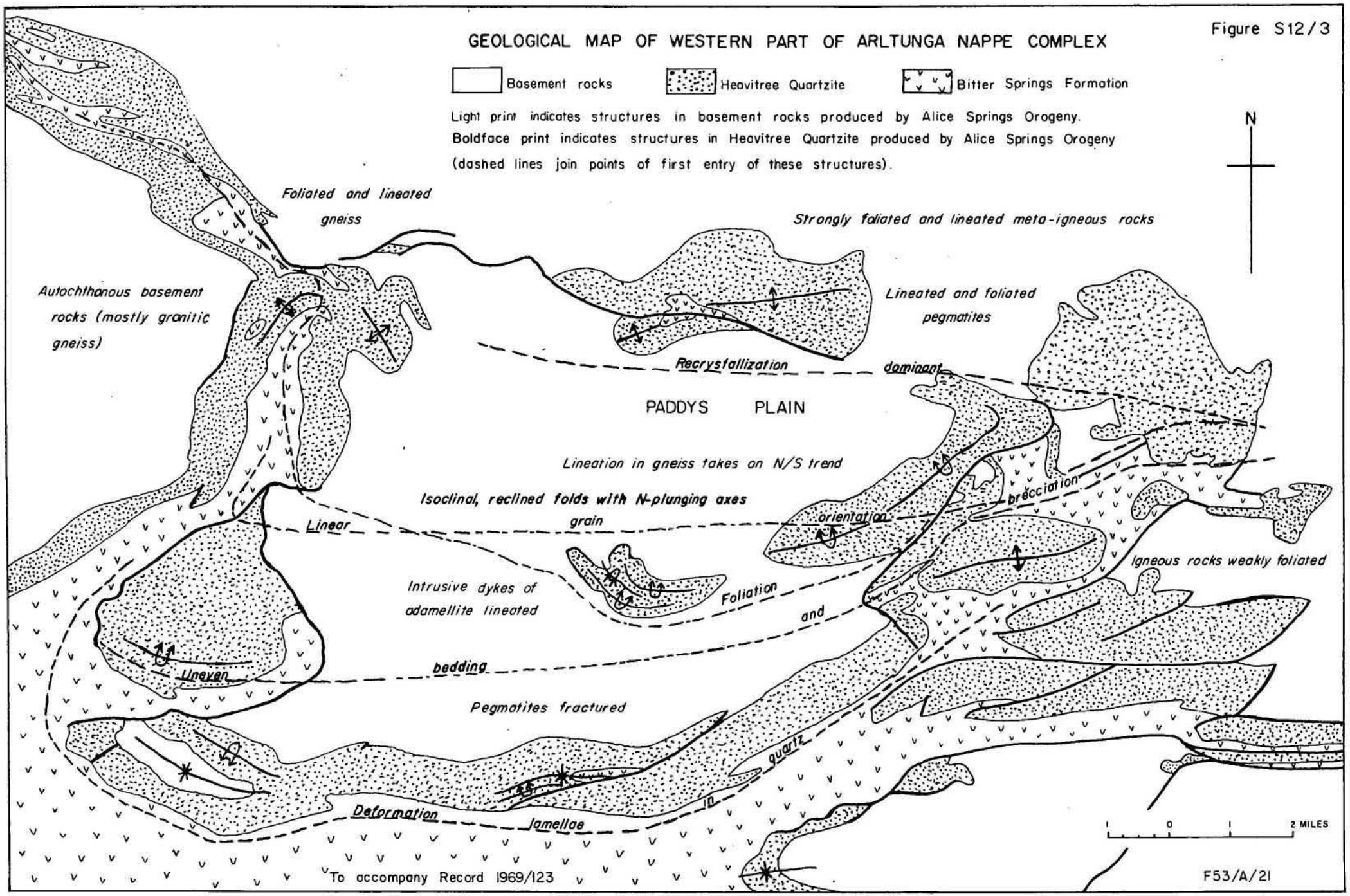
The Arltunga Nappe Complex, situated on the north-eastern margin of the Amadeus Basin, consists of two main parts, a large fold nappe in the west (itself with a lower and an upper lobe), and a group of thrust nappes in the east. The complex has been warped about two mutually perpendicular axes, a north-south synformal axis and an east-west antiformal axis, so that the fold nappe is saddle-shaped. The present ground surface thus provides a section through all but the uppermost parts of the nappe. Field work for this study was carried out in the western or lower part of the fold nappe (Fig. S12/3)

Figure S12/3

GEOLOGICAL MAP OF WESTERN PART OF ARLTUNGA NAPPE COMPLEX

Basement rocks | Heavitree Quartzite | Bitter Springs Formation

Light print indicates structures in basement rocks produced by Alice Springs Orogeny.
Boldface print indicates structures in Heavitree Quartzite produced by Alice Springs Orogeny
(dashed lines join points of first entry of these structures).

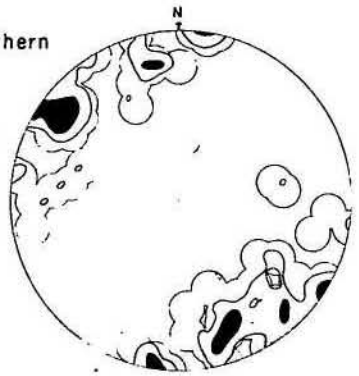


To accompany Record 1969/123

F53/A/21

(a)

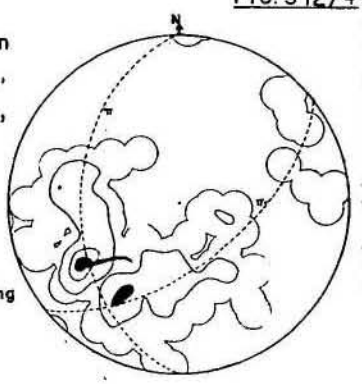
Basement rocks, southern part of nappe.
57 linear grain orientations.
Contours: 6%, 3%, 2%, per 1% area



(b)

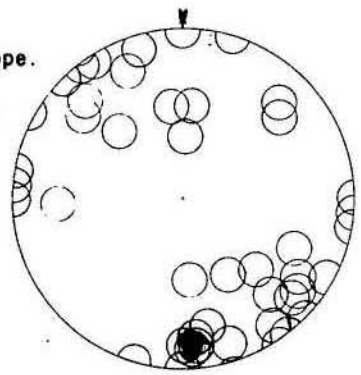
Basement rocks, southern part of nappe.
115 poles to foliation
Contours: 6%, 3%, 1%, per 1% area.

The NW-plunging π axis reflects the early mesoscopic phase of folding (cf. Fig 2a); the E-plunging π axis reflects a later macroscopic phase of folding



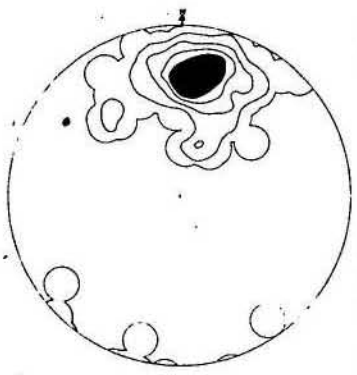
(c)

Basement rocks, southern part of nappe.
35 fold axes.
Contours: 12%, 9%, 6%, 3%, per 1% area.



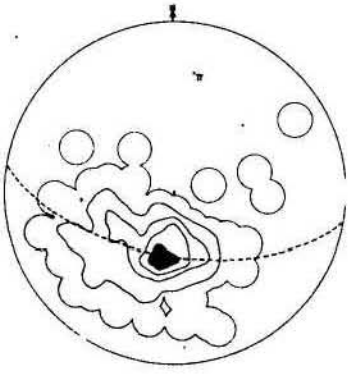
(d)

Basement rocks, central and northern part of nappe.
135 linear grain orientations.
Contours: 12%, 9%, 6%, 3%, 1%, per 1% area.



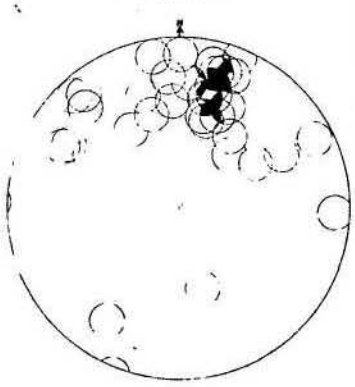
(e)

Basement rocks, central and northern part of nappe.
127 poles to foliation
Contours: 12%, 9%, 6%, 3%, 1%, per 1% area



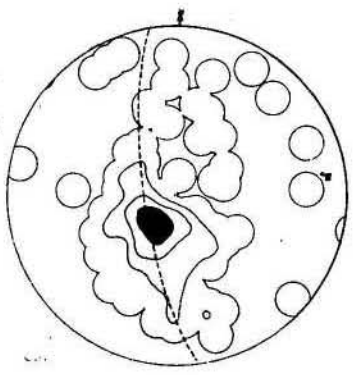
(f)

Basement rocks, central and northern part of nappe.
34 fold axes
Contours: 12%, 9%, 6%, 3%, per 1% area



(g)

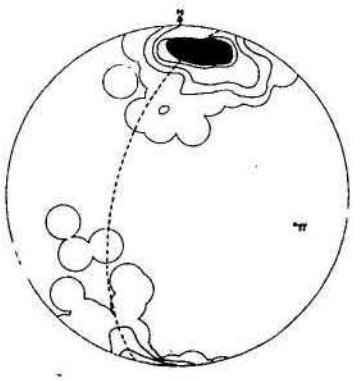
Heavitree Quartzite, entire area.
117 poles to bedding
Contours: 9%, 6%, 3%, 1%, per 1% area



(h)

Heavitree Quartzite, central and northern part of nappe.
134 linear grain orientations
Contours: 12%, 9%, 6%, 3%, 1%, per 1% area

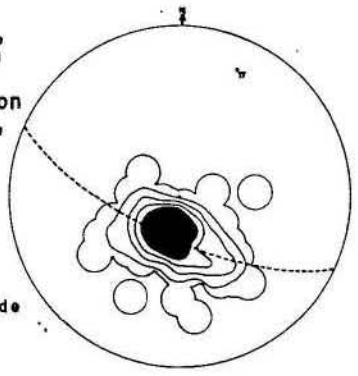
(Diagram includes measurements from areas with folded lineation.)



(i)

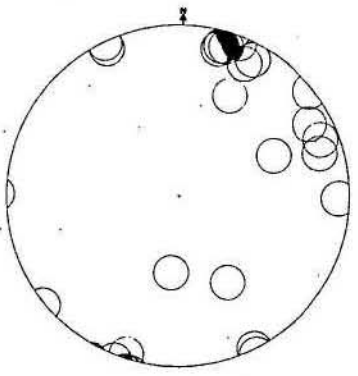
Heavitree Quartzite, central and northern part of nappe.
133 poles to foliation
Contours: 12%, 9%, 6%, 3%, 1%, per 1% area

(Diagrams includes measurements from quartzite ranges on south side of Paddys Plain, but does not include measurements from areas with folded foliation.)



(j)

Heavitree Quartzite, central and northern part of nappe.
20 fold axes of isoclinal reclined folds
Contours: 20%, 15%, 10%, 5%, per 1% area



π-diagrams for mesoscopic structural elements in basement rocks (Arunta Complex) and Heavitree Quartzite in western part of Winnecke-White Range Nappe of Arltunga Nappe Complex

and in the autochthonous rocks to the west of the nappe, and formed part of an investigation into the processes of emplacement of the nappe. The work consisted of the measurement of mesoscopic structural elements, and the collection of oriented rock specimens for microscopic and isotopic analysis.

The fold nappe (or 'Winnecke - White Range Nappe') consists of a heterogeneous, crystalline core of old basement rocks of the Arunta Complex, and a sedimentary envelope of Heavitree Quartzite and Bitter Springs Formation. The old metamorphic grade of the basement rocks is of the amphibolite facies, but the later emplacement of these rocks into the core of the nappe was accompanied by greenschist facies metamorphism that caused widespread retrogression of the amphibolite facies assemblage. The reactivation also formed new structures in both the basement rocks of the core and the sedimentary rocks of the envelope, and these structures show progressive changes from south to north across the nappe (Fig. S12/3).

Basement Rocks

The basement rocks of the autochthon are foliated (including lithologic layering, schistosity, and planar grain orientation) and lineated (linear grain orientation), and also show several episodes of superposed folding. The basement rocks in the southern part of the nappe show structures similar to those of the autochthon. Lineation (Fig. S12/4a) and foliation π-axes (Fig. S12/4b) in the gneisses trend north-west/south-east or plunge 50° east, and so bear no relation to the macroscopic B-axis of the nappe, which plunges gently east at about 10° as a result of the synformal warping. The mesoscopic fold axes in the gneisses also trend generally north-west/south-east (Fig. S12/4c), and the folds are mostly inclined or upright. In the central part of the nappe, the lineation of the gneisses takes on a moderate northerly plunge (Fig. (S12/4d), and farther to the north it is joined by a new, north-dipping foliation (Fig. S12/4e) which affects all the rocks. Both the lineation and foliation become more intense to the north. Folds in this area are reclined, and their axes also plunge moderately north (Fig. S12/4f).

Heavitree Quartzite

Poles to bedding from the whole western part of the nappe define a π-axis which plunges gently east, parallel to the B-axis of the nappe (Fig. S12/4g). In the autochthon and in the southern part of the nappe, the Heavitree Quartzite is virtually undeformed and unmetamorphosed; pseudopebbles in the sandstone beds and phenoclasts in the conglomerate beds show no distortion, and the clay content of the rock is unaltered. Diffuse, irregular quartz veins are common in the sandstone. Deformation lamellae in quartz grains are visible in thin section. Farther to the north the bedding becomes uneven and in places brecciated, and quartz veins have sharp, well defined margins. Foliation (gently north-dipping) without lineation first appears in the quartzite ranges south of Paddys Plain. However this foliation cross-cuts the folds in the quartzite and shows no geometric relation to them, and so it may have been caused by the arrival of the later, upper part of the nappe over the lower part. Pseudopebbles here are flattened in the foliation plane, and show a strain of approximately 35 percent. Clay has altered to sericite. On the

northern and eastern sides of Paddys Plain, the quartzite exhibits a north-plunging lineation (Fig. S12/4h), a north-dipping foliation (Fig. S12/Fi), and isoclinal recumbent to reclined folds which also plunge gently north (Fig. S12/4j). Pebbles are elongated north-south by several hundred percent, and sericite is coarser. As in the basement rocks, the lineation and foliation become more intense to the north. A set of upright, concentric to disharmonic folds with east-west axes post-dates the reclined folds, and also folds the foliation and lineation (Fig. S12/4h) in the quartzite. Both the quartzite and the basement rocks exhibit two sets of upright kink bands, one striking east-west, the other north-south; in places these curve into each other.

Conclusions

The data indicate that a temperature gradient existed in the nappe during its emplacement, with cooler rocks in the south and warmer rocks in the north, and that there was also a strain gradient in the nappe, the amount of strain ranging from virtually zero in the south to several hundred percent in the north. A possible sequence of events may have been as follows:

1) Greenschist facies metamorphism north of the present area of the nappe; imposition of a compressive stress field with its principal axis north-south.

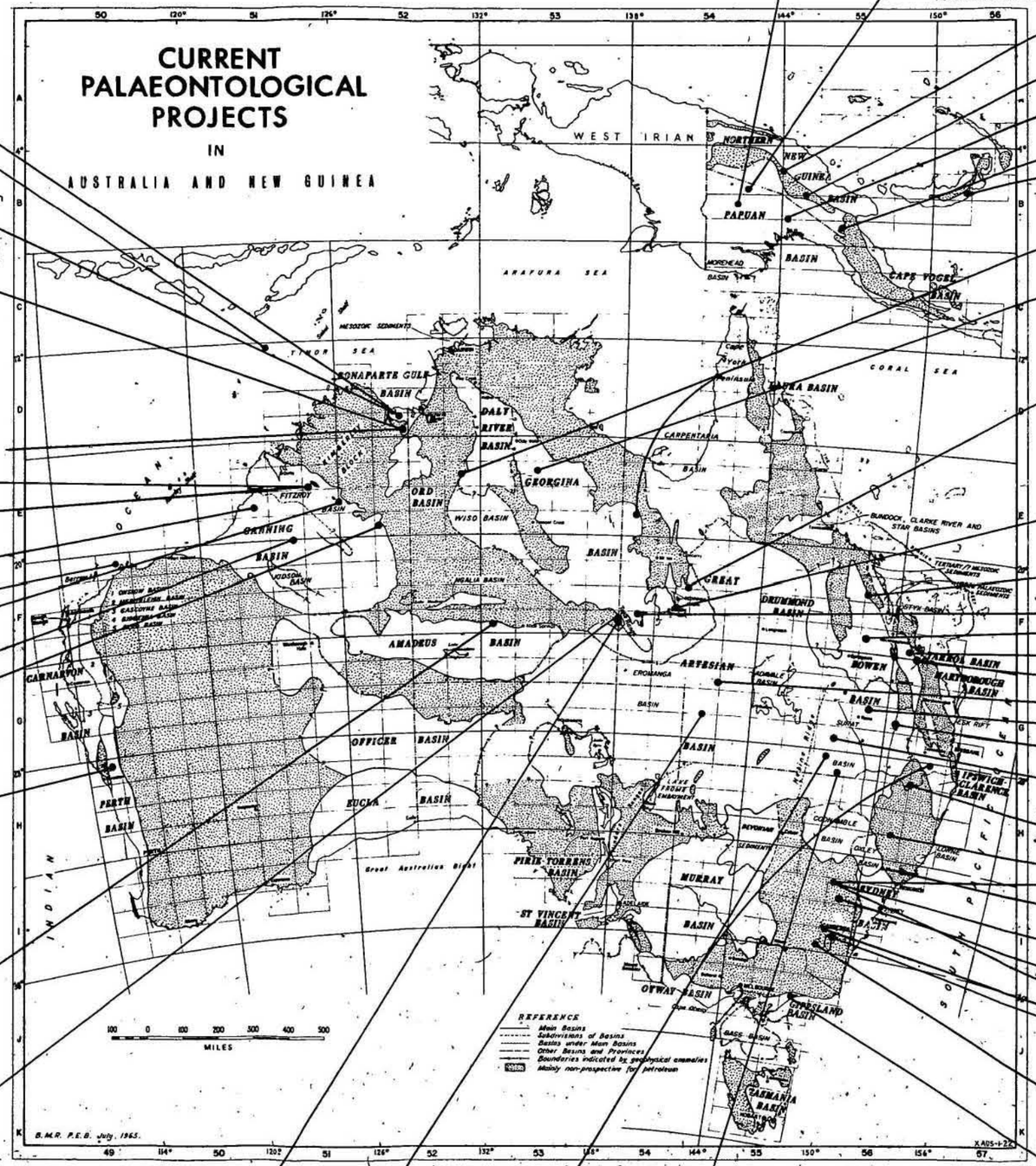
2) Southward movement of the nappe out of the boundary region between the cooler and warmer rocks; the nappe 'clipped off' the northern part of the cooler region and carried it along rather passively at the front of the nappe. In contrast, the rocks in the following part of the nappe were warmer and so underwent considerable strain; lineation and foliation formed by the elongation and flattening of grains and pebbles.

3) When the nappe was about half emplaced, the east-west intermediate stress increased sufficiently to form the north-south reclined folds and eventually bent the whole nappe into its synformal shape.

4) After the emplacement was completed and the nappe had cooled and stiffened, the remaining north-south stress formed the east-west upright folds and warped the nappe into an east-west antiform, thus producing its saddle-like shape. The last residual stresses formed the two sets of kink bands, probably contemporaneously.

Fig. S13/1

CURRENT PALAEONTOLOGICAL PROJECTS IN AUSTRALIA AND NEW GUINEA



Late Cambrian trilobites

Upper Cretaceous and Tertiary Foraminifera from off-shore wells

Upper Devonian brachiopods from the Bonaparte Gulf Basin

Reworked Ordovician conodonts in the Upper Palaeozoic rocks of the Bonaparte Gulf Basin

Lower Carboniferous brachiopods from the Bonaparte Gulf Basin

Tertiary larger Foraminifera Christmas Island

Lower Carboniferous ostracods, Bonaparte Gulf Basin

Lower Carboniferous and Upper Devonian ostracods, Canning Basin

Upper Devonian conodonts from the Canning Basin

Ordovician graptolites from the WAPET Canning Basin bores

Upper Cretaceous and Tertiary Foraminifera from off-shore wells

Upper Devonian receptaculitids from Fitzroy Basin, W.A.

Ordovician faunas from Canning Basin

Lower Ordovician Dikelokephalinidae from northern Australia

Revision of the Jurassic faunas of W.A.

Lower Ordovician conodonts from the Amadeus Basin, N.T.

Ordovician trilobites (Rusophycus)

Ordovician gastropods Toko Range

Palynology of the Cretaceous Rolling Downs Group, Eromanga Basin (Qld, N.S.W.)

Neocomian–Aptian–Albian palynological zonations in the Surat Basin (Qld)

Palynological Correlation of the Lower Jurassic in the Surat & Clarence Basins (Qld)

Polynomorphs and microplankton of Jurassic and Cretaceous in the Papuan–Morehead Basins

Land mammals Upper Cretaceous and Tertiary Foraminifera, T.P.N.G.

Middle and Upper Triassic faunas

Tertiary larger Foraminifera, Papua & New Guinea

Jurassic, Cretaceous and Tertiary palynomorphs from Papua

New Guinea Tertiary rodents

Tertiary larger Foraminifera, Papua & New Guinea

Tertiary mammals from N.T. and Qld.

Agnostid trilobites from N.T. and N.S.W.
Middle Cambrian trilobites of Northern Australia

Late Cambrian trilobites

Late Cambrian trilobites

Permian faunas of the Bowen Basin

Upper Cambrian conodonts from the Georgina Basin

Permian and Triassic palynostratigraphy of Bowen Basin

Upper Devonian conodonts from the Mt. Morgan area, Qld

Lower Devonian conodonts from the Yarrol Basin, Qld

Jurassic and Cretaceous palynomorphs from the Great Artesian Basin

Cretaceous ammonites from Australia

Carboniferous conodonts from the Yarrol Basin, Qld.

Palaeozoic and Mesozoic plants

Devonian, Carboniferous and Permian faunas from Warwick, Drake and Texas

Lower Devonian coral Cyathophyllum (Radiophyllum) in eastern Australia

Carboniferous brachiopods of the Hunter Valley area

Lower Devonian lichid trilobites from Wellington

Devonian conodonts from the Garra Area

Lower Devonian Brachiopods, south eastern Australia

Lower Devonian Brachiopods, south eastern Australia

Silurian encrinurid trilobites of south-eastern Australia

Tertiary macropod from Lake Tyers

To accompany Record 1969/123

M(P)213

S13 - PALAEONTOLOGY (Fig. S13/1)

Dr. Elizabeth M. Kemp resigned from BMR on the 1st August to join West Australian Petroleum Pty. Ltd. Dr. J. Roberts returned to Canberra on 1st July after completion of work in the United States under a Harkness Fellowship. Miss Elsa Meyer joined the staff as a technical assistant on the 28th January.

Specialist work under contract has been continued by Dr. Irene Crespin (catalogue of Australian type specimens), Dr. A.A. Opik (Cambrian crustaceans) and Mrs Mary E. White (fossil plants).

During the year a steady stream of geologists, both from elsewhere in Australia and from overseas, visited the section.

Macropalaeontology

Annual Report

by

J.M. Dickins

Preparation of the bulletin on the geology of the Bowen Basin, Queensland was continued and the draft of the text is now completed. Parts of the report of the Eddystone-Taroom Mundubbera area were checked after typing and editing. A paper was prepared on the "Geological History of the Bowen Basin" and published in the handbook for the 1969 Field Conference of the Queensland Division of the Geological Society of Australia. A joint paper with D.J. Belford was prepared on "Palaeontology in Australia" for the ECAFE Symposium on the Development of Petroleum Resources of Asia and the Far East.

Permian fossils were examined and reported on from Mt. Coolon, Queensland (St. Joseph's Phelp Dodge cores), Ulladulla No. 1 Bore (BMR) and the Canning Basin (Aquitaine Petroleum). The Carboniferous and Permian fossils collections from the Texas High Field Party were examined. Data was prepared for the Pt. Keats 1:250,000 preliminary map sheet.

Dickins spent approximately three weeks with the Texas High Field Party making fossil collections and examining the associated geology. The 1969 Field Conference of the Queensland Division of the Geological Society on the "Mineral Resources of Central Queensland" and the 41st Congress of ANZAAS in Adelaide, which included the inaugural meeting of the Specialist Group in Palaeontology and Biostratigraphy of the Geological Society of Australia, were attended.

Much time was spent in organising the work of the Palaeontological Group and its coordination with other parts of B.M.R. Reorganization of the collections of the Group in the Museum and at Fyshwick has continued.

Annual Report

by

M. Plane

During 1969 M. Plane continued work on the Bullock Creek and Riversleigh vertebrate faunas. No field work was done at Riversleigh but the Bullock Creek localities were collected by R.W. Brown, Technical Assistant. Fourteen cwt. of very good material has arrived in Canberra and preparation is proceeding.

Preparation of the Bullock Creek and Riversleigh material has been our major task and good progress is being made on skulls of the genus Neohelos. The Bullock Creek fauna is taxonomically poor, diprotodontids (kangaroo), dasyurid (marsupial carnivore) and thylacoleonid (native lion) have been prepared.

From Riversleigh a very good primitive macropodid maxilla, (upper jaw) has been prepared. A most interesting specimen was obtained from the National Museum of Victoria. This kangaroo is from the Pliocene marine sequence near Lakes Entrance in Victoria. It is strikingly like macropodids of similar age from the intermontane basins of New Guinea.

Administrative duties were attended to and professional correspondence with colleagues overseas and in Australia was undertaken.

Annual Report

by

J. Roberts

From 1st November, 1968 until 1st July, 1969 J. Roberts was on leave from B.M.R. on a Harkness Fellowship of the Commonwealth Fund of New York at the University of Illinois, Urbana, Illinois, U.S.A.

Work in the United States included:

1. Preparation of Bulletin 122 "Devonian and Carboniferous brachiopods from the Bonaparte Gulf Basin, northwestern Australia.

2. Field trips to the type area of the Mississippian in the Mississippi Valley area.

3. Field trip through the southern part of the Appalachian Geosyncline.

4. Visit to the Institute of Sedimentary and Petroleum Geology, Calgary, Alberta, Canada to consult with Dr. D.B. McLaren on brachiopod taxonomy.

Activities from 1st July, 1969 at B.M.R. in Canberra include:

1. Completion of Bulletin 122.

2. Organisation of the Bonaparte Gulf Basin brachiopod collections.

3. Visit to the N.S.W. Geological Survey, the University of Sydney and Newcastle University to arrange a forthcoming biostratigraphic study of the Carboniferous of the northern Hunter Valley area in N.S.W.

4. A visit from Dr. P. Sartenaer, Royal Natural Science Institute of Belgium, for discussions on Devonian and Carboniferous brachiopod taxonomy.

5. Preparation, with J.M. Dickins, of a paper on the Permian and Mesozoic geology of the Bonaparte Gulf Basin.

6. Compilation of maps and stratigraphical and palaeontological data on the Carboniferous of N.S.W. in preparation for field work in late 1969 and 1970.

Annual Report

by

S.K. Skwarko

During 1969 S.K. Skwarko directed his effort towards the completion of the description and datings of the Middle and Upper Triassic faunas of New Guinea - as a result of this he was able to pass on two manuscripts to the editor. The completion of the projects dealing with the revision of the Jurassic faunas of Western Australia, and the description of the Canning Basin Ordovician graptolites suffered as a result of this, and will have to be postponed to 1970. Skwarko was able to bring to near-completion a manuscript on the Australian Cretaceous ammonites. This manuscript has over 50 typed pages and 28 plates.

In addition to these Skwarko performed the following duties:

Initiated and maintained the Infol storage system of palaeontological bibliographic references.

Supervised the technical staff in the preparation and photography of fossils.

Engaged in correspondence and received visitors both local and from overseas.

Checked final drafts and proof-read his contribution to B.M.R. Bull. 108.

Dated and reported on a number of fossil collections from New Guinea, Western Australia, and the Northern Territory.

Annual Report

by

Joyce Gilbert-Tomlinson

UNPUBLISHED REPORTS

(1) Fossils from Continental Munyarai No. 1 Well;

(2) Devonian placoderms from Mount Liebig Sheet, Northern Territory (Magellan Petroleum (N.T.) Pty Ltd);

(3) Ordovician fossils from Total Edgar Range No. 1 Well, W.A.;

(4) Devonian fossils from WAPET Blackstone No. 1 Well (Core 12), W.A.;

(5) Informal note to E.C. Druce on Lower Ordovician sponges, Coolibah Formation, Toko Range.

MANUSCRIPTS READ

(1) J.H. Shergold (Upper Cambrian trilobites from Queensland);

(2) P.J. Jones (Lower Ordovician conodonts);

(3) B.C. Chatterton (A.N.U.), P.G. Flood, & D.L. Strusz (Revision of Devonian brachiopod 'Spirifer' yassensis, N.S.W.) (In accordance with a new policy within the Section, a written report was prepared on this manuscript).

CURATING

(1) Assembled the Amoseas collection of placoderm fishes from the Mulga Downs Formation, N.S.W., for despatch on loan to Dr. A. Ritchie, Australian Museum, Sydney, and supplied locality data;

(2) Assembled the greater part of the Bureau's stromatolite collection for despatch on loan to M.R. Walter, University of Adelaide, and extracted from several geologists in the Metalliferous Section the relevant stratigraphic and topographic data;

(3) Superintended setting up of palaeontological exhibit in foyer of B.M.R. Building and accompanying map;

(4) Rearranged collections in Fyshwick store.

NEW DISCOVERIES OF FOSSILS

(1) A problematical fossil from the Coolibah Formation of the Toko Range and from the Prices Creek Group of the Canning Basin (both of late Lower Ordovician age) can now be identified as the operculum of a macluritacean gastropod, closely related to forms from Malaya and three widely separated localities in North America. The genus (Teiichispira) appears to be a reliable index-fossil for the late Lower Ordovician. As indicated above, a short paper is in preparation for inclusion in the current bulletin of short palaeontological papers. The fossils will also be illustrated in the University of Queensland's forthcoming publication on Ordovician and Silurian fossils.

(2) The first instalment of collections made by J.H. Shergold in the past field season contains specimens of the trilobite Dikelokephalina s.str. from the Ninmaroo Formation, Mt Datson, Queensland. The material will be included in the current paper on dikelokephalinid trilobites. The genus has not previously been recorded in Queensland. No alteration in the estimated age of the Formation is involved.

(3) An unusually well-preserved trilobite from the 'Emu Creek Series' (Upper Carboniferous) of northern New South Wales (near Paddy's Flat, Clarence River), collected by J.M. Dickins during the past field season, is identified as a new genus of Phillipsiidae. Most of the described Carboniferous trilobites from the State come from the lower part of the System.

Annual Report

by

J.H. Shergold

The major part of the year was occupied in describing and illustrating late Cambrian trilobite faunas from the Burke River Structure, western Queensland.

Description and illustration of the trilobite faunas of the Gola Beds has been completed (Bulletin 112) and the results are in press.

Galley proofs on the Oryctocephalidae (Bulletin 104) have been corrected and returned to the Government Printer.

At Black Mountain, trilobites from the lowest 1200 feet of measured section have been assessed from 33 horizons. Specimens prepared, illustrated and card-indexed to date total 1042, distributed among an estimated 30 genera and 55 species.

Miomeran (agnostid) faunas have been described (first draft stage) and illustrated by 13 plates. Eleven text-figures have been completed.

Concurrently a statistical analysis has been initiated into specific discrimination within the genus Pseudagnostus.

The card index of Upper Cambrian agnostid genera and species, commenced during 1967-68, has been maintained with recent additions to the literature.

Palaeontological determinations for the Georgina Phosphate group were continued during October 1968. Two further reports on the Camooweal collections were made during that month. Determinations were made from 94 localities. Samples collected during the 1969 field season in the Urandangi area (67 localities) are being studied.

Two reports were written on fossiliferous samples submitted by Continental Oil Co. Australia.

A bibliography and index of Australian Cambrian trilobite references was commenced during 1969. To date 144 bibliographic references have accumulated, and there are 386 listings in the specific and generic index (up to 1958).

In collaboration with D.L. Strusz work continued on the distribution and taxonomic status of the trilobite genus Encrinurus.

From 19th April to 10th September was spent in the field, collecting further Upper Cambrian trilobite samples from the Burke River Structure and from the Bonaparte Gulf Basin.

Annual Report

by

D.L. Strusz

D.L. Strusz was mainly engaged in writing two taxonomic papers. The first of these, a joint paper with Dr. J.S. Jell (University of Queensland), was on a genus of Lower to Middle Devonian rugose corals from New South Wales and Queensland. This was submitted for inclusion in B.M.R. Bulletin 116. The second, undertaken in collaboration with B.D.E. Chatterton (Australian National University) and P.G. Flood (B.M.R.), is a revision of Spirifer yassensis de Koninck, a Lower Devonian spiriferid from Taemas, N.S.W. It is planned to finish this by the end of 1969, and submit it to the Linnean Society of New South Wales.

Statistical analyses of the species of the trilobite Encrinurus (described by Etheridge and Mitchell from the Silurian of Canberra and Yass) were made, as part of a joint study, with Dr. J.H. Shergold (B.M.R.). The types of E. etheridgei and E. robustus, together with the types of "Lichas" sinuata Ratte and Cyrtina wellingtonersis Dun, from the Lower Devonian of Wellington N.S.W., were borrowed from the Australian Museum.

A collection of Carboniferous corals from the Texas High area, made in September-October 1968, was identified.

The annual field camp for vacation students was held at the Cooleman Plains, near Kiandra, N.S.W., in February. A collecting trip in New South Wales and Queensland was undertaken from July 15th to August 8th. Good comparative collections of corals and brachiopods were obtained from the Upper Ordovician, Silurian and Lower Devonian of central New South Wales, the Lower to Middle Devonian of central New South Wales, the Lower to Middle Devonian of Queensland, and the Lower to Middle Devonian of Tamworth, N.S.W.

Micropalaeontology

Two thousand seven hundred and forty-three samples were washed and prepared for microfaunal study. Eight hundred and ninety-six thin sections and nine hundred and seventy-eight polished surfaces were prepared. One thousand two hundred and thirty samples with a total weight of about 9050 pounds were digested in acid for the extraction of conodonts.

Four hundred and fifteen samples were processed for spore and microplankton content.

The technical staff, Mr. F. Hadzel, Mr. A.T. Wilson, Mrs. L. Kraciuk and Miss E. Meyer also assisted with picking of microfossils from washed residues, organisation and relabelling of the microfaunal slide collection and photographic work.

A J.E.O.L. JSM - 2 scanning electron microscope was installed in the B.M.R. in May, and is being actively used for the photography of microfossils.

Annual Report

by

G.R.J. Terpstra

G.R.J. Terpstra examined surface samples collected by field parties from Queensland, Northern Territory, Papua and New Guinea. Faunas of Lower Cretaceous (Albian and Aptian) and Upper Cretaceous (Senonian) ages were recognized. Larger Foraminifera examined from limestone from Papua and New Guinea indicated Paleocene to Lower Eocene ages; Eocene; Upper T'e' stage (Lower Miocene) and lower T 'f' stage (Middle Miocene). The examination of core and cutting samples of A.O.G. Scout Bores No. 1 and No. 2 Talbalba (Thallon Basin, Queensland) and G.S.Q. Boreholes Surat 1, 2 and 3 (Queensland) revealed Lower Cretaceous (Albian and Aptian) faunas, while in B.M.R. Bulloo No. 1 Scout Hole an Albian fauna occurs. Work continued on the examination of samples of Lower Cretaceous sections encountered in B.M.R. Scout Bores. Time was spent on checking and labelling of slides of the foraminiferal collections and on supervising the preparation of records on plant fossils, collected by the field parties and determined by the palaeobotanist Mrs. Mary White.

Annual Report

by

D.J. Belford

Age determination studies of surface and subsurface samples from Western Australia and Papua-New Guinea were continued at the request of B.M.R. field parties and exploration companies. The stratigraphic sections penetrated by off-shore wells in Western Australia and the Northern Territory have been studied, particularly the Upper Cretaceous sequences. A complete Upper Cretaceous sequence from Cenomanian to Maestrichtian appears to be present in several wells, but delimiting the stages is difficult because of contamination of well cuttings. The fauna of these off-shore wells is now being studied in detail and photographs are being taken on the scanning electron microscope. The specimens require considerable cleaning in preparation for photographic work, and this will be a continuing long-term project.

Study of samples from Christmas Island continued. This material is now with Dr. C.G. Adams, British Museum (Natural History), who is examining the fauna; the text of a paper discussing the faunal sequence is in preparation.

A paper "Carboniferous Foraminifera, Bonaparte Gulf Basin, Western Australia", written with Professor B.L. Mamet, University of Montreal, appeared in Micropaleontology, volume 14, number 3, July, 1968.

A systematic paper describing Upper Devonian and Carboniferous Foraminifera from the Bonaparte Gulf Basin, Western Australia, is in press in B.M.R. Bulletin 108.

A paper discussing the development and applications of the scanning electron microscope was delivered to the inaugural meeting of the specialist group in Palaeontology and Biostratigraphy during the A.N.Z.A.A.S. Congress in Adelaide.

Annual Report

by

P.J. Jones

A paper (Bull. 117) describing the Lower Ordovician (Tremadocian) conodonts from the Bonaparte Gulf Basin and the Daly River Basin was handed to the Editor. Forty-two form-species are described, and their distribution in measured sections shows that the Tremadocian assemblage zones based on the limestone facies of the Boulia region, western Queensland (Bull. 110), can be recognized in the arenitic facies of northwestern Australia. These zones can be used for intercontinental correlation, particularly with North America.

Systematic description of the Lower Carboniferous ostracods from the Bonaparte Gulf Basin was continued, with emphasis on the Bairdiacea; part of this programme involved a preliminary computer analysis of species of Rectobairdia, as an experiment in numerical classification.

Upper Devonian ostracods have been recovered from samples collected by Druce from the Bugle Gap area of the Canning Basin; these await further study, and to date just over half of the residues have been picked.

Photography of ostracods using the scanning electron microscope has been started, and at present is in experimental stages.

Results from examination of exploration wells include:-

(i) Lower Permian ostracods in Lacrosse No. 1 Well (2620-2752 feet);

(ii) Lower Triassic conchostracans in Petrel No. 1 Well (10512 feet); and

(iii) Upper Devonian (Famennian) ostracods in Napier No. 1 Well (2352 feet) and the problematic microfossil Umbellina (alga or foraminifera) of probable late Famennian age (671 feet).

A brief summary on the Upper Palaeozoic sediments of the Bonaparte Gulf Basin was prepared for a CSIRO Land Research Report.

During the year, one paper was published on Upper Devonian Ostracoda and Eridostraca from the Bonaparte Gulf Basin (Bull. 99). Two papers are in press - Lower Triassic ostracods from the Perth Basin (Bull. 108-6), and Upper Cambrian and Lower Ordovician (Tremadocian) conodonts from western Queensland (Bull. 110, with Druce).

Annual Report

by

E.C. Druce

Work continued on the abundant conodont faunas from the Upper Devonian of Western Australia. Nearly three hundred species were identified and the systematic descriptions begun. Papers completed during the year and submitted to the editor include:

Cambro-Ordovician conodonts from the Burke River Structural Belt, Queensland. Bull. 110 (in press) (with P.J. Jones)

Lower Devonian conodonts from the Garra Beds, N.S.W. Bull. 116 (in press).

The following projects are in active preparation and should be complete by January 1970:

Silurian conodonts from the Yass Basin, N.S.W. (with A. Link).

Discovery of Ludlovian conodonts at Canberra (with D.L. Strusz).

Rough drafts have been prepared on the following topics:

Statistical analysis of conodonts from the Upper Cambrian and Lower Ordovician (Tremadocian) of Western Queensland.

The erection of stages in the Upper Cambrian and Lower Ordovician (Tremadocian) of Western Queensland (with P.J. Jones and J.A. Shergold).

Papers published during the year include:

British Avonian (Carboniferous) conodont faunas and their value in local and intercontinental correlation. Bull. Brit. Mus. (nat. Hist) Geol., Suppl. 5, pp. 1-363, pls. 1-33. (with F.H.T. Rhodes & R.L. Austin).

Devonian and Carboniferous conodonts from the Bonaparte Gulf Basin, Northern Australia. Bur. Miner. Resour. Aust. Bull. 98, pp. 1-242, pls. 1-43.

The value of conodonts in the recognition of the Devonian - Carboniferous Boundary, with particular Reference to Great Britain (with Austin, Rhodes and Williams).

The mobile conodont laboratory completed the sampling of the Cambrian-Ordovician sections in the Georgina Basin during the 1969 field season.

Annual Report

by

J.G. Binnekamp

J.G. Binnekamp was involved mainly in examination of samples collected by field parties in New Guinea. 130 samples collected by the Kubor Range Party 1968 were examined and a record on the results is in preparation. About 100 samples from Gazelle Peninsula (New Britain), collected by R.P. Macnab (Moresby Office), 60 from the Blucher Range, collected by J.A.J. Smit (Moresby Office) and 23 collected by the staff of the Moresby Office in the Kratke Range were examined and the results reported.

During February, March and April he worked with the New Britain Field Party. Samples collected during the traverses were cut and polished to enable a provisional determination of the foraminiferal fauna in the field. Specimens of selected samples were sent to Port Moresby for sectioning. About 180 of these samples were examined. Poor exposure and inaccessibility prevented measuring and detailed sampling of sections. After returning to Canberra a detailed examination of the larger Foraminifera occurring in New Britain was started. Most samples are massive limestones, which can not be broken down to give free specimens; preparation of oriented sections is therefore laborious and slow. The most promising samples from the Gazelle Peninsula, collected in 1967 and 1968 by R.P. Macnab, have been studied. Photographs of selected sections of the various species have been taken for a reference system and also for possible publication.

The larger Foraminifera from New Britain occur in three distinctive associations. The oldest fauna occurs in limestone lenses in the so-called Baining Volcanics, and includes Nummulites, Discocyclina and Pellatispira. This is a Tertiary "b" stage, upper Eocene fauna. An association of Lepidocyclina (Eulepidina), Lepidocyclina (Nephrolepidina) and Cycloclypeus is found in several samples from the Gazelle Peninsula and the headwaters of the Berg Berg and Ikoi Rivers. This fauna is of Tertiary "e" stage, upper Oligocene - Lower Miocene age. The majority of the samples collected come from the so-called Jacquinot Limestone. This formation appears to consist mainly of coralline and algal limestone with rare Foraminifera. Larger Foraminifera include Lepidocyclina (Nephrolepidina and "Trybliolepidina") Miogypsina, Austrotrillina, Flosculinella, Alveolinella and Sorites. This fauna indicates a Tertiary "f" stage, middle Miocene. Some samples from this formation contain planktonic Foraminifera which indicate an upper Miocene or lower Pliocene age (planktonic foraminiferal zone N 18). Raised reefs along the coast of the island are of Pliocene-Pleistocene age.

Annual Report

by

D. Burger and E.M. Kemp

After repeated changes of technical personnel for the palynological laboratory, the situation stabilized with the appointment of Miss Elsa Meyer on the 28th January; this increased the laboratory output by more than 50% over the previous 12 months and a total of 425 samples were treated.

E.M. Kemp, who resigned from the Bureau on 1st August, examined spores, pollen grains and dinoflagellates from the Upper Mesozoic in exploration wells in Western Australia. She studied the occurrence of microfossils in the Permo-Triassic of the Bowen and Galilee Basins in outcrop and subsurface. A study on the taxonomy of Lower Triassic mega-spores is in press. She also studied Permian microfloras from outcrop samples (Records 1969/98) collected in Antarctica during the field season of 1968-69. A preliminary report on three scout bores, which penetrated the Cretaceous in the Surat Basin, was prepared for the Geological Survey in Brisbane. The results seem to confirm earlier reports on relationships between palynological zonations and sedimentary boundaries, which might be interpreted to indicate that certain formations of the Rolling Downs Group have a time-transgressive character towards the Nebine Ridge.

She attended the 4th Symposium on the Sydney Basin in Newcastle in May.

D. Burger allocated most time to the study of Jurassic and Cretaceous stratigraphic palynology of the Great Artesian Basin, Queensland. Extension of this study into the Papuan Basin increased knowledge of the dinoflagellates connected with the Upper Jurassic and Lower Cretaceous Cannosphaeropsis and Scriniodinium attadalense/Dingodinium cerviculum Zones. Time relationship of palynological units K 1b-d and K2a-b to the formations of the Rolling Downs Group in the Eromanga Basin, Queensland, is being reconsidered from spore-stratigraphic studies since 1961 and prepared for publication. Time-stratigraphic occurrence of early angiospermous pollen grains in the Albian and Cenomanian of Australia and North America appears in certain aspects to be closely comparable. An initial study on the subject is in press. Study of the Upper Cretaceous in the Northern Territory and in Victoria is in progress.

Results of last year's field work in the Goondiwindi 1:250,000 Sheet area, Surat Basin, was compiled in cooperation with N.F. Exon, A. Medvecky and F. Olgers. Palynological comparison of the Lower Jurassic in the Surat and Clarence-Moreton Basins is almost ready for publication. Burger visited the Geological Survey of New South Wales in connection with palynological investigation of core material from Bellfields Scout Bore (December 1968). He visited BP Petroleum Development Australia in Melbourne in connection with the study of the Cretaceous in Papua (August) and also visited Mr. W.K. Harris, Department of Mines, Adelaide to discuss aspects of Tertiary palynology in Australia.

In September 1969, approval was obtained for the purchase of optical and electrical equipment necessary for fluorescence palynology. This type of study is based on the phenomenon of autofluorescence of fossil plant microfossils by ultraviolet light excitation. Research will be directed towards the study of Cretaceous and Tertiary spores and pollen for stratigraphic purposes.

The following exploratory wells and stratigraphic bores were examined during the period -

Exploratory wells:	Western Australia	Lennard Napier No. 1 B.O.C. Dampier No. 1 " Madeleine No. 1 Marathon Remarkable Hill No. 1
	Northern Territory	Arco Lacrosse No. 1 " Petrel No. 1
	Queensland	A.A.O. Latemore No. 1 Alliance Thunda No. 1 U.K.A. Foyleview No. 1 " Moombah No. 1 " Talwood No. 1 N.A.I. Whyenbirra No. 1 Sun Barcoo No. 1 Exoil Brookwood No. 1 Amerada Thunderbolt No. 1
	New South Wales	A.O.G. Mellong No. 1 " Belford No. 1
	South Australia	Alliance Caroline No. 1
	Papua	A.P.C. Iehi No. 1 I.E.C. Barikewa No. 1
Stratigraphic bores: (1:250,000 Sheet areas)	Northern Territory	Napperby
	New South Wales	Enngonia
	Queensland	Hughenden, Dalby, Chinchilla, Warwick, Eulo, Charleville, Bulloo, Cunnamulla, Wyandra, Muttaburra, Surat, Springsure, Tangorin, Buchanan.

Specialist Work

Dr. A.A. Öpik has continued work on "Agnostids of the family Ptychagnostidae and Diplagnostidae of the Northern Territory and New South Wales" and "Trilobites of Asian Affinities of the Middle Cambrian of Northern Australia".

Dr. Irene Crespin has continued preparation of catalogues of fossil type specimens. The N.S.W. catalogue is completed and considerable progress has been made on the second A.C.T. Catalogue.

Mrs. Mary E. White has examined plant fossils from the Springsure area; the Eromanga Basin; the Surat and Clarence Moreton Basins; Cape York Peninsula and from Beaver Lake and Prince Charles Mountains, Antarctica. The results have been reported in the B.M.R. Records listed in section S17 (publications).

S14 - SEDIMENTOLOGY

by

A.R. Jensen

Personnel: A.R. Jensen, M.C. Brown, P.J. Alcock, T.K. Zapasnik

Members of the sedimentology group have been involved mainly in two projects, the results of which are reported elsewhere. M.C. Brown continued his study of carbonates in the McArthur River area, Northern Territory, and Jensen and Alcock continued their study of the Triassic sequence in the Bowen Basin.

Jensen spent the year within the Geology Department at the Australian National University under the terms of a Commonwealth Public Service scholarship. He was able to undertake courses in palynology, pedology, and advanced sedimentology. Concurrent with a study of part of the Triassic sequence of the Bowen Basin, Jensen also investigated the use of clastic tourmaline in the solution of stratigraphic problems. Tourmaline grains can be grouped according to size, roundness and colour, and the relative abundance of each group is strongly influenced by provenance. It can be shown, for example, that the Rewan Formation and the Clematis Sandstone were derived from the same provenance, but that the provenance differs within the basin from place to place.

Zapasnik joined the group late in the year, and spent some time refining methods of heavy mineral concentration and recovery of bromoform. The basic method now in use involves the removal of iron oxide with oxalic acid and aluminium foil, centrifuge concentration of heavies with bromoform, and the freezing of the heavy fraction in ice while the light fraction is poured off. All washing is carried out with acetone or alcohol, and the bromoform is recovered with water.

S15 - PHOTOGEOLOGY

by

C. Maffi

Personnel: C. Maffi, C.J. Simpson

Work completed:

Northern Territory	Waterloo, Birrindudu, Tanami sheets; Reynolds Range Area (Napperby sheet); Mt. Nancar Damsite (Pine Creek sheet).
Queensland	Normanton and Dobbyn sheets (Dobbyn for field party use only, not available for issue);
Western Australia	Cape Preston Area (Dampier sheet): fracture analysis; Hamersley Iron Province: mapping of limonitic pisolitic ore bodies.
A.C.T.	North Molonglo Outfall Sewer Project (Canberra sheet): fracture analysis.
Victoria	Feasibility study of airphoto coverage on portion of Bendigo and Wangaratta sheets, for State Rivers and Water Supply Commission of Victoria.
Papua/New Guinea	New Britain: construction of photomosaics, photo-interpretation and field mapping on the central and eastern parts of the island; Sirinumu Damsite: fracture analysis.

Assistance with photo-interpretation was given to field party personnel working in the Louisiade Archipelago (Papua/New Guinea) and of Cloncurry sheet (Queensland).

Work in progress at 31st October 1969:

Queensland - Red River, Galbraith, Rutland Plains sheets.

Field work:

C. Maffi in New Britain from 29/1 to 5/5/1969. C.J. Simpson in Queensland and Northern Territory from 15/6 to 18/7/1969.

Special projects:

Stereoscopic marks for the evaluation of dips and altitude differences were produced.

A method of automatic selection of fracture-trace trends, by means of a laser scanner, was developed.

Training courses:

Five new staff members were trained in photointerpretation.

A display was arranged in July for 3rd year Australian National University students.

S16 - MISCELLANEOUS

B.K. Graham was engaged in various tasks, until her departure for the field at the end of May.

Data Filing and Indexing

1) Subsidy applications and completion reports on wells and geophysical surveys, received under the Petroleum Search Subsidy Scheme, were circulated and filed. Summary cards were prepared for all well applications and reports.

2) Sedimentary Basin index cards were kept up to date as applications, reports and other references were received.

3) Material received from exploration companies, and data from other sources such as scout reports and press releases, were added to the well progress files.

4) Punch cards summarising some well applications were prepared, and together with cards on applications and reports prepared by other officers, were punched and filed.

5) Queries from other officers and visitors concerning data available on specific areas were dealt with.

Map Compilation

1) International Geologic Atlas: Sheet 15 (Australia) at 1:10,000,000 scale - The compilation was largely completed after visits had been made to various State Geological Surveys for discussions on the most up to date information available for incorporation in the map.

2) Geological Map of the World : Australia and Oceania at 1:5,000,000 scale - Draft compilations of Sheets 9 and 13, prepared by the N.Z. Geological Survey, were examined for conformity with published sheets and comments made.

Field Mapping

During February, a week was spent in the Cooleman area of N.S.W. supervising, with other geologists, field mapping by a group of vacation student employees.

Georgina Basin Hydrology (M.A. Randal - G.S.Q.)

Collection of water samples, to provide geochemical control on groundwater movement, was continued. Water samples were mainly from Palaeozoic aquifers but a few samples were collected from Precambrian and Mesozoic rocks.

Samples were collected from the following 1:250,000 sheet areas:- Duchess, Boulia, northern quarter of Springvale and Mt Whelan. Check traverses were made on Glenormiston and the eastern margin of Urandangi.

Four hundred bores were sampled and the water is being analysed by A.M.D.E.L.

APPENDIX S17 STATUS OF RECORDS AND PUBLICATIONS ON 31ST OCTOBER, 1969

PROJECT / AUTHOR	TITLE		FORM OF PUBLICATION	STATUS
			Bulletin B Report R Explanatory Notes E.N. External Publication E.P. Records C	
AMADEUS BASIN				
WELLS, A.T., and others	Geology of the Amadeus Basin		B	With editor
COOK, P.J.	The Stairway Sandstone		B95	Received by editor
WELLS, A.T., and others	Geology of the north-east Amadeus Basin		R113	Issued
FORMAN, D.J., and others	Structure of the north-eastern margin of the Amadeus Basin		R103	Issued
STEWART, A.J.	KULGERA	SG-53/5	E.N.	Issued
SHAW, R.D.	HALE RIVER	SG-53/3	E.N.	Issued
COOK, P.J.	HENBURY	SG-53/1	E.N.	Issued
QUINLAN, T., and FORMAN, D.J.	HERMANNSBURG	SF-53/13	E.N.	Issued
COOK, P.J.	LAKE AMADEUS	SG-52/4	E.N.	Issued
STEWART, A.J.	McDILLS	SG-53/7	E.N.	Issued
RANFORD, L.C.	MOUNT LIEBIG	SF-52/16	E.N.	Map only, in press
RANFORD, L.C.	MOUNT RENNIE	SF-52/15	E.N.	Issued

STEWART, A.J.	Completion report, Alice Springs (BMR) Stratigraphic No. 3 (Ringwood), Northern Territory		C1969/7	(being assembled)
STEWART, A.J.	Progress report on the Arltunga Nappe Complex		C1969/71	Issued
STEWART, A.J.	An interpretation of the structure of the Blatherskite Nappe, Alice Springs, Northern Territory		E.P.	Issued
WELLS, A.T.	ALICE SPRINGS	SF/53-14	E.N.	Issued
WELLS, A.T.	MACDONALD	SF/52-14	E.N.	Issued
WELLS, A.T.	FINKE	SG/53-6	E.N.	Issued
COOK, P.J.	RODINGA	SG/53-2	E.N.	Issued
MILLIGAN, E.N., and SHAW, R.D.	ILLOGWA CREEK	SF/53-15	E.N.	Issued

BONAPARTE BASIN

ROBERTS, J., and VEEVERS, J.J.	The Carboniferous geology of the Bonaparte Gulf Basin, northwestern Australia. 6th Internat. Congress of Carb. Strat. 2 Geol., Sheffield 1967		E.P.	In press
VEEVERS, J.J., and ROBERTS, J.	Upper Palaeozoic Rocks, Bonaparte Gulf Basin of Northwestern Australia.		B97	Issued
DICKINS, J.M., ROBERTS, J. and VEEVERS, J.J.	Permian and Mesozoic geology of the Bonaparte Gulf Basin, northwestern Australia.		R	In prep.

NGALIA BASIN

EVANS, T.G. and GLIKSON, A.Y.	Geology of the Napperby Sheet Area, Northern Territory		C1969/85	(being assembled)
NICHOLAS, T.	Geology of the Lake Mackay Sheet, Northern Territory		C1969/89	(being assembled)
NICHOLAS, T.	LAKE MACKAY	SF-52/11	E.N.	In prep.

BOWEN BASIN

DICKINS, J.M., and MALONE, E.J.	Geology of the Bowen Basin, Queensland		B	In prep.
MALONE, E.J., and others	Geology of the Duaringa and Saint Lawrence 1:250,000 Sheet areas, Queensland		R121	Issued
MOLLAN, R.G., and others	Geology of the Springsure 1:250,000 Sheet area, Queensland		R123	In press
MOLLAN, R.G., and others	Geology of the Eddystone, Taroom and western third of the Mundubbera 1:250,000 Sheet areas, Queensland		R	With editor
MALONE, E.J.	MOUNT COOLON	SF-55/7	E.N.	In press
MALONE, E.J.	SAINT LAWRENCE	SF-55/12	E.N.	In fair drawing
KIRKEGAARD, A.G.*	DUARINGA	SF-55/16	E.N.	In fair drawing
EXON, N.F.	EDDYSTONE	SG-55/7	E.N.	Issued
FORBES, V.R.*	TAROOM	SG-55/8	E.N.	Issued
OLGERS, F.	EMERALD	SF-55/15	E.N.	In press

*G.S.Q.

OLGERS, F.	CLERMONT	SF-55/11	E.N.	In press

TEXAS HIGH

OLGERS, F.	Buchanan		E.N.	In press
OLGERS, F.	Geology of the Drummond Basin, Queensland		C/B	In prep.

SURAT BASIN

EXON, N.F., REISER, R.F., JENSEN, A.R., BURGER, D., and THOMAS, B.M.	The geology of the Chinchilla 1:250,000 Sheet area southern Queensland		C1968/53	Issued
EXON, N.F., LANGFORD-SMITH, T., and McDOUGALL, I.	The age and geomorphic correlation of deep-weathering profiles, silcrete and basalt in the Roma-Amby region, Queensland		E.P.	Final draft completed

EROMANGA BASIN

VINE, R.R.	Geology of the northern Eromanga and Galilee Basins, Queensland		B	In prep.
EXON, N.F. and others	The geology of the Tambo-Augathella area		R	With editors
CASEY, D.J.	MANUKA	SF-54/8	E.N.	Published
CASEY, D.J.	TANGORIN	SF-55/5	E.N.	In press
EXON, N.F.	TAMBO	SG-55/2	E.N.	In press
CASEY, D.J., & GALLOWAY, M.C.	BLACKALL	SG-55/1	E.N.	Edited
VINE, R.R.	MUTTABURRA	SF-55/9	E.N.	With editors
VINE, R.R.	RICHMOND	SF-54/4	E.N.	In press

GREGORY, C., & VINE, R.R.	CANTERBURY	SG-54/7	E.N.	In press
GREGORY, C., & VINE, R.R.	WINDORAH	SG-54/8	E.N.	In press
GALLOWAY, M.C.	AUGATHELLA	SG-55/6	E.N.	With editors
VINE, R.R. & GALLOWAY, M.C.	Shallow stratigraphic drilling, northern Eromanga Basin, 1963-64		C1969/20	Issued
GALLOWAY, M.C. and SENIOR, DANIELE	TICKALARA	SG-54/3	E.N.	In prep.
GALLOWAY, M.C.	ADAVALE	SG-55/5	E.N.	In press
INGRAM, J.A.	EROMANGA	SG-54/12	E.N.	Editing
INGRAM, J.A.	TOOMPINE	SG-55/13	E.N.	Editing
INGRAM, J.A.	BULLOO	SG-54/4	E.N.	Editing
SENIOR, DANIELE	DURHAM DOWNS	SG-54/15	E.N.	In press
SENIOR, DANIELE	THARGOMINDAH	SG-54/16	E.N.	In press
SENIOR, DANIELE	CHARLEVILLE	SG-55/10	E.N.	Editing
SENIOR, B.R.	CONNEMARA	SG-54/3	E.N.	In press
SENIOR, B.R.	JUNDAH	SG-54/4	E.N.	In press
SENIOR, B.R.	BARROLKA	SG-54/11	E.N.	In press
SENIOR, B.R.	QUILPIE	SG-55/9	E.N.	Editing
SENIOR, B.R.	EULO	SH-55/1	E.N.	Editing
THOMAS, B.M.	WYANDRA	SG-55/14	E.N.	In prep.
THOMAS, B.M.	CUNNAMULLA	SH-55/2	E.N.	In prep.

VINE, R.R.	Hydrological implications of recent geological work in the Great Artesian Basin		C1969/56	Issued
VINE, R.R.	LONGREACH	SF-55/13	E.N.	With editors
VINE, R.R. & DOUTCH, H.F.	GALILEE	SF-55/10	E.N.	In prep.
SENIOR, B.R., INGRAM, J.A., THOMAS, B.M. & SENIOR, D.A.	The geology of the Quilpie, Charleville, Toompine, Wyandra, Eulo, and Cunnamulla 1:250,000 Sheet areas, Q'ld.		C1969/13	Issued
INGRAM, J.A.	Drilling for opal in Queensland		E.P.	In press

SURAT BASIN

EXON, H.F. and others	The geology of the Chinchilla 1:250,000 Sheet area, southern Queensland		C1968/53	Issued
EXON, N.F. and others	The age and geomorphic correlation of deep-weathering profiles, silcrete and basalt in the Roma-Amby region, Queensland		E.P.	In press
EXON, N.F.	MITCHELL		E.N.	In prep.
EXON, N.F.	ROMA		E.N.	With editors
REISER, R.F.	CHINCHILLA		E.N.	With editors
REISER, R.F.	SURAT		E.N.	In prep.
MEDVECKY, A.	DALBY		E.N.	In prep.
EXON, N.F. & VINE, R.R.	Revised nomenclature of the "Blythesdale" sequence		E.P.	In prep.
EXON, N.F. & others	The post-Palaeozoic rocks of the Warwick 1:250,000 Sheet area, Queensland and New South Wales		C1969/80	In prep.

EXON, N.F.	The evolution of the Surat Basin - a summary	E.P.	In prep.
SEDIMENTOLOGY			
ALCOCK, P.J.	Progress Report on the Moolayember Formation, Bowen Basin, Queensland	C1969/43	Issued
JENSEN, A.R.	Progress Report on the Study of the Clematis Sandstone and Rewan Formation	C1969/66	Issued
BROWN, M.C.	Middle and Upper Cambrian sedimentary rocks in the northern part of the Northern Territory	C1968/115	Issued
PHOTOGEOLOGY			
SIMPSON, C.J.	North Molonglo Outfall Sewer Project - Photogeological analysis	C1968/122	Issued
MAFFI, C.	Report on photo-interpretation of Waterloo 1:250,000 scale sheet, N.T.	C1969/63	Issued
MAFFI, C.	Floating marks for the evaluation of altitude differences and slopes on air photographs	C1969/65	Issued
MAFFI, C.	Statistical analysis of photogeological linear features, Cape Preston, W.A.	C1969/116	Being assembled
SIMPSON, C.J.	Report on photointerpretation of Normanton 1:250,000 scale sheet, Q'ld.	C1969/120	To be issued soon

PALAEONTOLOGY

BELFORD, D.J.	Upper Devonian and Carboniferous Foraminifera, Bonaparte Gulf Basin, Western Australia. 1. The genus Nanicella; II. Tournayellidae III. Ozawainellidae; IV. The genus Haplophragmella.	B108	in press
DICKINS, J.M.	Correlation of the Permian of the Hunter Valley, New South Wales and the Bowen Basin, Queensland	B80	issued
DICKINS, J.M.	Discovery of the Crinoid Calceolispongia in the Permian of Queensland	B80	issued
DRUCE, E.C.	Lower Devonian conodonts from the northern Yarrol Basin, Queensland	B108	in press
DRUCE, E.C.	Frasnian conodonts from Mount Morgan, Queensland	B108	in press
DRUCE, E.C.	Carboniferous conodonts from the Yarrol Basin, Queensland	B108	in press
DRUCE, E.C. & JONES, P.J.	Cambro-Ordovician conodonts from the Burke River structural belt, Queensland	B110	in press
GILBERT-TOMLINSON, Joyce	Ordovician trilobites of northern Australia: 1. Dikelokephalinidae	B	in prep.
GILBERT-TOMLINSON, Joyce	The Lower Ordovician gastropod Teiichispira in northern Australia	B	in prep.
JONES, P.J.	Upper Devonian Ostracoda and Eridostraca from the Bonaparte Gulf Basin, northwestern Australia	B99	issued
JONES, P.J.	Marine Ostracoda (Palaeocopa, Podocopa) from the Lower Triassic of the Perth Basin, Western Australia	B108	in press
JONES, P.J.	Lower Ordovician conodonts from the Bonaparte Gulf Basin and the Daly River Basin, northwestern Australia	B117	with editor
OPIK, A.A.	Early Ordovician at Claravale in the Fergusson River area, Northern Territory	B80	issued

"OPIK, A.A.	The Ordian stage of the Cambrian and its Australian Metadoxididae	B92	issued
"OPIK, A.A.	Ordian (Cambrian) Crustacea Bradoriida of Australia	B103	issued
"OPIK, A.A.	Nepeid trilobites from northern Australia	B113	in press
"OPIK, A.A.	Redlichia	B114	in press
"OPIK, A.A.	Dolicho metopid trilobites	B	in manuscript
"OPIK, A.A.	Xystridura in Australia	B	with editor
"OPIK, A.A.	Trilobites of the Middle Cambrian of northern Australia of Asian affinities	B	in prep.
"OPIK, A.A.	Ptychagnostidae and Diplagnostidae of Northern Territory and New South Wales	B	in prep. (Feb. 1970)
PLANE, M.	Additions to the Riversleigh vertebrate fauna, northern Queensland.	B	in prep.
PLANE, M.	The Bullock Creek fauna	B.	in prep.
ROBERTS, J.	Devonian and Carboniferous brachiopods from the Bonaparte Gulf Basin, northwestern Australia.	B122	in press
RUNNEGAR, B.M.	Eurydesma and Glendella gen. nov. (Bivalvia) in the Permian of eastern Australia	B116	in press
SHERGOLD, J.H.	Oryctocephalidae (Trilobita: Middle Cambrian) of Australia	B104	in press
SHERGOLD, J.H.	Late Cambrian trilobites from the Gola Beds, western Queensland	B112	in press
SHERGOLD, J.H.	Bibliography and index of Australian Cambrian trilobites (1884-1969)	B	in prep.
SHERGOLD, J.H.	Meneviella viatrix, a new conocoryphid trilobite from the Middle Cambrian of western Queensland	B	in prep.

SHERGOLD, J.H.	Late Cambrian Pseudagnostidae from the Burke River structure, western Queensland	B	in prep.
SHERGOLD, J.H.and BASSETT, M.G.	Lithofacies and biofacies at the Wenlockian/ Ludlovian junction, Wenlock Edge, Shropshire. Submitted to Lethaia	EP	in prep.
SKWARKO, S.K.	Lower Cretaceous Trigoniidae from Stanwell, eastern Queensland	B80	issued
SKWARKO, S.K.	Chapter on 'Mesozoic' in the Katherine-Darwin Bulletin	B82	issued
SKWARKO, S.K.	Bibliography of the Mesozoic Palaeontology of Australia and Eastern New Guinea	B108	in press
SKWARKO, S.K.	Aptian (Lower Cretaceous) 'Apictrigonia' from the Melligo Quartzite, Dampier Peninsula, Western Australia	B108	in press
SKWARKO, S.K.	On the discovery of Halobiidae (Bivalvia, Triassic) in Eastern New Guinea	B	with editor
SKWARKO, S.K	Middle and Upper Triassic Mollusca from the Yuat River, Eastern New Guinea	B	with editor
SKWARKO, S.K.	A correlation chart for the Cretaceous System in Australia	B	Prepared for ECAFE Sympos.
SKWARKO, S.K.	Some Ordovician graptolites from the Canning Basin, W.A.	B	in prep.
SKWARKO, S.K.	Revision of the marine Jurassic faunas of Western Australia	B	in prep.
SKWARKO, S.K.	Australian Cretaceous Ammonoidea	B	in prep.
STRUSZ, D.L.	A new species of rhynchonellid brachiopod from the Devonian of New South Wales	B108	in press
STRUSZ, D.L.	Rhizophyllum and Calceola from the Devonian of New South Wales	B108	in press

STRUSZ, D.L. (with J.S. JELL)	Cyathophyllum (Radiophyllum) from the Devonian of eastern Australia	B116	in press
STRUSZ, D.L. (with J. SHERGOLD)	Revision of Etheridge and Mitchell's encrinurid trilobites from the Silurian of Canberra and Yass (provisional title)	B	in prep.
BELFORD, D.J. and DICKINS, J.M.	Palaeontology in Australia ECAFE Symp. Dev. Petr. Resour. Asia Far East	E.P.	issued
DICKINS, J.M.	Correlation and subdivision of the Permian of Eastern and Western Australia. Rep. int. geol. Congr., 22	E.P.	in press
DICKINS, J.M.	Correlation chart for the Permian System in Australia with accompanying notes and bibliography Proc. 1st International Symposium on Gondwona Stratigraphy and Palaeontology	E.P.	in press
DICKINS, J.M.	The Permian of Australia and New Zealand and Theories of Tectonism. Proc. Continental Drift Symposium, Montevideo, October 1967	E.P.	in press
DICKINS, J.M.	Geological History of the Bowen Basin, Queensland Div. Geol. Soc. Aust. 1969 Field Conference	E.P.	published
DICKINS, J.M., GOSTIN, V.A., and RUNNEGAR, B.M.	Age of the Permian Sequence in the southern part of the Sydney Basin, New South Wales. Stratigraphy and Palaeontology Essays in Honour of Dorothy Hill, edited by K.S.W. Campbell, A.N.U. Press, Canberra 1969	E.P.	published
GILBERT-TOMLINSON, J.	An Ordovician gastropod and trilobite from Queensland (a single plate with captions for incorporation in the University of Queensland's forthcoming publication on Ordovician and Silurian fossils from Queensland).	E.P.	in prep.
ROBERTS, J.	Mantle canal patterns in Schizophoria (Brachiopoda) from the lower Carboniferous of New South Wales. Palaeontology, 11, 389-405	E.P.	published

SHERGOLD, J.H. and SHIRLEY, J.	The faunal-stratigraphy of the Ludlovian rocks between Craven Arms and Much Wenlock, Shropshire. Geol. J. 6(1): 119-138	E.P.	published
SKWARKO, S.K.	On Upper Jurassic Apiotrigonia from Mexico. Paleont. Mexicana	E.P.	published
STRUSZ, D.L.	Cystiphyllum americanum var australe Etheridge Jnr 1892, from North Queensland. (Stratigraphy and Palaeontology: Essays in honour of Dorothy Hill; ANU Press)	E.P.	published
STRUSZ, D.L.(with B. CHATTERTON and P. FLOOD)	Revision of the New South Wales brachiopod "Spirifer" Yassensis	E.P.	in prep.
STRUSZ, D.L. (with E. DRUCE)	Discovery of Ludlovian conodonts at Canberra (provisional title)	E.P.	in prep.
BURGER, D.	Relationship of palynology to stratigraphy in the Lower Cretaceous of the Surat Basin, Queensland	C1968/125	issued
BURGER, D.	(in cooperation with Dr G.R.J. Terpstra) Micropalaeontology and palynology of samples from BMR Bulloo No.1 Scout Hole, Queensland	C1969/39	issued
BURGER, D.	Palynological observations of Jurassic and Cretaceous strata at the border of Queensland and New South Wales	C1969/94	issued
KEMP, E.M.	Palynological examination of samples from the Beaver Lake Area (Antarctica)	C1969/98	issued
SHERGOLD, J.H.	Cambrian Palaeontology In de Keyser, F. The Cambrian of the Burke River Outlier	C1968/67	issued
STRUSZ, D.L.	Bibliography of the Geology and Geomorphology of the Canberra 1:250,000 Sheet	C1968/94	in prep.
STRUSZ, D.L.	List of Australian Palaeontological research projects revised edition	C1968/118	in prep.

TERPSTRA, G.R.T.	Micropalaeontological examination of samples from A.D.G. Scout Bores No.1 and No.2 Talbalba, Thallon Basin, Queensland	C1969/55	in prep.
TERPSTRA, G.R.T.	Micropalaeontological examination of outcrop samples from the Kemp Welch River and Tapini areas of the Central District, Papua-New Guinea	C1969/68	in prep.
TERPSTRA, G.R.T.	Micropalaeontological examination of cores from the Rolling Downs Group in GSQ Boreholes Surat 1, 2 and 3 Queensland	C1969/114	in prep.
TERPSTRA, G.R.T. and BURGER, D.	Micropalaeontology and Palynology of samples from BMR No.1 Scout Hole Queensland	C1969/39	issued
WHITE, M.E.	Reports on the 1968 Collection of Plant Fossils from the Moolayember and Teviot Formations	C1969/51	in prep.
WHITE, M.E.	Reports on 1967 Collection of Plant Fossils from Cape York Peninsula	C1969/53	in prep.
WHITE, M.E.	Reports on the 1968 Collection of Plant Fossils from the Eromanga Basin, Queensland	C1969/54	in prep.
WHITE, M.E.	Report on the 1968 Collection of Plant Fossils from Surat and Clarence-Moreton Basins	C1969/57	in prep.
WHITE, M.E.	Reports on Plant Fossils from the Beaver Lake Area, Prince Charles Mountains, Antarctica	C1969/100	in prep.

METALLIFEROUS DEPOSITS SECTION

METALLIFEROUS DEPOSITS SECTION

CONTENTS

ILLUSTRATIONS

SUMMARY

This report summarizes the work of the Metalliferous Deposits Section from November, 1968, to October, 1969. Figures M1 and M2 show areas where fieldwork was carried out in 1969, and areas which it is proposed to map in 1970.

Regional mapping was carried out in the Victoria River Basin, New Britain, eastern Papua, and Antarctica.

Mapping of the Victoria River Downs, Wave Hill, Waterloo, and Limbunya 1:250,000 Sheet areas completed a three-year survey of the Victoria River Basin. Stratigraphic drilling of the Antrim Plateau Volcanics was started, and will be completed in 1970. Prospects of finding economic mineral deposits in the area as a whole do not appear to be promising; however, minor copper mineralization in the Antrim Plateau Volcanics and the overlying Cambrian limestone has been known for a long time, and the possibility of finding payable deposits can not be dismissed.

Mapping of New Britain was completed during the year. Two visits were made to the island - one from February to mid-May, and the other from September to mid-November; during the first, a helicopter gravity survey was carried out concurrently with the geological mapping. Formations on the island consist of volcanics, volcanogenic sediments, tonalitic to gabbroic intrusives, limestone, terrestrial sediments, and raised coral reefs, and range in age from Eocene to Recent. Many of the intrusive rocks contain pyrite and pyrrhotite, and a few also carry traces of chalcopyrite; authorities to prospect have been taken out over the more promising areas in the hope of finding porphyry-copper type deposits.

Fieldwork for the eastern Papua project has been wound up with surveys in the Louisiade Archipelago, check and follow-up mapping on Normanby Island and the East Cape peninsula, and further investigation of the Dayman Dome. Gold on Sudest Island appears to be the only possibly economic prospect in the Louisiade Archipelago, excluding Misima Island.

Four geologists took part in a reconnaissance survey in the Prince Charles Mountains, Antarctica, from 10th January to 18th February. Apart from a small area of Permian sediments near Beaver Lake, the rocks observed are amphibolite to granulite facies metamorphics, charnockites, and granitic intrusives. Coal seams up to 4 metres thick are abundant in the Permian rocks; samples of these are being studied by the C.S.I.R.O. A small pocket of disseminated molybdenite was found in a metamorphic rock on Rauer Island.

Bulletin 106, on the geology of the east Kimberley area, was published during the year, and Bulletin 107, on the Lamboo Complex, east Kimberley, is in press. Records on various aspects of the geology of the Kimberley Basin and of the west Kimberley area were completed, and four 1:250,000 maps and Explanatory Notes for the east Kimberley were published. Two Preliminary maps for the west Kimberley were issued.

Writing of the first draft of the Arnhem Land Bulletin is nearly complete, as is a Report on the basement rocks of that area.

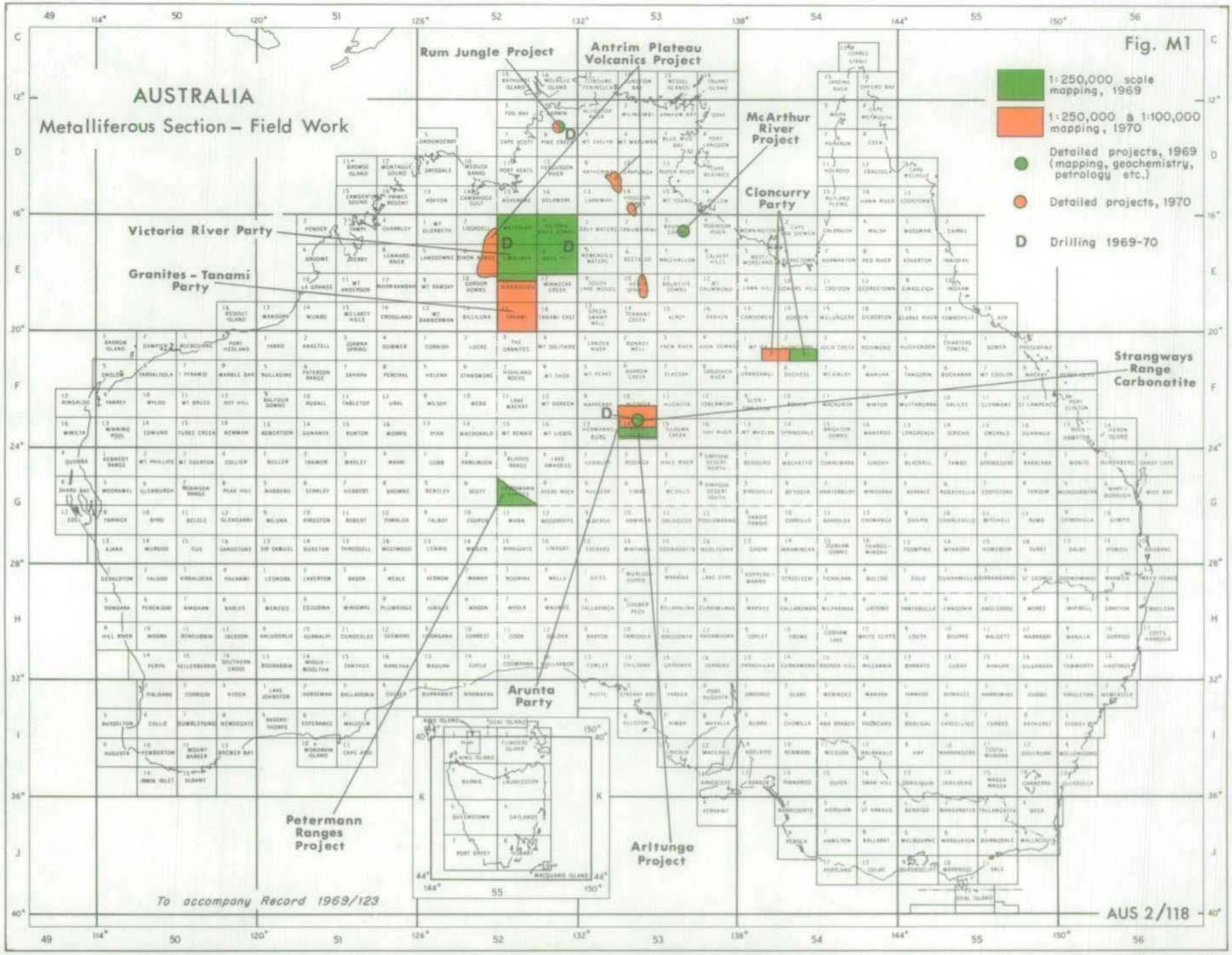
Preparation and checking of maps and reports on the Burdekin River Region, Queensland, continued.

Reporting of the results of the mapping of Cape York Peninsula and the Torres Strait islands is progressing well. The first draft of the Bulletin on the whole project is almost complete, and compilation of the 1:500,000 map to accompany the Bulletin was started. Completion of coloured maps and Explanatory Notes for the area will mostly have to await mapping of the Carpentaria Basin by the Sedimentary Section.

Completion of the Central Highlands project, N.G., awaits further mapping to be carried out in 1970. Preparation of the Ramu and Karimui 1:250,000 sheets for Preliminary Edition is well advanced.

Mapping of the Cloncurry and Marraba 1:100,000 sheets was completed. Colour aerial photographs, which were available for part of the area, were found to have many advantages over black and white. The broad stratigraphic divisions set up during the 1:250,000 mapping carried out in the 1950's provided a very useful basis for more detailed subdivisions arising out of this year's mapping. Apart from uranium at the Mary Kathleen mine, economic interest in the area centres on copper and, to a lesser extent, on uranium; about a dozen companies have holdings in the area mapped. Some experimental geochemical sampling was carried out by the field party, but the results are not yet available.

As a result of a policy decision to reduce the area under Reservation at Rum Jungle, field work was confined to the 100 square miles retained for further investigation. Many enquiries were received about prospects in the areas relinquished. Diamond drilling results on base metal and radiometric anomalies drilled during the year were disappointing, and three holes did not reach their target depths because of difficult conditions. Check auger drilling was carried out in a number of anomalous areas, and deeper rotary drilling in selected localities mostly showed that shallow radiometric anomalies did not persist in depth. After a radiometric reconnaissance of all outcrops of the Crater and Beeston's Formations, part of the Crater Formation east-north-east of Batchelor was selected for radiometric gridding and detailed mapping; this will be followed by deep diamond drilling to test for uranium mineralization below the zone of weathering. Evaluation was begun of a radon detector as a guide to areas where further testing for uranium mineralization might be warranted. Further sampling of the Celia and Coomalie Dolomites to delineate magnesite bodies within them yielded encouraging results.


AUSTRALIA
Metalliferous Section – Field Work
Fig. M1
1:250,000 scale mapping, 1969
1:250,000 & 1:100,000 mapping, 1970
Detailed projects, 1969 (mapping, geochemistry, petrology etc.)
Detailed projects, 1970
D Drilling 1969-70
Rum Jungle Project
Antrim Plateau Volcanics Project
McArthur River Project
Cloncurry Party
Victoria River Party
Granites – Tanami Party
Strangways Range Carbonatite
Arunta Party
Petermann Ranges Project
Aritunga Project
To accompany Record 1969/123
AUS 2/118

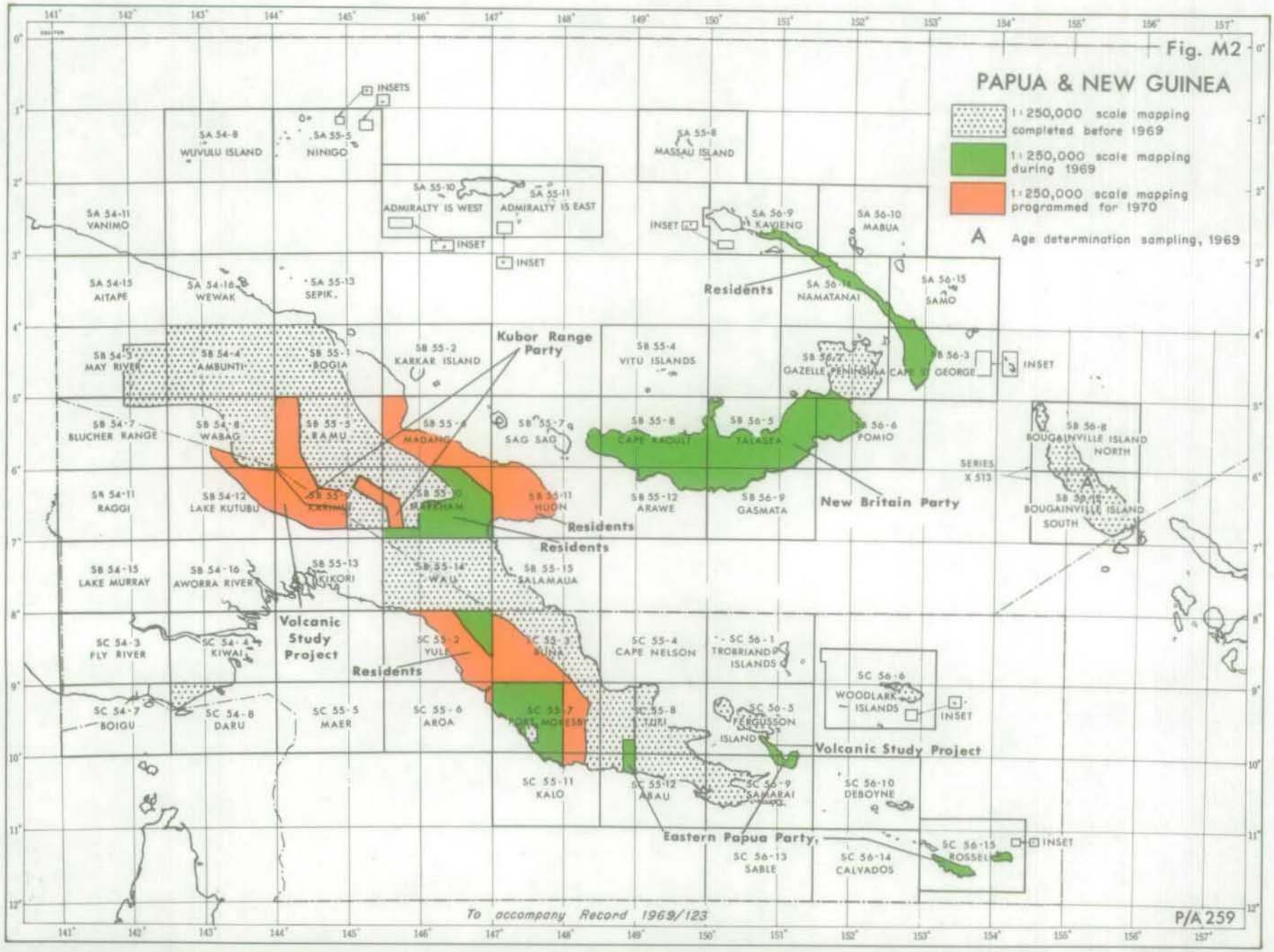


Fig. M2
PAPUA & NEW GUINEA
1:250,000 scale mapping completed before 1969
1:250,000 scale mapping during 1969
1:250,000 scale mapping programmed for 1970
A Age determination sampling, 1969
INSETS
SA 54-8 WUVULU ISLAND
SA 55-5 NINIGO
SA 55-8 MASSAU ISLAND
SA 55-10 ADMIRALTY IS WEST
SA 55-11 ADMIRALTY IS EAST
INSET
SA 54-11 VANIMO
SA 56-9 KAVIENG
SA 56-10 MABUA
Residents
SA 54-15 AITAPE
SA 54-16 WEWAK
SA 55-13 SEPIK
SA 56-14 NAMATANAI
SA 56-15 SAMO
Kubor Range Party
SB 54-3 MAY RIVER
SB 54-4 AMBUNTI
SB 55-1 BOGIA
SB 55-2 KARKAR ISLAND
SB 55-4 VITU ISLANDS
SB 56-7 GAZELLE PENINSULA
SB 56-3 CAPE ST GEORGE
SB 54-7 BLUCHER RANGE
SB 54-8 WABAG
SB 55-3 RAMU
SB 55-6 MADANG
SB 55-7 SAG SAG
SB 55-8 CAPE RACULT
SB 56-5 TALASEA
SB 56-6 POMIO
SB 56-8 BOUGAINVILLE ISLAND NORTH
SERIES X 513
SA 54-11 RAGGI
SB 54-12 LAKE KUTUBU
SB 55-9 MARKHAM
SB 55-11 HUON
SB 55-12 ARAWE
SB 56-9 GASMATA
New Britain Party
Residents
Residents
SB 56-15 BOUGAINVILLE ISLAND SOUTH
SB 54-15 LAKE MURRAY
SB 54-16 AWORRA RIVER
SB 55-13 KIKORI
SB 55-14 WAU
SB 55-15 SALAMAUA
Volcanic Study Project
SC 54-3 FLY RIVER
SC 54-4 KIWAI
SC 55-2 YULE
SC 55-3 BUNA
SC 55-4 CAPE NELSON
SC 56-1 TROBRIAND ISLANDS
SC 56-6 WOODLARK ISLANDS
INSET
Residents
SC 54-7 BOIGU
SC 54-8 DARU
SC 55-5 MAER
SC 55-6 AROA
SC 55-7 PORT MORESBY
SC 55-8 TURI
SC 56-5 FERGUSSON ISLAND
Volcanic Study Project
SC 55-11 KALO
SC 55-12 ABAU
SC 56-9 SAMARAI
SC 56-10 DEBOYNE
Eastern Papua Party
SC 56-13 SABLE
SC 56-14 CALVADOS
SC 56-15 ROSSEL
INSET
To accompany Record 1969/123
P/A 259

Progress reports, in the form of Records, on completed work in the Rum Jungle area have been issued, and others are in preparation. Compilation of geological, geochemical, and radiometric data for the Hundred of Goyder was suspended in May owing to the resignation of Y. Miezitis, but arrangements have been made for him to complete the work in the near future.

Chemical and petrological studies on samples already collected in the McArthur River area, N.T., were continued, and nearly two months were spent in the field examining and sampling diamond drill cores and carrying out further mapping to determine the limits and environment of deposition of the Barney Creek Formation (which contains the sulphide-bearing HYC Member) and associated dolomite units. Elucidation of the palaeogeography of these beds could point to other areas where search for further sulphide mineralization might be warranted.

Amendments and additions have been made to the Record on the Herberton-Mount Garnet area, Queensland, and this has now been submitted to the editor for publication as a Bulletin.

Progress was made in the re-organization and staffing of the petrological, mineralogical, and chemical laboratories. Over 700 chemical analyses of igneous and metamorphic rocks were collected for inclusion in a forthcoming compilation by Dr. Joplin, and petrographic data for the project on north Queensland granites were compiled. There was a reduction in the number of completed X-ray fluorescence analyses of rocks, but a greatly increased number of X-ray diffraction determinations was turned out.

A scanning electron microscope, so far used mainly by palaeontological staff, has been installed, and the chemical laboratory has acquired a gamma-ray spectrometer.

The direct-reading optical spectrograph contributed to a number of projects, and was also used quite extensively to help in identification of minerals by X-ray diffraction. Some progress was made in developing a method for the simultaneous determination of volatile and involatile elements.

Writing of a Bulletin on the Mount Isa geochemical project was completed.

The electron probe microanalyser was used to study the compositions of pyroxenes, olivines, and spinels in rocks from the Papuan Ultramafic Belt, and to investigate kyanite-, pyrophyllite-, mica-, and amphibole-bearing assemblages in metamorphic rocks from the Petermann Ranges, N.T.. Results for the P.U.B. indicate that the ultramafic rocks are not of deep-seated origin, but have probably formed just below the oceanic Moho.

The chemical laboratory was involved in several major projects, and also undertook a number of ad hoc and minor investigations. Most effort went into the major and trace-element analysis of carbonate rocks from the McArthur River and Victoria River areas, N.T., and into an investigation of the nature and origin of waters issuing from the Corin Dam (A.C.T.) and its outlet tunnel. An extensive sampling programme was undertaken at the dam, and it was concluded that the high acidity and abnormal salt content of the water were due to oxidation of pyrite in the rock fill. The oxidation was aided by a bacterium whose activity is thought to have been enhanced by a supply of nitrogen probably derived from residues of the ammonium nitrate explosive used in quarrying.

The geochronological laboratory worked on samples from T.P.N.G., the West Kimberley area, W.A., Cape York, Q., Victoria, and Antarctica. Problems revealed in the Kimberley study require further work for their elucidation, and more samples are needed to clarify results obtained on Cape York and Antarctic rocks. The work on the T.P.N.G. and Victorian samples has yielded some interesting results which point to the necessity for major revisions in the presently formulated world-wide Tertiary time scale.

The work of the Biological Group of the Baas-Becking Laboratory involved laboratory investigations on the ecology, physiology, metabolism, and metal-concentrating ability of sulphate-reducing bacteria (concentration factors of up to 20,000 have been demonstrated); on the biochemistry of organic sulphur metabolism, on pyrite synthesis by microorganisms and fractionation of stable sulphur isotopes by microorganisms, on the mechanism of formation of sulphide bands in a range of materials, and on copper toxicity and resistance in microorganisms. The Mineralogical Group has carried out experimental studies on sulphide synthesis and transformation at various temperatures and pressures, on problems of pH measurement in saline solutions, on the influence of pH on the activity of the sulphide ion, and on the conditions under which dolomite and sulphides may be precipitated together. Construction of apparatus for studying the effects of pressure, temperature, time, nature of host rock, intergranular fluids, etc. on the stabilities, textures, compositions, and metamorphic redistribution of sulphides is nearing completion. Field and laboratory studies of the movement and re-precipitation of copper in an arid environment (Pernatty Lagoon, S.A.), and of iron and base metals in a volcanic-marine environment (Matupi Harbour, New Britain) have been started; both investigations are still at a very early stage.

Further work was carried out on instrumentation for volcano surveillance in T.P.N.G. A report on interference to seismic recording at Rabaul by power house noise was prepared; the Administration appears to be favourably disposed to eventual removal of the power house to a site outside the caldera. Other work included participation in the organization and execution of the New Britain crustal study, and collection of rock and water samples from volcanic islands off the eastern coast of New Ireland.

Further work was carried out on the petrology and geochemistry of the Strangways Range carbonatite, and an area of about 120 square miles in the vicinity of the carbonatite was mapped. Additional diamond drilling of the carbonatite and its contact-zone was still in progress at the end of the period under review.

Compilation of the new tectonic map of Australia and New Guinea is nearing completion; publication of the map is planned for late 1970.

Members of the Section attended several conferences and symposia during the year.

Two geologists visited overseas countries during the year, and another is in the latter stages of completing his work for a Ph.D. degree at Stanford University, U.S.A.

Training in phases of field and laboratory work related to mineral exploration was given to a United Nations Fellow and a Colombo Plan Fellow.

Publications and Records issued, and publications in press or in preparation, are listed in Appendix M1. Following are totals for the period under Review:

Bulletins - Issued 2, in press 2, with editor 3, in preparation 4.

Reports - Issued 4, in press 4, with editor 5, in preparation 13.

Records - Issued 28.

Explanatory Notes - Issued 6, in press 4, with editor 5, in preparation 11.

Outside Publications - Published 24, in press 4, submitted for publication 3, in preparation 13.

REGIONAL PROJECTS

FIELDWORK

VICTORIA RIVER PARTY, N.T.

C.M. Morgan, I.P. Sweet, J.R. Mendum, R.J. Bultitude

Between October, 1968, and May, 1969, the party was engaged in compiling the Record and 1:250,000 scale maps on the Precambrian geology of the Delamere, Fergusson River, Port Keats, and Cape Scott 1:250,000 Sheet areas, which were mapped during the 1968 field season. Between May and October, 1969, the party mapped the Victoria River Downs, Wave Hill, Waterloo, and Limbunya 1:250,000 Sheet areas. In addition to the Precambrian rocks, the Cambrian Antrim Plateau Volcanics and rocks of the Hardman Basin were mapped. A programme of stratigraphic drilling in the Antrim Plateau Volcanics, which was due to start this year, was delayed, and only two holes were drilled. A helicopter was used for about 130 flying hours.

The mapping of the Victoria River Basin is now virtually complete, but further work, including stratigraphic drilling, will be done on the Antrim Plateau Volcanics in 1970.

Geology (Fig. M3)

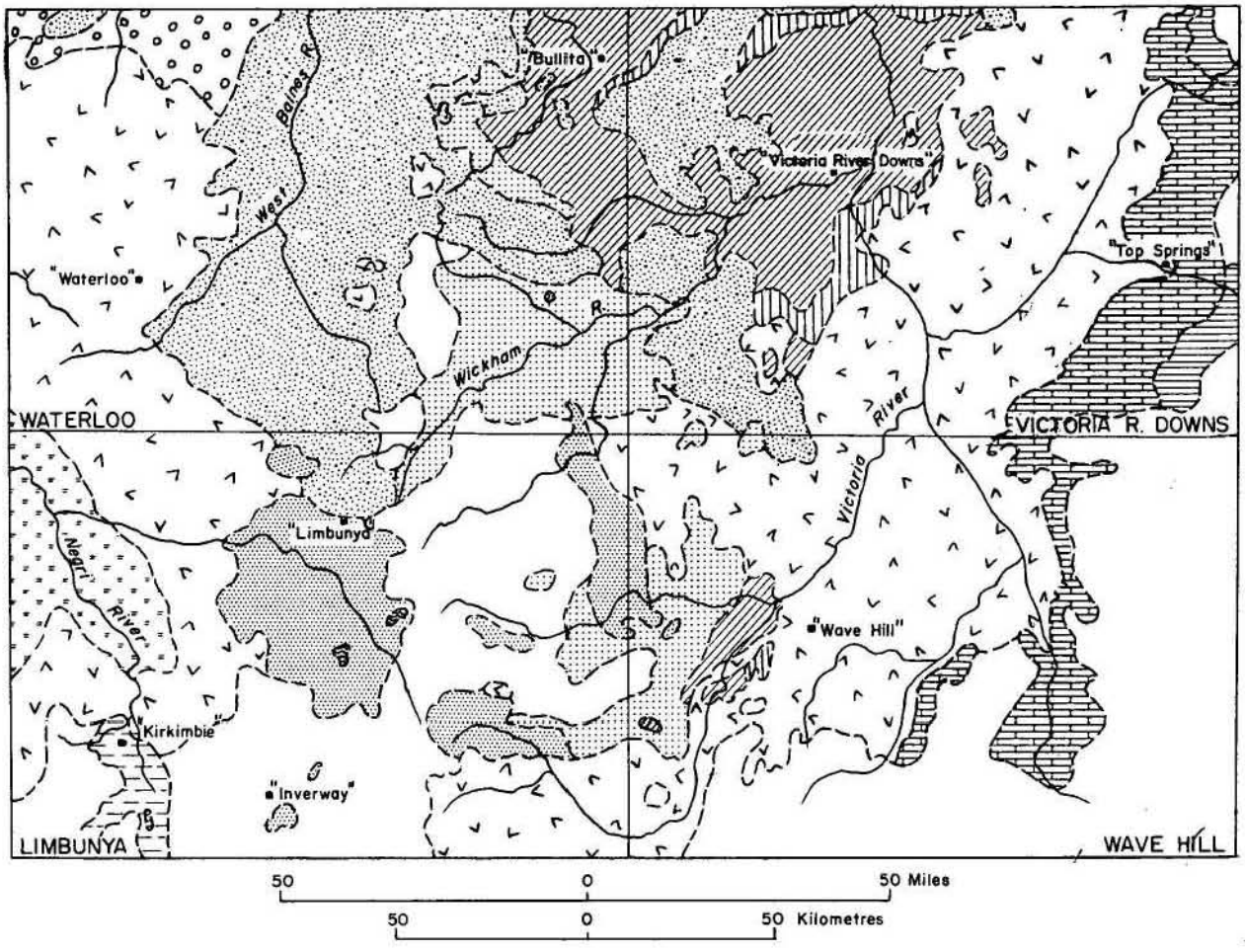
The four Sheet areas mapped in 1969 contain well exposed Proterozoic sediments and minor metamorphics (possibly Archaean) surrounded to the west, south, and east by the Antrim Plateau Volcanics. The latter are overlain to the east by a north-trending belt of Cambrian sediments, and in the west by a north-west trending tongue of Cambrian sediments (the Hardman Basin).

Two small outcrops of low-grade metamorphics are exposed near the centre of the Limbunya 1:250,000 Sheet area. The rocks are grey quartz-feldspar-muscovite schists, and are probably derived from greywacke.

The Farquharson Beds are a newly recognized sequence of sediments which crop out on all the Sheet areas mapped this year. The best and most extensive exposures are in the Limbunya Sheet area. The beds have also been traced onto the southern part of the Auvergne 1:250,000 Sheet area.

The entire sequence is exposed in an inlier south of Limbunya Homestead, where it is 3500 feet thick. It consists mainly of dolomite, dolarenite, sedimentary dolomitic breccia, and dolomitic siltstone, and also contains some sandstone. A sequence of sandstone, chert, and claystone at the base of the beds has been included in the formation, although it has not been proved that it is conformable with it. Stromatolites are well developed, and beds of chert are also common.

GEOLOGICAL SKETCH MAP OF THE WATERLOO, VICTORIA RIVER DOWNS, LIMBUNYA AND WAVE HILL 1:250,000 SHEET AREAS.



Cainozoic — *Laterite, Sand, Soil etc.*

Mesozoic — *Mullaman Beds*

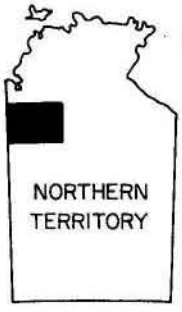
Palaeozoic — *Negri Group*; *Montejinni Limestone*; *Antrim Plateau Volcanics*

Proterozoic — *Duerdin Group (tillites, etc.)*; *Auvergne Group*; *Wondoan Formation*; *Bullita Group*; *Wattie Creek Beds*; *Farquharson Beds*; *Kirkimbie Beds*

Proterozoic or Archaean — *Metamorphics and sheared Sandstone*

Geological Boundary

Homestead



The Farquharson Beds have been subdivided into twelve units, all of which can be recognized in the field and on air photos. The beds unconformably overlie the metamorphics, and are unconformably overlain by the Wattie Creek Beds. It is thought that they may be correlated with the Bungle Bungle Dolomite in Western Australia, as they are made up of similar rock types.

The Wattie Creek Beds are another newly recognized sequence of sediments which crop out on all four Sheet areas mapped this year. They are about 1300 feet thick, and have been subdivided into seven units, each of which will probably be given formation status. Four of the units consist of medium-grained feldspathic sandstone, and the other three are of claystone, micaceous siltstone, and dolomitic siltstone and dolomite. At the base of the sequence is a thick bed of sedimentary breccia composed largely of chert fragments. The sequence is overlain conformably by the Timber Creek Formation of the Bullita Group.

The Kirkimbie and Inverway Beds occur as isolated outcrops of sandstone, dolomite, and siltstone in the south-western corner of the Limbunya 1:250,000 Sheet area. Their relationships with other units are not yet known, but it is suspected that the dolomite and siltstone near Kirkimbie Homestead may be an extension of the Farquharson Beds. South-west of Kirkimbie Homestead they unconformably overlie sheared sandstone and conglomerate, which may belong to the metamorphics rather than the Farquharson Beds.

In the area mapped this year the Bullita Group contains the Timber Creek, the Skull Creek, and the Bynoe Formations, and also a sequence of sandstones and ferruginous dolomites conformably overlying the Bynoe Formation. From this year's mapping it appears that there is an unconformity between the Skull Creek and Bynoe Formations; otherwise lithologies and relationships are similar to those found previously.

The Wondoan Formation of glauconitic sandstone, siltstone, and claystone is unconformable on the Bullita Group, and is unconformably overlain by the Auvergne Group.

The Auvergne Group and glacials were traced southwards from areas previously mapped, and their character did not change significantly.

About half the area mapped in 1969 is covered by the Antrim Plateau Volcanics. In some places, particularly in the west of the area, it was possible to differentiate individual flows, but outcrop was not good enough in most places to differentiate flows on the scale of the mapping. Several thick beds of agglomerate crop out both in the east and in the west of the area, and can be traced for at least thirty miles. An extensive tuff band crops out in the southern part of the Limbunya Sheet area. Interbeds of sandstone, chert, limestone, and breccia are common.

The lower Middle Cambrian Hardman Basin extends from Western Australia onto the Limbunya Sheet area, where it consists of the Headleys Limestone (base), Nelson Shale, Linnekar Limestone, Panton Formation, and Elder Formation. These beds occupy a major north-west trending syncline.

Economic Geology

There is very little of economic interest in the area. However, small deposits of copper have been found associated with the Antrim Plateau Volcanics, mostly as secondary copper minerals at the contact between the volcanics and the overlying Cambrian limestone. Copper is also found in quartz veins and rarely as the native metal in the upper flows of the volcanics. Prehnite, amethyst, and agate are common fillings of amygdales and veins in the flow-tops at the top of the unit. In some places these minerals are of gem quality.

Near Lily Hole Yard, in the Victoria River Downs Sheet area, manganese, as psilomelane, occurs in veins, and is also disseminated through siltstone and ferruginous dolomite of the unnamed formation which overlies the Bynoe Formation. It does not appear to be of economic significance.

Metals Exploration, N.L. (in association with Australian Selection and Freeport Sulphur) and the Hooker Corporation are currently exploring for copper in the Antrim Plateau Volcanics and the overlying Cambrian limestone.

NEW BRITAIN PARTY

R.J. Ryburn, R.W. Johnson, R.P. Macnab, D.E. Mackenzie,
C.E. Maffi (photogeologist), J.G. Binnekamp (palaeontologist);
R.J. Tingey and P.E. Pieters (Resident Staff)

In 1968, regional mapping of the Gazelle Peninsula, north-eastern New Britain, was carried out by R.P. Macnab, and in 1969 the mapping of the rest of the island was completed.

The island of New Britain lies between 148°10' and 152°00'E longitude, and 5°00' and 6°20'S latitude, and is about 250 miles long, and mostly less than 45 miles wide. It is heavily forested and sparsely populated, with a central range rising to 6000 feet a.s.l. east of 149°40'E longitude. Because of the central range rainfall is high on the south coast from May to October during the south-east season, and high on the north coast from December to March in the north-west monsoon; coastal areas protected from the prevailing wind by the central range experience a relatively "dry season". Annual rainfall, where recorded, ranges from 150 inches to more than 300 inches.

Between early February and mid-May a helicopter-supported survey was conducted, and most of the area east of 149°30' was mapped, except for the fringe of Quaternary volcanics along the north coast. J.G. Binnekamp was attached to the party until mid-April, carrying out some traverses, and preparing and examining microfossil samples in base camp. R.J.S. Cooke and R. Harrison, of the Geophysical Branch, co-ordinated with the field party while conducting a regional gravity survey, and the helicopter was also used by the Crustal Study Group. In all about 240 hours were flown, and about half of this time was used by the geological party.

Owing to dense rainforest, narrow and swiftly flowing streams, and sparse population away from the coastal fringe, helicopter landing sites are scarce in the hinterland. Consequently most of the central areas of the island had to be reached on foot. Difficulty in helicopter operation was greatly increased by rain and low-lying cloud on the windward side of the central range, and rapidly changing weather conditions and frequent rain on the protected side. Because of its high speed and range, a Bell Jetranger helicopter was used, allowing the positioning in one trip of a geologist and three carriers with cargo for two- to six-day traverses as far as sixty miles from base camp. The skill and co-operation of the pilots of Crowley Airways contributed greatly to the success of the helicopter operations. Major bases were established at Pomio on the south coast, and, later, Kwalakessi (Cape Hoskins) on the north coast; a temporary base was established at Kandrian on the south coast in the final stages of the survey.

After experiences with helicopter failure, illness of geologists while on traverse, and difficulties in field parties' reaching pre-planned pick-up points early in the season, use was made of small portable radio transceivers hired from the T.P.N.G. Department of Forests. Field parties had regular contact with base camp, so that any changes in plans due to weather, helicopter failure, or medical emergency could be communicated. The radios proved to be of great benefit in saving of helicopter time and geologists' time, and would be invaluable in a medical emergency.

Between early September and mid-November a study was made of the Quaternary volcanics along the north coast and at the western end of the island, and regional mapping was completed in the area west of 149°30'. A boat, M.V. "Explorer", was used for transport and partly as a mobile base until early November, and a Bell 47G3B1 helicopter was used in late October for 40 hours to complete the mapping. Personnel consisted of R.J. Ryburn (leader, until early November), R.W. Johnson, R.P. Macnab (until mid-October) and P.E. Pieters (10 days for helicopter work).

Geology (Fig. M4)

The geology of New Britain is relatively uncomplicated. The core of the island is made up of early Tertiary (probably Eocene) basic to intermediate volcanic rudites with minor lavas and volcanically derived sediments - the Baining Volcanics. These rocks crop out over most of the length of the island, but are covered at the western end by the Quaternary volcanic and sedimentary rocks of the Cape Gloucester area. The central ranges and the ranges between Wide Bay and Pomio are made up largely of this formation. The volcanics are intruded in several areas by tonalitic, dioritic, and gabbroic rocks.

Unconformably overlying the Baining Volcanics is the Middle Miocene Jacquinot Limestone which is on the average about 2000 feet thick, and ranges from a few feet to well over 3000 feet. The limestone thins rapidly near Montague Harbour and also near its margins of outcrop east and west of Kandrian.

On the southern side of Wide Bay, and on the northern (downthrow) side of the Wide Bay Fault is a wedge of terrestrial, largely conglomeratic sediment, the Ip Formation, which was derived from the rising fault scarp to the south. The Wide Bay Fault has been traced most of the way from the south-eastern extremity of Wide Bay across to Open Bay.

The low saddle between Commodore Bay and Montague Harbour is covered by 200 to 300 feet of acid tuffs and minor conglomerates, probably of Pliocene age. These are the Umua Beds, and they are typically soft and deeply incised by rivers and streams.

A number of volcanic centres lie along the north coast of the island. These are of Quaternary age, and some are still active.

Quaternary coral reefs, raised up to 300 feet above the present sea level, are scattered along the south coast, and also form numerous small islands near the coast. More recent reefs are almost continuous along the south coast, and are partly emergent. On the north coast the reefs are more patchily distributed, and are generally submerged. Quaternary alluvium covers wide areas south of Open Bay, around Commodore Bay, and around the lower reaches of some rivers.

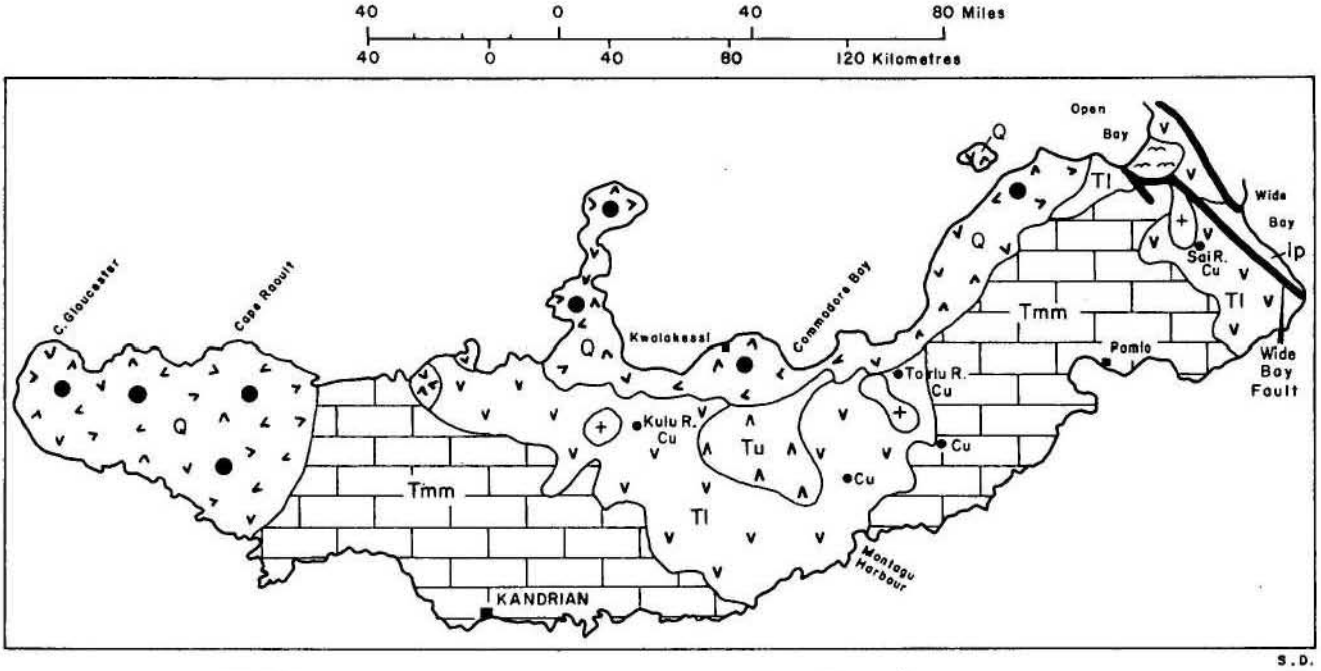
Economic Geology

Sulphide mineralization is widespread in the pre-Miocene intrusives along the axis of the island. In hand specimens sulphides appear to be mainly pyrite and pyrrhotite; traces of chalcopyrite were seen in plutonic rocks from the Sai, Torlu, and Evili Rivers. An authority to prospect has recently been taken out by B.H.P. in the Sai River area to the south-east of Open Bay. C.R.A. has previously investigated copper prospects in the Evili River (Uasilau area) and East Kulu River, but has recently relinquished both areas. At present Placer Prospecting is investigating a large area in the centre of New Britain, and has completed a detailed stream sediment sampling programme over most of its lease.

Gold is present in small quantities in the Ala River.

AREA MAPPED BY NEW BRITAIN PARTY 1969

Fig. M 4



Alluvium

Quaternary volcanics

Ip Formation

Umua Beds

Jaquinot Limestone

Baining Volcanics

Plutonic intrusives

Fault

Volcanic centre

•Cu Copper occurrences

To accompany Record 1969/123

P/A 260

Hydro-electric damsites

No suitable sites for dams were seen, the main failing being the lack of storage volume behind the numerous sites in gorges where high dams could be built. The rivers in New Britain are short and very fast-flowing; their headwater sections and middle reaches are steep and deeply incised, and their lower reaches meander or form braided patterns across the narrow coastal plains. The seasonal very high and irregular rainfall causes very large and rapid rises in river levels, so that large storages, which do not appear to be available, would be needed to control sudden huge influxes of water.

EASTERN PAPUA PARTY

I.E. Smith, G. Cifali (until June); P.E. Pieters,
P.D. Hohnen (Resident Staff)

Following fieldwork during September and October, 1968, three months were spent in map compilation and thin-section study. The party left Canberra for further fieldwork in mid-February.

Cifali and Pieters spent two weeks in the Dayman Dome area in an attempt to gain more detailed information on the structure and nature of the dome. Smith simultaneously sampled the Cloudy Bay Volcanics behind Abau, and investigated the southern contact of the Dayman Dome with the Dawa Dawa Beds. Both parties returned to Port Moresby in early March. Cifali then joined the Crustal Study Group in New Britain.

Smith and Pieters spent one month in mapping the geology of the Louisiade Archipelago, excluding Misima Island. M.V. "Explorer", chartered from Exploration Enterprises, of Port Moresby, was used as a mobile base throughout the survey. Mapping was completed by mid-April, and the party returned to Port Moresby. Smith then went to Normanby Island, in the D'Entrecasteaux Group, to follow up a helicopter reconnaissance made by H.L. Davies in 1967. Pieters joined the party for the last two weeks of this survey. Cifali, on completion of the New Britain Crustal Study, spent a week in the Milne Bay area examining the rocks on the north side of East Cape peninsula.

Smith and Cifali returned to Canberra in mid-May, and Cifali resigned at the end of May. Since May, Smith has been engaged in the preparation of a Record on the geology of the Louisiade Archipelago, and in map compilation and thin-section work for a final report on the geology of Eastern Papua.

Pieters and Hohnen carried out helicopter-supported fieldwork on the Dayman Dome for a week during early July, followed by three weeks in Canberra preparing a Record on the geology of the Dayman Dome.

Geology

1) Dayman Dome.

The geology of the Dayman Dome was discussed in the 1968 Summary of Activities. Recent work suggests that the metamorphic grade does not decrease with depth, as was previously thought. Gabbroic intrusives not previously known were discovered at the summit of the Dome. A satisfactory theory for the origin of the dome has not yet been formulated.

2) Louisiade Archipelago (Fig. M5)

The geology of the Louisiade Archipelago, excluding Misima Island, has been written up in Record 1969/93. The major rock unit in the area is the Calvados Schist, consisting of low-grade metamorphics; the unit is probably correlative with low-grade meta-volcanics in the Deboyne Group, named the Deboyne Metamorphics; both units are thought to be of Cretaceous age. Minor Miocene limestone and (?)Pliocene volcanics occur at the western end of the Calvados Chain. Quaternary raised coral limestones are common throughout the archipelago.

Syntectonic ultrabasic and basic intrusives occur on Rossel Island, and basic syntectonic intrusives occur elsewhere in the archipelago. Basic, intermediate, and minor acid post-tectonic intrusives are also known.

3) Normanby Island (Fig. M6)

The 1969, fieldwork on Normanby Island substantially confirmed the results of earlier helicopter reconnaissance by H.L. Davies (Record 1967/50). Some differences in detail were found, and the more important of these are noted below.

(a) The Gidigidora Granite, in the north-western arm of the island, probably crops out over less than one quarter of the area indicated on Davies' map; the area of adjacent quaternary volcanics is correspondingly larger.

(b) The (?)Miocene sediments behind Sewa Bay are less extensive than indicated on Davies' map.

(c) An area of fossiliferous conglomerates, sandstones, and mudstones occurs in the hills to the south of Sewataitai Bay. These can probably be correlated with the Sewa Beds.

(d) Raised coral limestone is extensive along the north coast.

(e) Granite and intermediate igneous rocks crop out behind Esa-ala at the north-western end of the island.

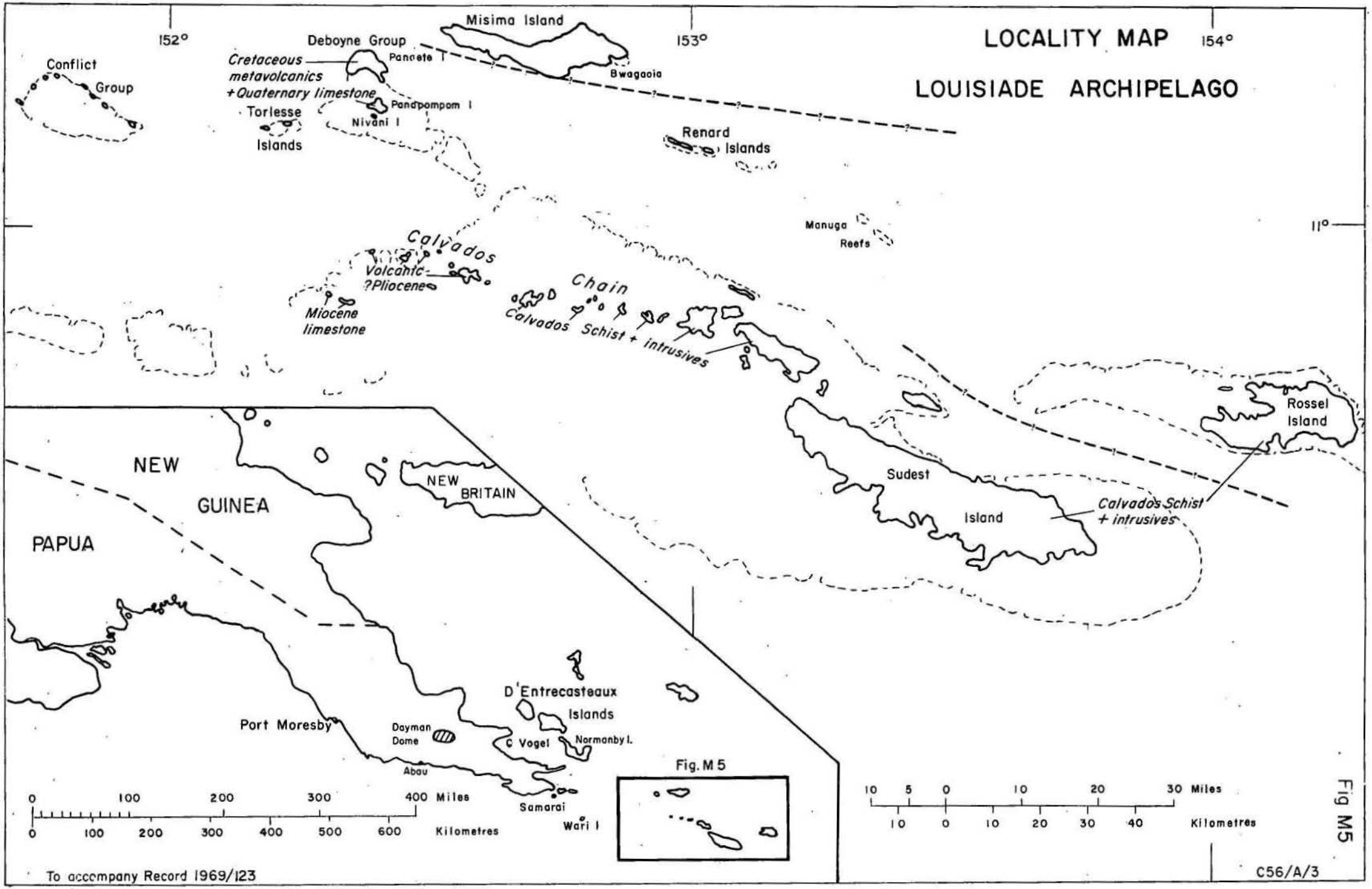
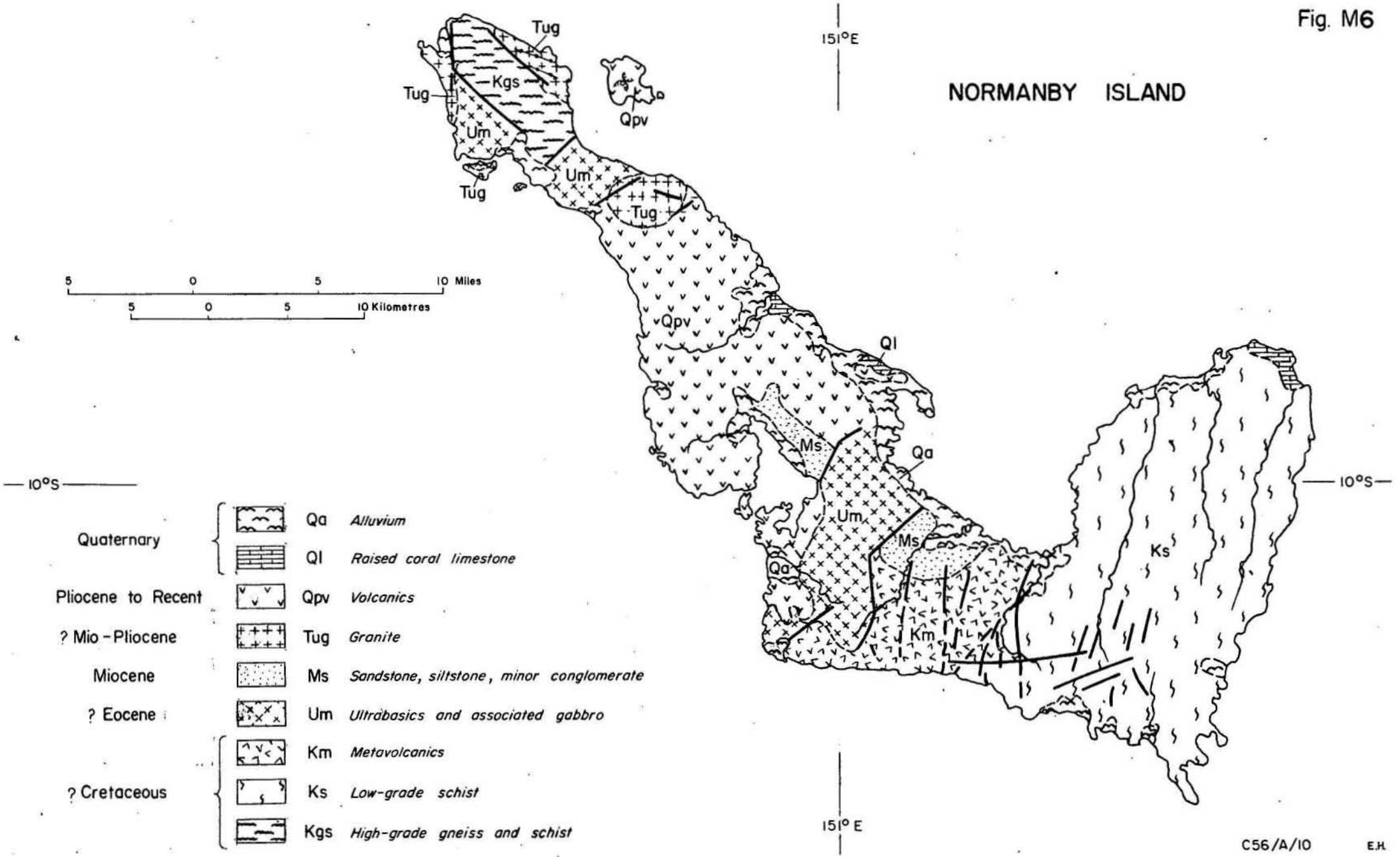

LOCALITY MAP
LOUISIADE ARCHIPELAGO
152°
153°
154°
11°
Misima Island
Deboyne Group
Panaete I
Bwagaoia
Cretaceous metavolcanics + Quaternary limestone
Conflict Group
Torlesse Islands
Pandpompom I
Nivani I
Renard Islands
Manuga Reefs
Calvados Chain
Volcanic ?Pliocene
Miocene limestone
Calvados Schist + intrusives
Rossel Island
Sudest Island
Calvados Schist + intrusives
NEW GUINEA
PAPUA
NEW BRITAIN
D'Entrecasteaux Islands
Port Moresby
Dayman Dome
C Vogel
Normanby I.
Abau
Samarai
Wari I
Fig. M 5
0 100 200 300 400 Miles
0 100 200 300 400 500 600 Kilometres
10 5 0 10 20 30 Miles
10 0 10 20 30 40 Kilometres
Fig M5
To accompany Record 1969/123
C56/A/3

Fig. M6

NORMANBY ISLAND



C56/A/10 E.H.

(f) High-grade schist and gneiss occurring at the north-western tip of the island are probably correlative with similar metamorphics elsewhere in the D'Entrecasteaux Islands. These rocks were previously thought to be low-grade metamorphics correlative with metamorphics at the eastern end of the island.

(g) The Quaternary volcanics are mainly basic to intermediate, and calc-alkaline rather than alkaline, as was previously thought.

The accompanying geological map of Normanby Island (Fig. M6) incorporates the results of 1969 fieldwork.

ECONOMIC GEOLOGY

Gold on Sudest Island, known since the 1890's, probably offers the only economic prospect in the Louisiade Archipelago, excluding Misima Island.

Gold also occurs in small quantities in metamorphics on Normanby Island. The ultrabasics on Normanby Island were examined for traces of mineralization, but none were found.

PRINCE CHARLES MOUNTAINS, ANTARCTICA

I.R. McLeod, J.H.C. Bain, D.J. Grainger, A. Medvecky

The party spent the week of 27th October to 4th November, 1968, in Melbourne attending induction lectures at the Antarctic Division, Department of Supply, and sailed from Melbourne for Antarctica on 20th December, 1968. Field work commenced on 10th January.

One geologist (A.M.) spent four weeks near Beaver Lake, on the western side of the Amery Ice Shelf, on a detailed study of the surrounding Permian sedimentary rocks. Two geologists (J.B., D.G.) worked with surveyors engaged in a second-order tellurometer survey of the Amery Ice Shelf, northern Prince Charles Mountains area; after survey commitments had been met, the geologist with each party was able to examine the outcrop in the vicinity of the survey station, and in some instances short helicopter trips were made to examine outcrops within 20 km of the station. In this manner, coastal outcrops from Davis to the Bolingen Islands, and Rubeli Bluff to Mount McCarthy, were examined, and specimens for isotopic dating were collected. The geologist in charge (I.M.) used helicopter reconnaissance and 'taxi' work from the base-camp on the Amery Ice Shelf to visit outcrops from Gillock Island in the south to the Rauer Islands in the north, and was able to join the survey party geologists for work in the Rauer, Larsemann, and Bolingen areas. Specimens for isotopic dating were also collected from the Sandefiord Bay area and Mawson Harbour. Gravity readings were made as circumstances permitted,

using a LaCoste and Romberg Geodetic instrument. Field work was completed on 18th February, and the party sailed via Mawson, returning to Melbourne on 27th March.

Report writing commenced immediately on return to Canberra, and the first draft of a Record on the reconnaissance geology of the coastline from Davis to Beaver Lake was prepared before party members returned to their usual jobs in May. Editing and re-writing of the draft, and preparation for the next field season in Antarctica, continued as opportunities arose.

Petrographic descriptions of 109 rocks were prepared by A.M.D.L., and this work was extended to an assessment of the regional relationships and metamorphic history of the rocks. Work has commenced at A.N.U. on the dating of about one hundred specimens.

Geology

The area studied is part of the Precambrian Antarctic shield. With the exception of a small area of unmetamorphosed Permian sediments of the Amery Group at Beaver Lake, outcropping rocks consist of high-amphibolite to granulite facies metamorphics, charnockites, and granitic intrusions.

Because of the widely scattered outcrops and the lack of time to examine critical areas in detail, knowledge of the relationships between the several units is incomplete. The oldest rocks are probably those forming the 'Munro Kerr Gneiss', which originally were probably greywacke-type sediments, now intensely folded and metamorphosed under pyroxene-granulite facies conditions. They crop out from the Polar Record Glacier in the north to Rubeli Bluff in the south, and rocks typical of the unit are exposed at Mount Caroline Mikkelsen in the Munro Kerr Mountains. A suite of migmatitic rocks termed the 'Prydz Bay Migmatite' crops out along the eastern side of Prydz Bay from the Sørsdal Glacier in the north to the Polar Record Glacier in the south. A small patch of disseminated molybdenite was found in one outcrop in the Rauer Islands at the northern end of this belt of rocks. A second migmatite suite called the 'New Year Migmatite' crops out along the eastern side of the Amery Ice Shelf from Gillock Island in the north to Pickering Nunatak in the south. The two migmatite units contain interbanded amphibolite and granulite facies metamorphic rocks. In some areas, amphibolite facies metamorphism has been overprinted on the earlier granulite facies metamorphism. Boundaries between the 'Munro Kerr Gneiss', the 'Prydz Bay Migmatite' and the 'New Year Migmatite' are transitional. The southern limits of the 'New Year Migmatite' are not yet known.

The massive, coarse-grained 'Jennings Charnockite' crops out at Jennings Promontory and Gillock Island, but was not seen in contact with other units. Post-tectonic biotite granites - the 'Landing Bluff Granite' and the 'Polarforschung Granite' - intrude 'Munro Kerr Gneiss' at Sandefiord Bay and near the Polarforschung Glacier. Similar granite crops out at Corry Rocks on the northern end of Gillock Island.

In the northern Prince Charles Mountains, on the western side of the Amery Ice Shelf, interbedded reddish-brown and light grey quartz-feldspar gneisses of granulite facies occur. They are massive and complexly folded.

At Beaver Lake and Radok Lake, the metamorphic rocks are overlain by gently dipping arkosic sandstone and shales of the 'Amery Group'. Palynological work has confirmed that the age of these is Upper Permian. Numerous coal seams, up to 4 metres thick, were sampled; the samples are being studied by C.S.I.R.O. Much plant material was collected. The sediments are intruded by several mafic dykes and sills.

REPORT WRITING

KIMBERLEY PROJECT, W.A.

East Kimberley and Kimberley Basin. K.A. Plumb, D.C. Gellatly, G.M. Derrick; J. Sofoulis (G.S.W.A.).

During the year Bulletin 106, Geology of the Kimberley Region, Western Australia - The East Kimberley, by Dow and Gemuts, was published. Bulletin 107, Metamorphism and Igneous Activity in the Lamboo Complex, East Kimberley Region, Western Australia, by Gemuts, is in press.

Records 1968/141, Proterozoic Palaeocurrent Directions in the Kimberley Region, by Gellatly, Derrick, and Plumb, and 1969/97, Notes on the Geology of the Medusa Banks 1:250,000 Geological Sheet SD 52-10, by Plumb and Perry, were issued. Record 1968/141 has been revised, and accepted for publication by the Geological Magazine.

The following 1:250,000 maps and Explanatory Notes were published during the year: Gordon Downs, Dixon Range, Lissadell, Mount Ramsay. Mount Elizabeth, Ashton, Drysdale-Londonderry, Prince Regent-Camden Sound, and Cambridge Gulf are with the printer. Medusa Banks Preliminary Edition was issued, and the first edition is being fair-drawn. Montague Sound is in the final stages of correction.

West Kimberley - D.C. Gellatly, G.M. Derrick; J. Sofoulis (G.S.W.A.).

Field work in the West Kimberley was completed in 1967, and writing up of the results is well under way. Seven separate Records and outside Publications were completed and issued during the year. One set of Explanatory Notes has been completed, and two others are largely compiled. Two 1:250,000 Preliminary Edition maps were issued: a third (Yampi) is currently being compiled, and should be issued as a Preliminary towards the end of 1969.

CARPENTARIA PROJECT, N.T.

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

The Arnhem Land Bulletin by Roberts, Plumb, and Dunn is nearing completion. Writing of the first draft should be completed by Christmas. Completed sections have already been checked by the Editor. A Report by Plumb on the Petrology of the Basement Rocks of Arnhem Land is at a similar stage.

No work was done on the Roper River-Queensland Border Bulletin. A brief paper on revisions to the stratigraphy of the McArthur Group is being prepared for inclusion in a B.M.R. collection of geological Papers to be published during 1970.

BURDEKIN RIVER REGION, Q.

A.G.L. Paine

Further progress was made in drafting a detailed report on the geology of the Bowen 1:250,000 Sheet area, which is now about 70 percent complete. Much of the period from January to March was spent in arranging an overseas visit, on which a separate report appears on pages 110 and 111.

Approval for the typing of the Record "Geology of the Ravenswood 1-Mile Sheet area, Queensland" by D.E. Clarke (ex-G.S.Q.) had been delayed owing to a disagreement by the Resident Geologist, Charters Towers, with the author's hypothesis for the origin of the gold mineralization at Ravenswood. In order to reconcile the differing views, Paine visited Charters Towers for four days; at the same time he checked the final drafts of the Reports on the geology of the Townsville and Charters Towers Sheet areas with the senior author of both reports, D.H. Wyatt (G.S.Q.), who is stationed in Charters Towers. The Ravenswood report was submitted for typing as a Record in mid-September, and the 1-Mile map was sent to the Government Printer at the same time for printing as a

Preliminary Edition. Amendments relating to the Ravenswood 1-mile Sheet area were incorporated in the Report and Explanatory Notes on the Charters Towers 1:250,000 Sheet area (which contains the Ravenswood 1-Mile area), and both were cleared for publication in September. The Charters Towers 1:250,000 map was cleared for publication as a Standard Edition early in the year.

Two 1:250,000 Sheet area reports were edited for issue in the Records Series - Torres Strait (Willmott et al.) and Charnley (Derrick et al.). A paper entitled 'Palaeovulcanology of central eastern Queensland' was approved by the Director for publication by the Geological Society of Australia. Further progress was made in preparing the Records on the geology of the Hughenden and Proserpine Sheet areas for publication as Reports. Guidance was given to the map editing section in the preparation of a 1:1,000,000 map of the Burdekin-Townsville region for publication by the Department of National Development in the Resources Series.

CAPE YORK PROJECT, Q.

W.F. Willmott, W.D. Palfreyman, D.S. Trail; W.G. Whitaker (G.S.Q.)

During 1969 the writing of the Bulletin on the igneous and metamorphic rocks of Cape York Peninsula and Torres Strait was started, and by the end of the year the first draft of the text was largely completed. Compilation of the 1:500,000-scale map to accompany the Bulletin was also commenced (see Fig. M7).

Writing of Record 1969/119, Igneous Rocks of Torres Strait, was completed, and its issue is only awaiting the printing of the Preliminary Editions of the Torres Strait and Daru-Maer Island 1:250,000 Sheets, which were drafted during the year.

Record 1969/64, the Igneous and Metamorphic Rocks of the Coen and Cape Weymouth 1:250,000 Sheet areas, was issued during the year with accompanying Preliminary Edition maps. Parts of the Explanatory Notes and Standard Edition maps of the 8 Sheet areas mapped during the three-year survey of Cape York Peninsula will be prepared early next year, but final production of the Sheets and Notes will have to wait until the sediments of the Carpentaria Basin of the western side of the Peninsula have been mapped.

CENTRAL HIGHLANDS PROJECT, N.G.

J.H.C. Bain, D.E. Mackenzie

Fieldwork for the Central Highlands Project was commenced in 1968. No field work was carried out in 1969, but further detailed mapping will be undertaken in June-August 1970 to measure sections, and to clarify stratigraphic problems revealed by the initial work.

Eighteen 1:50,000-scale geological compilation sheets have been produced. This involved preparation of topographic bases for twelve of the sheets from uncontrolled mosaics of air photographs. A 1:250,000-scale compilation of these geological sheets has been completed, and is presently being re-drawn. Examination of about 600 thin sections and the writing of a Record on the geology are well under way. It is intended that the Record will be a draft of a Bulletin on the geology of the Central Highlands of New Guinea. Work is proceeding on the production of Preliminary Editions of the Ramu and Karimui 1:250,000 geological sheets. The Ramu sheet was being drawn in October, and drawing of the Karimui sheet is expected to begin early in 1970.

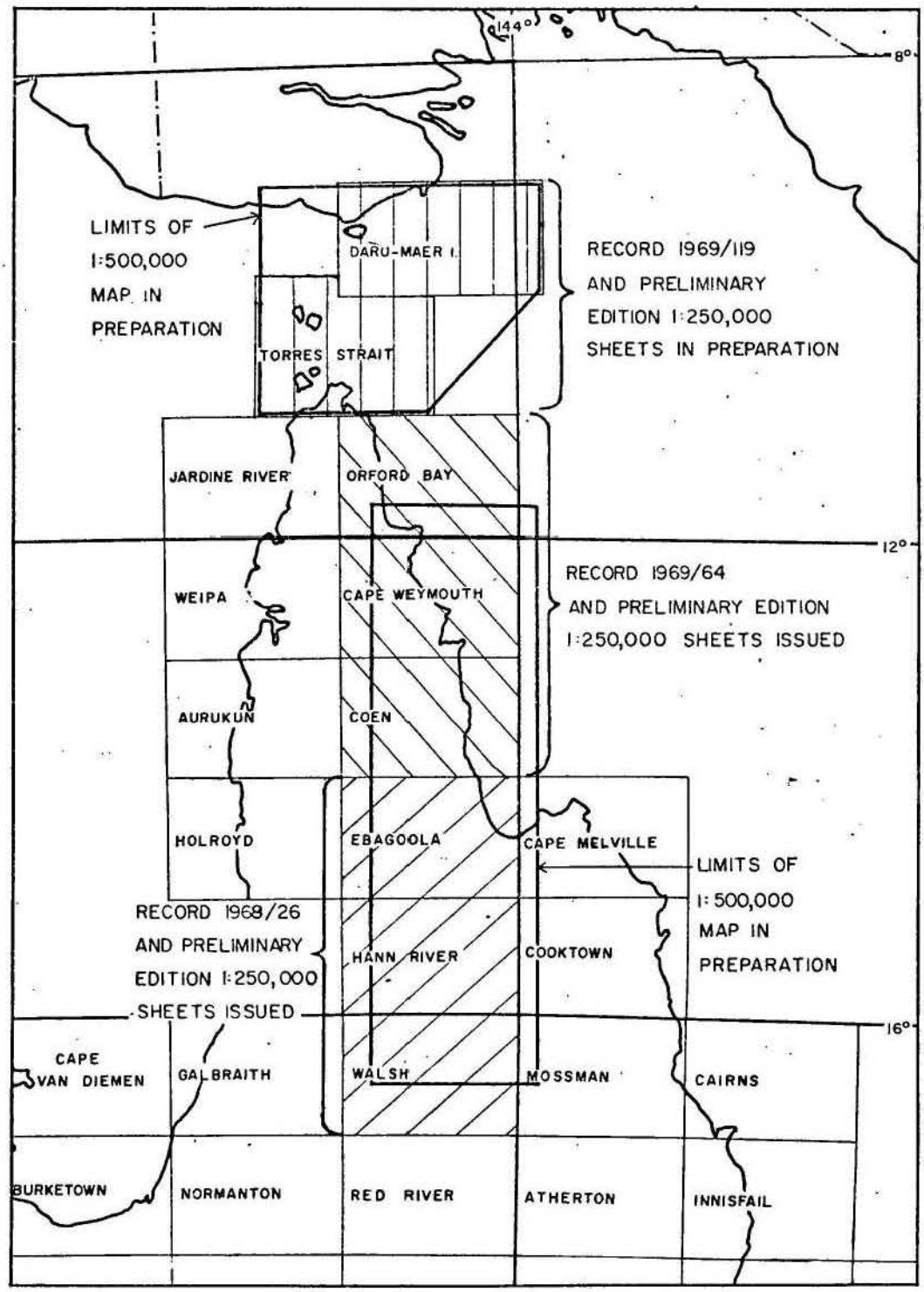
Short papers on the Highlands Volcanoes (D.E.M.) and the Miocene Volcanics (J.H.C.B.) are being prepared for presentation at ANZAAS in 1970.

Both geologists spent some time on other projects during the year. Bain participated in the 1968-69 Prince Charles Mountains Survey (Antarctica) from mid-December until late April, and has since spent part of his time in reporting on that work. Mackenzie joined the New Britain Party at the start of 1969, and was engaged in fieldwork until the end of April. Both Bain and Mackenzie were involved in the final preparation of the Record on the Geology of the South Sepik Region (1968/80) after their return from the field in the latter part of 1968.

Fig. M7

CAPE YORK MAP AREAS

0 50 100 MILES



To accompany Record 1969/123

AUS 2/119

DETAILED PROJECTS

FIELDWORK

CLONCURRY PROJECT, Q.

G.M. Derrick, A.Y. Glikson, J.E. Mitchell, R.M. Hill; I. Wilson (G.S.Q.)

Detailed mapping of two 1:100,000 Sheet areas was completed during the year (see Fig. M8). Aerial photographs at 1:25,000 scale were used in most areas except the Norna 1:63,360 Sheet, where only 1:50,000 photographs were obtainable. Colour aerial photographs were available for part of the area, and a report on their usefulness is presented below.

Stratigraphy (Fig. M9)

The broad stratigraphic divisions of Carter et al. have provided a useful framework for the subdivision of units mapped in more detail this year. In the oldest unit, the Argylla Formation, a younger quartz-rich porphyry and an older quartz-poor porphyry were delineated in the eastern exposures; towards the west only the basal porphyry is present. The Marraba Volcanics consist of a lower basaltic sequence and an upper sequence of slate, limestone, and sandstone; like the Argylla Formation, this formation appears to thin westwards, where the two units are increasingly disconformable.

The Soldiers Cap Formation, tentatively considered to warrant Group status, is characterised by amphibolite-grade schists in the cores of anticlines, and by abundant metamorphosed basic igneous rocks. The stratigraphic succession is as follows (from base to top):

(1) The lowermost unit consists of alternating staurolite-garnet-andalusite schists and garnetiferous quartzo-feldspathic schists. This unit occupies the cores of the main anticlinal zones. The top is marked by two thick gabbroic sills, and the lower parts are intruded by metadolerite dykes.

(2) A unit consisting of garnetiferous light-coloured phyllite, garnetiferous black phyllite, and relatively minor feldspathic meta-sandstone. This unit is particularly well developed in the Mount Norna area.

(3) A unit consisting of over 50 percent concordant amphibolite bodies (including fine-grained types, meta-dolerite, and meta-gabbro) intercalated with white cross-bedded and groove-casted quartzite, phyllite, meta-sandstone, and meta-siltstone.

(4) A unit consisting of over two thirds conformable amphibolite, which is intercalated with siliceous meta-siltstone, white quartzite, chert, meta-jaspilite, and phyllite. The amphibolite bodies show considerable variations in thickness, which have brought about complications in the structural trends.

The Mitakoodi Quartzite overlies Marraba Volcanics in the east, and acid volcanics of the Argylla Formation in the west; a small domal inlier of Mitakoodi Quartzite occurs four miles west of Chumvale homestead, where it is associated with a jaspilite marker bed. A persistent band of amygdaloidal basalt occurs near the top of the formation, and thinner and more discontinuous flows appear lower in the sequence.

The Corella Formation contains limestone, marl, sandstone, slate, breccia, and their metamorphosed equivalents, especially calc-silicate rocks. Acid volcanics are common in the Corella River-Lake Corella area, and, contrary to previous suggestions, appear not to belong to the Argylla Formation. They form large lenses grossly concordant with quartzite and schist. Granitisation has taken place locally in the same area, where sillimanite-bearing schist has also been found; andalusite and garnet occur in pelites elsewhere. Calcareous beds throughout the formation contain scapolite, diopside, amphibole, and feldspar (usually plagioclase).

Calc-silicate breccia overlaps most units in the Corella Formation; its origin remains obscure, but it is considered to be variously a folded and brecciated unconformity, a slump deposit, biohermal reef debris, or a large-scale collapse structure associated with dissolution of salt-rich layers.

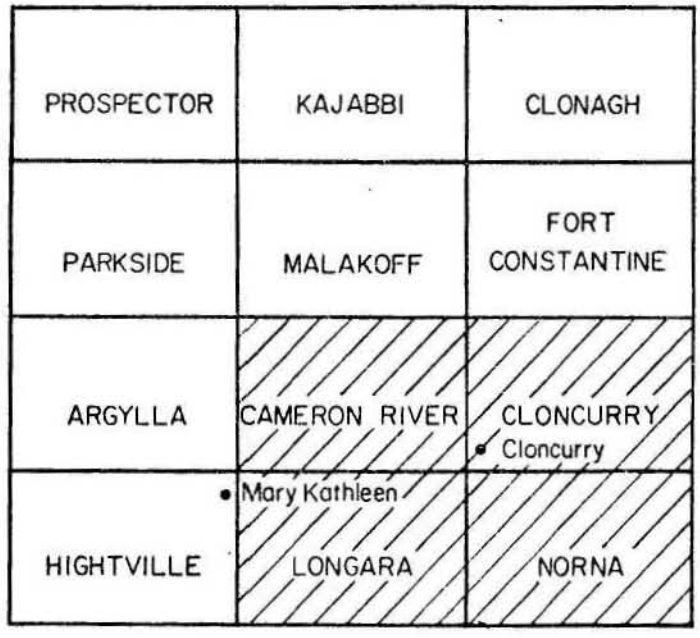
Relations between the Corella Formation and Marimo Slate are conflicting; the slate probably overlies the Mitakoodi Quartzite, and in most areas appears older than the Corella Formation. The Corella Formation overlies the Soldiers Cap Formation unconformably.

The Chumvale Breccia is not stratigraphically distinct from the Corella Formation. It is a local phenomenon produced by solution of carbonate from calcareous sediments, followed by brecciation and silicification.

The Roxmere Quartzite east of Roxmere Homestead is younger than the Corella Formation, but to the south a similar rock-type appears to form older anti-formal structures overlain by Corella Formation. Here it is possibly part of the Marimo Slate.

Figure M8

1:63,360 SHEETS IN THE CLONCURRY 1:250,000 SHEET AREA



To occompany Record 1969/123

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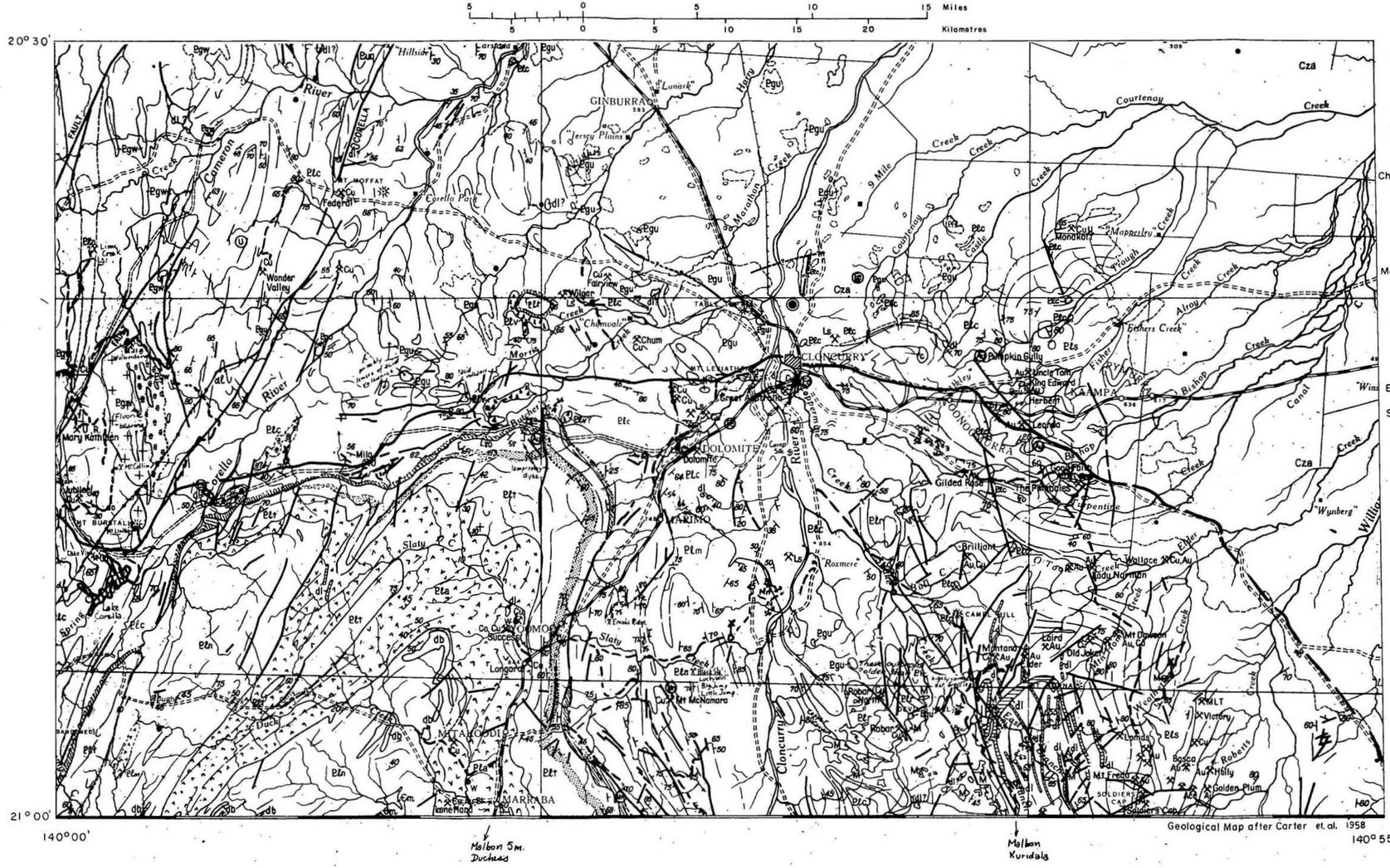
GEOLOGICAL MAP – CLONCURRY AREA



Geological Map after Carter et. al. 1958

Reference

Chumvale Breccia	Pbv	Breccia, with quartzite and sericitic schist and recrystallized limestone
Roxmere Quartzite	Pbr	Quartzite
Knapdale Quartzite *	Pbk	Quartzite
Charley Creek Formation *	Pbh	Interbedded calc silicate rocks and quartzite, some schist
Corella Formation	Pbc	Layered basic to intermediate intrusions. Calc-silicate rocks with, schist, quartzite, slate and recrystallized limestone breccia
Marimo Slate	Pbm	Slate, carbonaceous in part, quartzite, recrystallized limestone, schist, basalt, and tuff
Mount Philp Agglomerate	Pbp	Agglomerate and basalt with interbedded quartzite, calcareous in part; and calc-silicate rocks
Mitakoodi Quartzite	Pbt	Jaspilite marker-bed. Quartzite with altered basalt tuff, and schist. Amygdaloidal basalt.
Marraba Volcanics	Pba	Altered basalt and tuff with interbedded metamorphosed sediments
Eastern Creek Volcanics *	Pbe	Altered thinly interbedded basalt, and arenaceous sediments with tuff, slate and recrystallized limestone
Soldiers Cap Formation	Pbs	Schists, including mica-garnet-andalusite schist, interbedded altered basalt, quartzite, slate and "felsites"
	dl	Dolerite dykes and sills, intruding Pbs, Pbc, Pba, etc.
	db	Altered dolerite dykes and basalt
Ballara Quartzite	Pbb	Quartzite with conglomerate
Leander Quartzite *	Pbq	Quartzite with few altered basalt flows and tuff
Mount Guide Quartzite	Pbg	Quartzite feldspathic in part, conglomerate
Argylla Formation	Pbn	Acid and basic lavas with quartzite recrystallized limestone agglomerate arkose and schist

* Formations not present on this map

Proterozoic undifferentiated

Granites

Naraku Granite	Pgu	Mainly medium-grained red granite with some older coarse-grained granite
Wonga Granite	Pgw	Mainly porphyritic red granite and augen gneiss. Some younger massive granite, fluorite-bearing

Bore with mill
Tracks
Bitumen Road
Aerodrome
Trend lines
Mine or quarry

Au	Gold
Bi	Bismuth
Co	Cobalt
Cu	Copper
Fe	Iron
Ls	Limestone
Mn	Manganese
U	Uranium
W	Wolfram

To accompany Record 1969/123

F54/A2/17

Intrusive Rocks

Granitewas found for the first time intruding the Marimo Slate - both leucogranite and pyritic diorite plugs were noted in the Slaty Creek area. Numerous small leucogranite bodies intrude the Corella Formation south of Roxmere homestead, where they are associated with small dolerite masses. These latter rocks may intrude the Corella Formation, or be windows of dolerite belonging to the Soldiers Cap Formation. Contact metamorphism is not significant adjacent to the intrusive bodies, although a small amethyst deposit near Cloncurry is probably related to granite. In the Butchers Bore area high-level leucogranite and some problematical granite are present. The latter forms large concordant lenticular bodies in slate and calc-silicate rocks, and could be recrystallised acid volcanic or arkosic material. At Mount Burstall the Wonga Granite is massive and notably fluorite-bearing. The Wonga Granite at Mary Kathleen is gneissic; it contains some meta-sedimentary remnants, and has been affected locally by anatexis. Both types of granite are cut by late-stage aplogranite or porphyry dykes.

Basic rocks are widespread. Metadolerite sills and dyke swarms of at least two ages extensively intrude the Argylla Formation, Marraba Volcanics, and Mitakoodi Quartzite. In the Corella Formation dykes and large basic sills are common; layered intrusions up to 5000 feet thick occur north-east of Mount Burstall and near the Corella River, with rock types ranging from hornblendite to granodiorite. Small monzonite bodies occur with dolerite near Butchers Bore, and a lamprophyre dyke cuts Mitakoodi Quartzite in the same area. The youngest basic intrusive phase is represented by a dolerite dyke 25 miles long extending from near Lake Corella to near the Wonder Valley mine.

As far as could be ascertained in the field ortho-amphibolites appear to be more abundant than para-amphibolites.

Basic Extrusive Rocks

Many basic masses contain amygdales, and due north of Mary Kathleen, along the Cameron River, pillow lavas occur. These are also found in parts of the Soldiers Cap Formation. Metamorphosed basic tuff occurs just west of Butchers Bore.

Mineralisation

Many unworked minor mineral occurrences were found during the survey. Copper mineralisation is widespread, and a number of associations are evident:

(a) In the Marraba area copper occurs in quartz reef or vein deposits in or adjacent to dolerite.

(b) Copper in massive calcite lenses appears to be related to meta-dolerite; however, chalcopyrite in bedded limestone near the Corella River is possibly syngenetic.

(c) Relatively large copper deposits (Mt. Lindsay, Mt. Colin mines) occur in the contact aureole of the Mt. Burstall Granite, associated with large amounts of chalcedonic silica; minor mineralization occurs in a pegmatitic phase intruding the Corella Formation north of Mary Kathleen.

(d) In the same area economic mineralisation (Jubilee, Lake View mines) occurs in concordant quartz reefs in zones of granitisation, and in amphibolite-facies rocks; these deposits appear to be unrelated to granite, dolerite, etc., and have probably been formed by mobilization and concentration of copper during metamorphism and metasomatism.

(e) Mineralisation in the Marimo Slate occurs in quartz reefs and veinlets subparallel to cleavage and/or bedding. The slates are pyritic and carbonaceous in places, and locally a high content of base metals (Cu, Pb, Zn) has been recorded. There is no obvious igneous source for the mineralisation, which has been localised along faults and breccia-zones.

Copper mineralisation is associated with small quartz veins and quartz-hematite veins emplaced mainly within units (3) and (4) of the Soldiers Cap Formation. Gossanous enrichment zones are usually present. The mineralisation is preferentially developed within metasediments.

Gold is associated with concordant and discordant quartz reefs in meta-sediments and amphibolites of units (3) and (4). The mineralisation appears to be controlled by intersections of cross-fractures with favourable host-beds.

Manganese. Manganese ore was mined at The Overhang, 20 miles south of Cloncurry, to provide MnO_2 for the treatment of uranium ore at Mary Kathleen. Manganiferous slate has been found in the area, and basic volcanic and limestone units similar to those lying stratigraphically below The Overhang deposit have been postulated as likely source-rocks for the manganese.

Massive manganese oxide occurs sporadically along the upper contact of the Mitakoodi Quartzite in the Marimo-Slaty Creek area. Impure carbonate rocks containing abundant concretions of manganese oxide were found in the same area.

Limestone. Large limestone lenses were mapped near the Corella River, along the Cameron River north of Mary Kathleen, and near Marimo and Cloncurry. The Lime Creek deposit, 8 miles north of Mary Kathleen, is the only operating limestone mine in the area; a ten-foot wide zone containing veins of coarse chalcopyrite and pyrrhotite, together with very rare molybdenite, occurs within the limestone, which is being mined as flux for smelting at Mount Isa. Most of the limestone deposits occur as introduced lenses in the Corella Formation; in some places they appear to be genetically related to dolerite intrusions. Dykes of calcite occur in the Argylla Formation, near the headwaters of Slaty Creek.

Uranium. The Mary Kathleen uranium mine is on a care and maintenance basis pending negotiation of further contracts for the sale of uranium oxide; diamond drilling carried out since the mine closed has added substantially to reserves. Radioactivity up to three times background was found in a ferruginous fault-zone in the Copper Canyon area.

Structure

Cross-folding has affected most of the area studied; in the Marimo Slate the fold axes trend north and east, the latter system being younger. A similar system has affected the central block of Mitakoodi Quartzite, in the Morris Creek area. Just west of this creek the cross-fold pattern is itself deformed, suggesting at least three possible periods of deformation. Intricate drag folding and crenulation occur in calc-silicate rocks along certain faults. Similar folding away from faults is attributable in many places to gravity sliding of poorly consolidated carbonate rocks.

Faulting is extensive, the major trends being northeast and north. Most large faults, e.g., the Cameron and Wonga faults, show some transcurrent displacement. In the east, faults in the Soldiers Cap-Roxmere area are predominantly high-angle with reverse movement, though some, near the Robur mines, are low-angle. In the Marimo Slate many apparent fault-zones contain silicified and ferruginised but otherwise undeformed strata; it is possible that many of these zones are a result of reactivation of older faults.

In the Soldiers Cap Formation, a high degree of conformity exists between structures and metamorphic grade; the high-grade rocks occur in the cores of the anticlines. The post-Soldiers Cap evolution of the belt east of the Cloncurry River may be interpreted as follows:

(1) Isoclinal folding on NS-trending axes, represented by the central anticlinal zone and the synclinal zones on the east and west of the central anticline; b-axis lineation which can be ascribed to this folding phase has been recorded in the Gilded Rose area.

(2) Regional metamorphism reached the staurolite grade at the anticlinal core; successively lower grades are found at higher stratigraphic levels. A flow-cleavage system and a fracture-cleavage set, with their strikes repsectively parallel and perpendicular to the fold axes, were developed during the metamorphism. The fracture-cleavage set dips northward, except where the folds have been affected by later cross-folding.

(3) Cross-folding affected the northern part of the area, and resulted in the deflection of the previously meridional folds into WNW to NW directions. The box-folding shape of some of the folds in this area probably resulted from this movement. That this phase is younger than the metamorphism is indicated by the deflection of both the flow-cleavage and the fracture-cleavage sets along with the fold axes.

(4) Elevation and erosion.

(5) Deposition of a limestone-dolomite-marl-quartzite sequence (Corella Formation).

(6) Intense folding, resulting in the deformation and extensive brecciation of the Corella Formation. This phase is represented by the extensive breccias, mega-breccias, chaotic block structures, and a tight folding pattern in the calc-silicate rocks. The extensive brecciation may be interpreted in terms of the differential stresses induced by the folding of the irregular unconformity surface on which the Corella Formation was deposited. This is supported by the observation that brecciation is particularly common immediately above the unconformity, whereas unbrecciated bedded rocks are confined to the axial zones of synclinal troughs. An alternative explanation for the origin of the breccias involves large-scale collapse movements associated with the dissolution of salt-rich layers. This hypothesis may be supported by the abundance of scapolite in the calc-silicate rocks.

(7) Low-grade metamorphism.

(8) Post-metamorphic intrusion of leucocratic granites, which appear to represent the latest Precambrian event in the area. There is a preferential association of small granitic bodies with calc-silicate rocks of the Corella Formation. Alternatively, the cross-folding phase (3) and phase (6) may represent one and the same tectonic event. In this case, only one metamorphic phase is implied.

Geochemistry

Stream sediment samples were collected from two areas of known but unworked copper mineralisation (near Butchers Bore and east of Longara). Sampling density ranged up to 20 samples per square mile over areas of from four to eight square miles. The object of the programme was to determine an optimum sampling density for the delineation of small mineralised zones in areas uncontaminated by old mine workings. To date results are available for the Longara area, but remain to be plotted and analysed. Copper content of basic rocks in the vicinity of the sampled areas was also determined.

Numerous samples of gossan, manganese ore, and calcite were also collected for geochemical analysis.

Petrology

Petrological work to date has been restricted to rocks from the area east of the Cloncurry River, which have been grouped as follows:-

(a) Meta-igneous rocks -

Meta-basalts, meta-dolerites, meta-gabbros, meta-basites (ortho-amphibolites), and granites (usually leucocratic biotite-poor types).

(b) Meta-sediments -

Meta-siltstones, phyllites, schists and porphyroblastic schists, arenaceous schists, meta-cherts, and calc-silicate rocks (including para-amphibolites, scapolite-rich, and diopside-rich types).

The amphibolites and basic meta-igneous rocks are disequilibrium assemblages including amphibole (actinolite, hornblende, and tremolite), plagioclase (albite to labradorite), and accessory ilmenite, magnetite, sphene, clinozoisite, epidote, scapolite, apatite, biotite, sericite, and quartz. Muscovite, chlorite, biotite, andalusite, garnet, and staurolite have been formed successively in the meta-sediments with rising metamorphic grade. The prograde metamorphism was followed by weak retrograde metamorphism, as suggested by the growth of porphyroblasts of chlorite along fracture-cleavage planes. The association of andalusite and staurolite suggests intermediate-pressure type regional metamorphism of the Soldiers Cap Group. Retrograde metamorphism within this Group is evident, and may have taken place at the same time as the low-grade metamorphism of the Corella Formation. Typical assemblages in the Corella Formation include albite-tremolite, edenite-dolomite, dolomite-calcite-quartz, diopside-albite, and scapolite-rich rock-types. The metamorphism of these rocks has, therefore, reached the low-pressure hornblende-hornfels facies. The petrographic examinations will be followed by a study of the chemical composition of the amphibolites and their constituent minerals, with relation to metamorphic grade, and of the distribution of base metals in relation to metamorphic grade and host rock composition.

Company activity

Carpentaria Exploration Co. Pty Ltd is stationed in Cloncurry, and conducts exploration over a wide area in the north-west; currently it is undertaking drilling at the Mt. Colin mine.

Mount Annable Mines: A large number of leases have been granted in the Duck Creek area, near the old Success mine, for the mining of copper. Sedimentary Copper, a subsidiary of VAM, have leases in the same area.

Western Nuclear hold an option on the Great Australia Mine at Cloncurry, and are currently assessing the results of a geochemical and drilling programme. Detailed mapping and a geochemical survey in an Authority to Prospect field in the Mary Kathleen-Lake Corella area are almost complete.

Pegmin Pty Ltd are drilling cupriferous limestone deposits in the Wilgar area, north-west of Cloncurry.

Nickel Mines Pty Ltd hold an area of 98 square miles adjoining that of Western Nuclear, near the Milo uranium prospect, and are interested in copper and uranium.

Eastern Copper Mines N.L., a newly floated company, intend mining copper in the Ballara area from the numerous old workings in the district.

Newmetal Mines Ltd. are also newly floated, and intend working the Mt. Lindsay copper mine.

Geophoto Resources Consultants and Frio Mining and Exploration hold prospecting authorities in the area south of Marraba towards Duchess and Kuridala.

Mary Kathleen Uranium, Queensland Mines, and Placer Development are investigating alluvial deposits east and north-east of the Precambrian areas for uranium.

C.R.A. is continuing exploration in an area near Mary Kathleen.

Use of colour aerial photography

In 1968 Queensland Aerial Survey Company produced a series of colour aerial photographs covering an area of about 1200 square miles between Mount Isa and Mary Kathleen, at a scale of 1:20,000 (1600 feet to 1 inch). Part of this photography covered areas mapped in 1969.

The quality of the colour photographs appeared superior to all existing black and white photography covering the area at various scales; the colour tonings, though slightly exaggerated in places, were quite realistic. Accurate navigation, especially in difficult granitic terrain, was made simple using colour photographs. Amphibolite bands and dark-toned sedimentary units were readily distinguishable from each other, and certain parts of the Corella Formation showed a characteristic blue-grey colour.

Small (3 to 5 feet) veins (especially calcite veins in amphibolite), mines, gossans, and soil-covered gossan extensions were particularly obvious in colour. In general, photo-interpretation from colour photos was more accurate and detailed than that possible from black and white photos; in particular, intricate folding was much more evident in colour.

At about $4 a print (compared with 80 cents per print for black and white) the colour photographs are not cheap, and they were not extensively used in the field, primarily for this reason. However, it is recommended that further areas be flown in colour, and that all mapping be done using colour photographs. More comprehensive and accurate geological maps, a greater awareness of potentially economic areas, and possibly an increased rate of mapping will more than compensate for the apparent high cost.

DARWIN URANIUM GROUP

C.E. Prichard, D.J. French, R.S. Needham

Following a policy decision to reduce the area under Reservation, field work at Rum Jungle in 1969 was restricted to an area of 100 square miles. The Minister for the Interior invited interested parties to apply for prospecting and mining rights to the rest of the previously reserved area in the Rum Jungle district. Many company representatives called at the Darwin and Canberra offices for information and discussion on the areas to be released.

Areas of activity for 1969 are shown in Fig. M10.

Diamond Drilling

Seven diamond drill holes have been drilled by a contractor.

One hole at Mount Minza tested a zone of geophysical and radiometric anomalies, and verified the calculated depth of the conductor, but did not intersect significant mineralisation.

Three holes were sited to test a base metal anomaly in the Acacia area. Drilling conditions were difficult in this area. One hole was abandoned before target depth, and core recovery from the others was poor. Traces of lead, zinc, and copper occurred in the cores, but no ore-grade material was intersected.

In Area 44 Extended, coincident base metal and radiometric anomalies were tested by one hole. No significant mineralisation was present, and logging of the hole recorded only normal levels of radioactivity.

A hole to test for possible uranium mineralisation in the Whites Extended area had to be abandoned when tailings under pressure entered the hole at about 400 feet depth. Another hole to test for an extension of Dysons ore body was also abandoned before target depth. In November drilling was in progress from another collar position to test this latter target.

Auger Drilling

Part of the Huandot area, in which anomalous base metal values had been recorded in 1969, was re-sampled on a closer grid (200 by 100 feet). Results available to date confirm the anomalies, and outline them more precisely. Strong lead and zinc anomalies and weak copper anomalies are present.

A number of isolated high values recorded in 1968 in the Huandot and Coomalie Creek areas have also been re-sampled on a closer grid. Results are not yet available.

Follow-up drilling was also carried out at a number of localities in the Rum Jungle Triangle area. These comprise five small areas near Kerles Homestead, and three near Jefferys; others were at Finniss South, near Flynns, Baseline, Siding, and Area 55 A. Most of these had been indicated as radiometrically anomalous areas in past surveys. Only two required further investigation after augering. At Kerles No. 4 area, one rotary drill hole showed that anomalous radioactivity did not persist in depth. At Jefferys No. 3 area, five rotary drill holes confirmed highly anomalous peaks at 0 - 5 feet and 30 - 35 feet below surface, and two of these holes also showed anomalous values persisting to greater depth. Three further rotary holes are planned in this area.

The Gemco unit also drilled holes for the Alpha Counting Investigation described below.

Rotary Drilling

In Area 44 Extended, eight rotary drill holes, mostly to about 200 feet depth, were sited on radiometric anomalies. In most of these holes, anomalous values were restricted to within 40 feet of the surface.

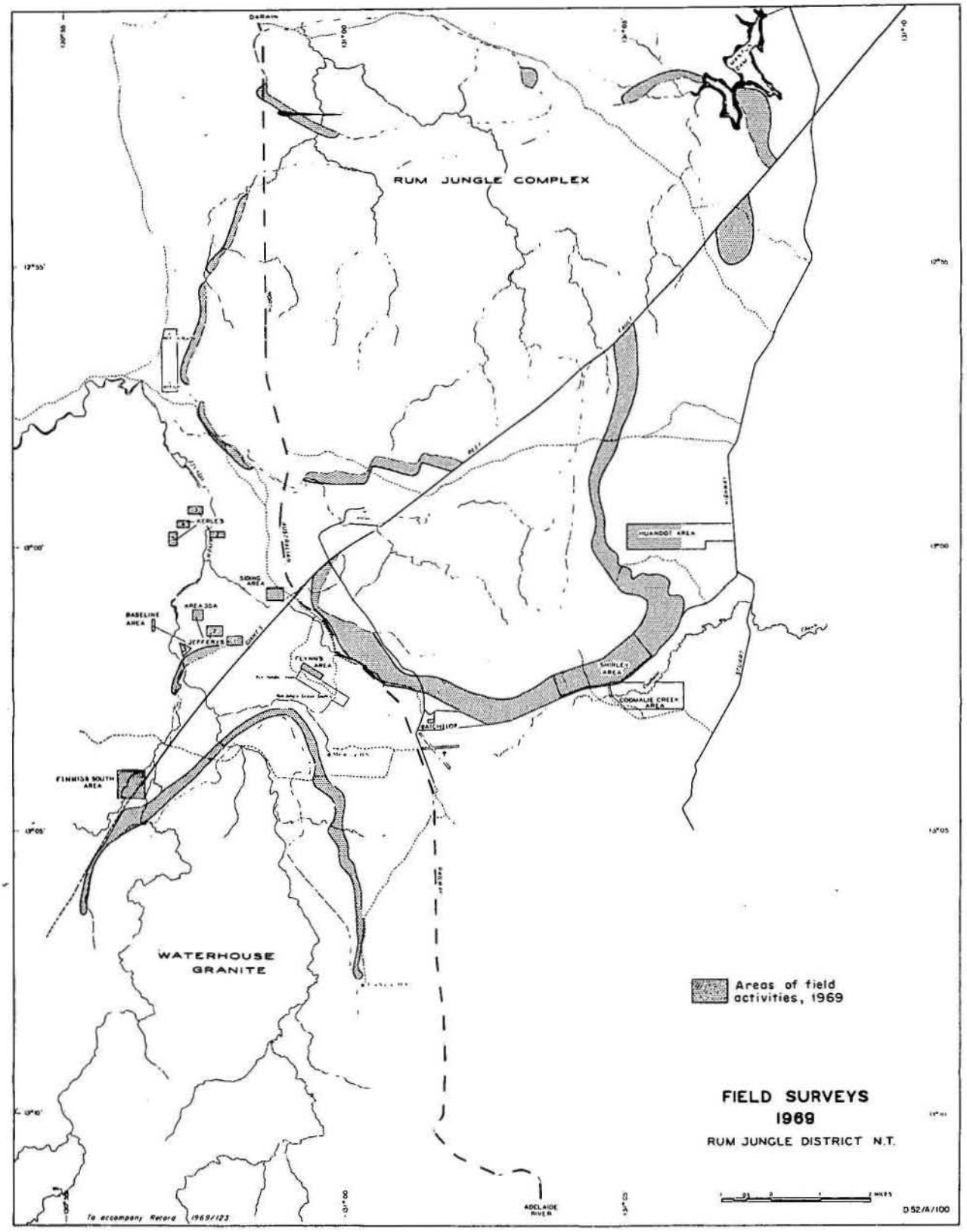
Drilling at Kerles No. 4 and Jefferys No. 3 areas has been reported above.

In November drilling was in progress immediately south of the Rum Jungle Creek South open cut, where sixteen holes are planned to test for a possible extension of that ore body.

Crater Investigation

To determine the distribution of sub-units and anomalously radioactive zones in the Crater and Beestons Formations, a reconnaissance was made of all outcrops around the Rum Jungle Complex and the northern part of the Waterhouse Granite. The "Crater Line", comprising the zone south of the Giants Reef Fault past Batchelor and four miles east, was then examined more closely, and the Shirley Area, about three miles east-north-east of Batchelor was finally selected as the most promising area for detailed testing of the Crater

Fig. MIO


RUM JUNGLE COMPLEX
WATERHOUSE GRANITE
KEPLER
SIDING AREA
AREA 30A
BASELINE AREA
JEFFERIES
FLYNNS AREA
HUANDOT AREA
SHIRLEY AREA
COOMALIE CREEK AREA
BATCHELOR
FINNISS SOUTH AREA
ADELAIDE RIVER
Areas of field activities, 1969
FIELD SURVEYS
1969
RUM JUNGLE DISTRICT N.T.
To accompany Record 1969/123
D52/A/100

Formation for uranium mineralisation. Radiometric gridding and detailed mapping of this area have shown that maximum radioactivity occurs in the No. 1 Conglomerate, which is well developed. The No. 2 Conglomerate also has some very high values, but is generally not as well developed. The "Crater Pebble Beds", comprising a sequence about 200 feet thick immediately below the No. 1 Conglomerate, are also well developed and strongly radioactive. At least two diamond drill holes, up to 2,000 feet in length, are proposed to test the No. 1 and No. 2 Conglomerates and the "Crater Pebble Beds", and detailed planning of the holes is in progress.

The reconnaissance examination of the Crater and Beestons Formations has made necessary a number of minor alterations and additions to the regional map. The Beestons Formation was found to rest unconformably on the Waterhouse Granite at one locality, indicating that this granite, like the Rum Jungle Complex, is probably of Archaean age.

Investigation of Magnesite Occurrences

Following earlier indications of the wide-spread occurrence of magnesite in the Celia and Coomalie Dolomites, three areas were selected for further examination and closer sampling. Results confirm that both formations contain significant amounts of magnesite with better than 85% $MgCO_3$ contents, including at least some high-grade material of better than 95% $MgCO_3$ contents.

Alpha Counting Investigation

This project is being carried out in conjunction with the Geophysical Branch. The first phase of the investigation was designed to see if alpha counting on the Crater Formation could provide an indication of the radon contents, and could thus be used to delineate uranium-rich zones. However, this was found to be impracticable, because of excess thoron derived from the thorium present in the Crater Formation. Secondly, tests are now in progress to see if the method is capable of, and suitable for, locating non-outcropping uranium ore bodies of the type previously worked in the Rum Jungle area. To date, anomalous count rates have been obtained on a number of test traverses in the Mount Fitch and Rum Jungle Creek South areas, but further work is required.

McARTHUR RIVER PROJECT

M.C. Brown (Sedimentary Basins Section)

The McArthur River project was continued from the previous year. The period to the end of July, 1969, was spent mainly in interpreting the results of previous field work, and in compiling a revised 1:250,000 map of the McArthur Group of the Bauhinia Downs Sheet area, based on mapping in 1968, photo interpretation, and detailed mapping by Carpentaria Exploration Company geologists. Some time was also spent on preliminary microscopic examination of prepared surfaces and thin sections of outcrop samples of Emmerugga Dolomite, Barney Creek Formation, and Reward Dolomite. A Record based mainly on results of 1968 field work has been written, and is now being edited by colleagues.

Analysis of samples from stratigraphic sections measured in 1968 for Ca, Mg, and insoluble residue, and for several other major and trace elements, is being carried out in the B.M.R. Chemical Laboratory, and is reported elsewhere.

In August and September, $7\frac{1}{2}$ weeks were spent in the McArthur River area. About $\frac{1}{3}$ of this time was taken up examining and sampling diamond drill cores from the HYC deposit and adjacent areas, and the remainder on field traverses aimed mainly at improving the existing picture of the regional distribution and palaeogeography of the Barney Creek Formation and associated dolomite units.

Examination of drill cores

Two diamond drill cores, from holes Ie 115 and Te 115, were examined in some detail. Te 115, a vertical hole 1730 ft deep, intersects one of the thickest known sequences of the shaly and sulphide-bearing HYC Member of the Barney Creek Formation, and includes the interval containing zinc and lead sulphides. Ie 115, a 2500-ft deep vertical hole located about 1000 feet east of Te 115, intersects mainly clean carbonate rocks, regarded by Company geologists as a reef-like body of shallow-water carbonates (the Cooley Reef Member) which may have built up during deposition of the HYC Member.

Examination of these cores confirmed the idea that the thick sequences of clean carbonate rocks east of the HYC deposit represent a build-up of shallow-water carbonates the same age as at least part of the HYC Member, as the distinctive "basal tuff" subunit of the HYC Member occurs near the bottom of Ie 115. However, the carbonates are almost entirely evenly laminated to thin-bedded dololutites (now generally brecciated) which seem to have been deposited as carbonate muds not bound together by organisms; thus the term "reef" is not appropriate. Further, the dololutites are very similar to an outcropping dololutite mapped in 1968 as the upper part of the Mitchell Yard

Member of the Emmerugga Dolomite; and the Cooley Reef Member can be interpreted as a build-up of the Mitchell Yard Member, as forecast after the 1968 field work.

Of interest was the discovery of a small amount of limestone occurring as probable slumped blocks enclosed in a dark mudstone at the top of the "basal tuff" in Te 115.

Field traverses

Field traverses extended the previously known limits of occurrence of the Emmerugga Dolomite, Barney Creek Formation, and Reward Dolomite.

Areas of Emmerugga Dolomite not previously mapped include: (a) part of the outcrop mapped as undifferentiated McArthur Group in the north-west part of the Bauhinia Downs Sheet area; (b) portions of areas mapped as Billengarah Formation in the Mount Young Sheet area; and (c) two small outcrops previously mapped as Amelia Dolomite, near Smythe Creek in the northern part of the Bauhinia Downs Sheet area. In the last area a small thickness of Barney Creek Formation and Reward Dolomite may occur between the Emmerugga Dolomite and the Batten Subgroup, but in the other areas sedimentary rocks younger than these formations rest unconformably on the Emmerugga. In all three areas the Emmerugga is silicified to a rubbly chert breccia, except for some small remnants of the unsilicified unit in areas (b) and (c).

The existence of outcrops of Barney Creek Formation and Reward Dolomite, not previously mapped, but photo-interpreted before the field season, was confirmed in the field: (a) on the Wallhallow Sheet area 6 miles west of Top Springs homestead; and (b) in the Bauhinia Downs Sheet area, forming extensive outliers on areas of Emmerugga Dolomite north and south of the Daly Waters road between 5 and 10 miles west of the junction with the Anthony Lagoon to Borroloola road.

In the Robinson River Sheet area, within the Karns Dolomite about 10 miles north west of Robinson River homestead, a sequence of cherty dololutite, shaly dololutite, dolomitic shale and doloarenite, less than 200 feet thick, is very similar to the Reward Dolomite near McArthur River, and in places contains the small silica spheroids characteristic of that unit. It is underlain by cherty dololutite with abundant stromatolites (including Conophyton and basinal types) which resembles the Emmerugga Dolomite.

Channel-filling conglomerates and sandstones in the Robinson River homestead area, previously mapped as part of the (?)Cambrian Bukalara Sandstone, are stratigraphically below the dolomites mentioned above, and fill channels eroded in older beds of the Karns Dolomite and in the underlying Tawallah Group.

REPORT WRITING

RUM JUNGLE PROJECT, N.T.

C.E. Prichard, J.E.F. Gardener, D.J. French, R.S. Needham

A comprehensive report on exploration in the Rum Jungle East area, excluding the Woodcutters L5 prospect, is being prepared. Geochemical results for 1969, and the results of radiometric gridding of selected parts of the Crater Formation, will be written up during the wet season. Progress reports on work done in 1968 have been issued.

COMPILATION OF DATA, HUNDRED OF GOYDER, N.T.

Y. Miezitis

Compilation of geological, geochemical, and radiometric data for the Hundred of Goyder was not quite complete when Miezitis resigned early in May. Arrangements have now been made for him to spend a short time in Canberra to complete the writing up.

An interim Record covering compilation of part of the Embayment Area was issued early in the year under review.

HERBERTON-MOUNT GARNET AREA, Q.

D.H. Blake (C.S.I.R.O.)

Amendments have been made to Record 1968/79, including the addition of 34 text figures of mining localities. The amended Record has been submitted to the editor for publication as a Bulletin. The Preliminary Editions of the Herberton and Mount Garnet 1-mile geological maps have been checked and edited, and fair drawing is in progress.

PETROLOGICAL, CHEMICAL, AND GEOCHRONOLOGICAL LABORATORIES

Professional Staff: K.R. Walker, A.D. Haldane, C.D. Branch (resigned Jan.), S.E. Smith, J. Ferguson (transferred to Baas-Becking Laboratory, Feb.), W.D. Palfreyman (transferred to laboratory, Feb.), R.N. England, R.W. Page, Miss R. Bennett, Miss H.R. Lord, D.W. Bennett (resigned Jan.), C. Claxton (commenced March), Miss B. Labonne (commenced Sept.).

Technical Staff: G.H. Berryman, T.I. Slezak, (commenced Nov., 1968) J. Weekes (commenced Feb.), T.K. Zapasnik (transferred to Sedimentary Section, June), A. Maenner (commenced June), Z. Roksandic (resigned Dec., 1968), W.C. Whitwell (commenced Aug.), C. Robison (commenced Feb.), W.G. Pascoe (died Sept.).

The past year is the first in which the petrological and mineralogical, chemical, and geochronological laboratories have had a full time supervisor. Technical staff to assist with the analytical and preparatory work was increased during the year, and fuller use was made of most major analytical instruments acquired over the last few years. These include a direct-reading optical spectrograph, automatic X-ray fluorescence spectrograph, electron probe microanalyser, electron scanning microscope, atomic absorption spectrophotometer, and gamma-ray spectrometer.

Following the re-organization of the Bureau late in 1968, it has been possible to review laboratory functions and activities, and proceed more purposefully towards objectives than in the past. Although professional staff numbers are still below full strength, steady progress has been made on most projects to which the laboratory was committed in the programme, and it has been possible to meet most requests for ad hoc determinations and analyses. Project work culminates in Records, Reports, Bulletins, and scientific papers. The results of most ad hoc work come out as Laboratory Reports, which are gathered together at the end of each year, and produced as a Record; 103 Laboratory Reports on minor investigations were written during the year. Four project reports were completed, and fourteen project reports are in various stages of preparation.

Assistance with professional and technical training of students continued at various times during the year. A. Annamalai, U.N. Fellow, was provided with laboratory assistance in his geochemical investigation of weathered rocks from Rum Jungle. J. Staim, Colombo Plan Student, received technical training in the various phases of activity in a geological and geochemical laboratory. P. Tonkin, a cadet geologist, was provided with laboratory assistance for his investigation of pegmatites in the Broken Hill district.

Continuing interest in work of the laboratories was shown by numerous visitors, and enquiries were received from Government agencies, industry, and educational organizations, and from overseas.

The results of project activity issue from the three main laboratory sections (i) petrology, mineralogy, and mineragraphy which presently includes the major instrument laboratories, (ii) chemistry, and (iii) geochronology. They are presented on this basis below.

PETROLOGY, MINERALOGY, AND MINERAGRAPHY

Effort in the petrological section has been concentrated on re-establishing the section to a point where it can provide a full range of facilities for petrographic, mineralogical, and mineragraphic work, to assist field investigations in which this type of study is required, to provide specialist guidance and advice, and to undertake research on selected projects arising out of fieldwork. To this end laboratory space has been modified to accommodate such facilities, the availability of equipment and its condition have been ascertained, and recruitment of staff is being pursued. A period contract has been arranged to service and maintain all microscopes and ancillary equipment.

The main work done in the petrological section during the year was:

(i) Collating all silicate analyses of igneous and metamorphic rocks done or obtained by the Bureau for inclusion in the second part of the Analyses of Australian Igneous and Metamorphic Rocks, which is being compiled by Dr. G. A. Joplin. For this 720 analyses have been collected.

(ii) Compiling petrographic data for the project on the geochemistry of Australian granites. For this, overlays showing the localities of about 600 specimens to be used in the initial study - the North Queensland Granites - have been prepared, and brief petrographic descriptions of 430 of them have been made by A.M.D.L.

(iii) A few ad hoc descriptions and determinations were made as required. These included a petrographic investigation of the main rock types of the Panguna porphyry copper area, Bougainville Island.

During the year 854 thin sections, 173 polished sections, 62 polished thin sections, and 454 slabs and polished hand-specimens were prepared in the thin-section laboratory.

The technician attached to the laboratory used to prepare samples for X-ray fluorescence and optical emission spectrograph analyses resigned in December, 1968, and it was not possible to replace him until August. As a result there was only a small output of prepared samples, and not as much use of the X-ray fluorescence equipment was obtained as would otherwise have been possible. The Geochemistry of Australian Granites was the project most affected. During the year 200 fusion discs and 200 pressed pellets were prepared for X-ray fluorescence analysis, and 500 rock powders for direct-reader analysis.

The preparation of whole-rock samples and mineral concentrates required for isotopic dating continued sporadically during the year. The technician in charge had an unfortunate run of sickness, and died in September.

In the direct reading optical spectrograph laboratory 7500 element determinations were made on 524 samples. In addition, 2100 determinations were made to assist in the interpretation of X-ray diffraction charts. Most of the samples determined were submitted by field geologists requiring chemical data for their projects. Development work was carried out with some success on a method for determining both the volatile and involatile groups of elements simultaneously. If fully successful, the method will be adapted for use in the project on the Geochemistry of Australian granites.

Analytical data obtained contributed to the following projects:

(i) A study of the geochemical variation in a Proterozoic siltstone of the Kimberley region, W.A., by T. Quinlan. For this 2000 element determinations were made on 180 shales and siltstones of the Albert Edward and Duerdin Groups, and X-ray diffraction charts were prepared for each sample.

(ii) Trace-element analyses of rocks from the Canadian Shield to assist geologists of the Geological Survey of Canada who are determining the composition of about 200,000 square miles of the earth's crust, and are investigating the chemical differences between amphibolite and granulite facies rocks in terms of shield development. About 2500 element determinations were made on 155 samples. Additional interest lies in evaluating the success of the sampling procedure, and, if judged successful, the degree of compositional variation to be expected in regional geochemical investigations in continental shield areas. Interpretation of the data is being done by the Canadians.

(iii) A preliminary chemical investigation of the Antrim Plateau Volcanics was made by analysing 65 selected samples for 17 elements, to establish compositional variations, including those resulting from alteration, and to obtain a general understanding of petrogenesis in the volcanic province. The current programme includes further work on these volcanics, particularly in respect of associated mineralization.

(iv) The writing of the Bulletin by S.E. Smith and K.R. Walker on the Mount Isa Geochemical Project was completed. This investigation mainly involved a study of primary element dispersions associated with mineralization in the Urquhart Shale at Mount Isa. It was found that no pronounced dispersions are associated with the concordant or bedded type Ag-Pb-Zn mineralization, whereas dispersions typical of epigenetic hydrothermal mineralization surround theCu mineralization. The distinction between the dispersion surrounding the two types of ore body suggests that two epochs of mineralization occur at Mount Isa. The distribution of elements suggests that much of the Cu was selectively removed from the basic rocks in the vicinity of the mineralization, and concentrated in the overlying Urquhart Shale which provided a suitable physico-chemical environment for Cu deposition.

(v) Some manganese nodules from the Pacific and Southern oceans were examined. Their compositions are consistent with those of nodules from similar localities which have been analysed by other workers. They contain up to 27% Mn, 24% Fe, 1.3% Co, 1.2% Ni, and 0.16% Cu in their outer zones.

(vi) Numerous requests were met from field geologists for chemical data. One hundred rock and mineral analyses were made of recent sediments from Milne Bay, T.P.N.G., of Cape Nelson volcanics (eastern Papua), of iron ore concentrates from West Kimberley, W.A., and of laterites from Western Samoa at the request of a representative from U.N.E.C.A.F.E. Many of the samples were also examined by X-ray diffraction.

Two hundred and ninety-seven silicate analyses were done on the X-ray fluorescence spectrograph. Some of these were for the Geochemistry of Australian Granites project, for which about a quarter of the analyses required for Part 1 - the Northern Queensland Granites - are now completed. In another project, C.D. Branch conducted further investigations into the chemistry of the Bagstowe Ring Dyke Complex, Queensland, and concluded that there is a hiatus in the chemical evolution of the complex which can be correlated with a change in structural evolution from the caldera phase to the underground stoping phase of igneous intrusion.

The electron probe microanalyser has been used largely for work on two projects. The first is a mineralogical study of rocks from the Papuan Ultramafic Belt, and the second a study of the medium-grade metamorphic rocks from the Petermann Ranges, N.T. Probe determinations are complete for the first project, and about half complete for the second. Results obtained to date are summarized below:

(i) Papuan Ultramafic Belt Project - A study was undertaken of the compositions of pyroxenes, olivines, and spinels in rocks collected by H.L. Davies. The pyroxenes and olivines are highly magnesian, and have compositions typical of those found in alpine ultramafic bodies rather than those from cumulates of mafic intrusions. Olivines contain up to 0.04% NiO. Pyroxenes and olivines appear to have equilibrated quite well under

roughly similar conditions for all the rocks studied. This is indicated by parallelism of tie-lines and constant distribution-coefficients.

Chromian spinels are quite Fe-rich and Al-poor compared with spinels from ultramafites which have equilibrated at depths well below the Moho. D.H. Green (J. Petrol. 5, 134-188, 1968) has shown that pyroxenes in equilibrium with aluminous minerals can accommodate more Al_2O_3 at high pressures than low pressures. As these spinels are not particularly aluminous it is necessary to plot Al_2O_3 in the pyroxenes against Al_2O_3 in the spinels, and compare them with values for high-pressure peridotites (those formed at depths of about 100 km). The results suggest that the rocks of the Papuan Ultramafic Belt have equilibrated at quite low pressures, and this conclusion is compatible with the theory that they formed just below the oceanic Moho.

It is evident from Fig. M11 that Cr distribution between chromite and orthopyroxene is markedly different in the Papuan peridotites from that in nodular peridotite inclusions in alkali basalts. These nodular inclusions are thought to have originated at depths in the region of 80-100 km. By contrast, the Papuan rocks are typical of intrusive peridotites like the Dun Mountain and Twin Sisters bodies, which are assumed to be of comparatively low-pressure origin. The figure (M11) shows that Cr behaves in a similar manner to Al (see previous paragraph), in that it is more acceptable to the orthopyroxene lattice at high pressures than at low pressures.

(ii) Petermann Ranges Project - this project can be divided into three main sections: the study of a kyanite-pyrophillite-quartz assemblage, the study of phengitic white micas, and the study of amphiboles and associated minerals in the mafic rocks.

Rocks containing kyanite, pyrophyllite, and quartz occur in the Dean Quartzite over 20 km along strike as a transition between those to the west which contain pyrophyllite as their aluminium silicate, and the higher grade rocks to the east which contain kyanite. The textural relationships between pyrophyllite and the associated muscovite can be seen only with an electron probe, as the two minerals are optically very similar. Phengitic muscovite occurs in fine lamellae disposed parallel to (001) in pyrophyllite. The Fe and Mg contents of the mica decrease gradually in the direction of increasing metamorphic grade.

Amphiboles analysed so far are very aluminous hornblendes, although the rocks containing them are probably only slightly higher grade than rocks containing actinolite. It is hoped to delineate the zone of transition between actinolite and aluminous hornblende, and to study in detail the changes in composition during the transition.

Requests for a few ad hoc microprobe determinations were met during the year.

A transmitted light stage has been fitted to the probe, and the acquisition of silicate standards is continuing. A method of reducing inaccuracies in the analysis of light elements due to specimen surface irregularities has been developed.

A scanning electron microscope was installed in the laboratory in July, and this to date has been used largely for palaeontological work, though some exploratory work on other applications has been done by workers in the Baas-Becking Geobiological Laboratory. These workers also use the probe for routine determinations as required.

The demand for X-ray diffraction work increased considerably compared with previous years. Mineral identifications were carried out on 1050 specimens. In addition, 100 standard charts were prepared to assist mineral identification from diffraction patterns, as problems have been encountered in interpreting patterns of minerals not listed in the A.S.T.M. index, and in distinguishing individual members of mineral series. On this basis a supplementary index will be established.

Some of the aspects of diffraction work which bore interesting results while making determinations for field geologists are as follows:

(i) Some samples of "travertine" from Gosses Bluff were found to be magnesite. Similar material is fairly plentiful in the area, and further samples have been collected to determine if any parts of the deposit are potentially economic.

(ii) The occurrence of pentahydroborite, $Ca\ B_2\ O_4.SH_2O$ was considered possible from the diffraction data on a sample from B.M.R. Alice Springs No. 3. The occurrence could not be confirmed, as the peaks which correspond to those given for this mineral were small. So far the mineral has been found only at one locality in Siberia.

(iii) It is thought that high sanidine exists in some samples from Mount Pyroclast, as the X-ray pattern obtained for this phase in the rocks is closer in fit to high sanidine than to normal sanidine. However, high sanidine has not been found in natural rocks before, and the occurrence requires further investigation.

(iv) On two occasions during the year anthropologists from ANU have sought assistance in identifying materials used in native implements and pigments of New Guinea. Details of natural materials selected by native people for their artifacts are reported in Laboratory Reports 53 and 95 for 1969.

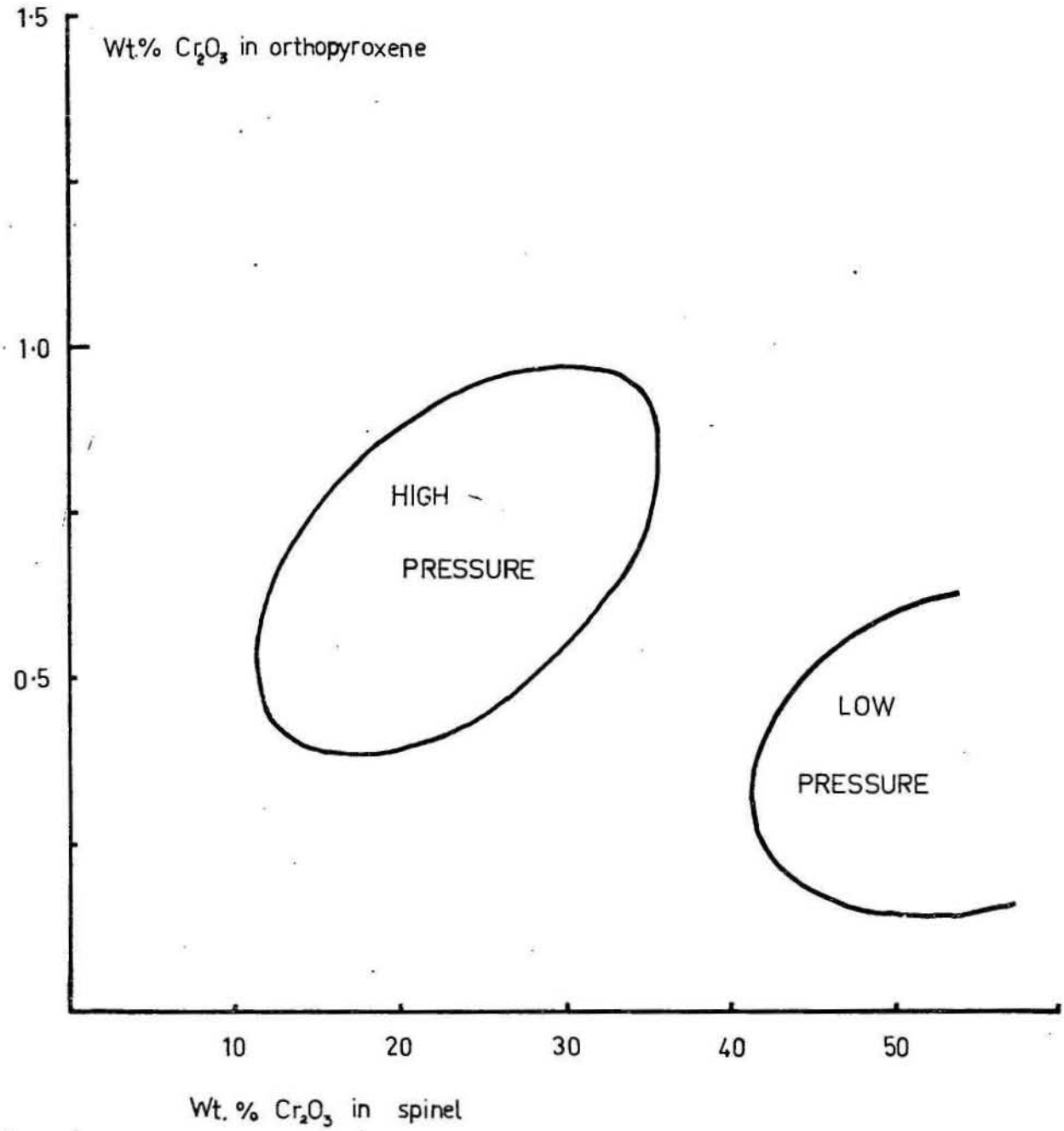


Fig. M11: Distribution of Cr_2O_3 between orthopyroxene and spinel in high- and low-pressure peridotites.

Bureau of Mineral Resources, Geology and Geophysics.
To accompany Record 1969/123.

CHEMISTRY

Progress with project work is as follows:

(i) Geochemistry of Precambrian Carbonate Rocks of Northern Australia - The analytical work on this project was interrupted by the resignation of D.W. Bennett in February. Work resumed late in April following the appointment of C. Claxton, and has continued for the remainder of the year. Trace element analyses have been completed on samples from 10 measured sections, and major element analyses on just over half the samples. Compilation of the results has started for the purpose of preparing a progress report. This project will continue into 1970.

(ii) Absorption of Base Metals on Hydrous Oxides - The first stage of this project has been completed, and a report is in preparation for issue in the Records series. As J. Ferguson, who was responsible for the project, transferred to the Baas Becking Geobiological Laboratory early in the year, no work was done on stage two, and the project has lapsed for the present, pending the availability of other staff.

(iii) Corin Dam Investigation - Increased spring activity at Corin Dam first appeared in June, 1968. In November an investigation was started to determine the source of the spring, and assess its possible effects on the dam structure. The spring water proved to be abnormally acid, and so the scope of the investigation was widened to include the source and effects of the acidity.

An extensive programme of sampling was carried out over several months, and detailed analyses were made of water samples and precipitates deposited from the effluent waters. A limited amount of bacteriological testing was done to support the conclusions derived from the chemical analyses. A survey was also made of the temperatures of groundwater, reservoir water, springs, and all leaks in the outlet tunnel. The sampling programme included the collection of water from each leak in the outlet tunnel, both before and after substantial rain, detailed monitoring of the spoil spring, and collection of water from the Cotter River and Cotter Fault springs. Samples of various carbonate-, iron-, aluminium-, and manganese-rich deposits were collected from the outlet tunnel.

Initially the acidity and abnormal salt content of the water were considered to be due to the oxidation of natural sulphides contained either in the rockfill forming the bulk of the dam or in faults and joints in the country rock. It has now been established that pyrite in the rock fill is being steadily oxidized, aided bacterially by Thiobacillus ferro-oxidans. The biological factor is enhanced by an abundant supply of nitrogen thought to have been derived from residues from the ammonium nitrate quarrying explosive.

The phase of intensive study has now been concluded. Monthly monitoring of the acidity and salt content of the spoil spring is being maintained, and further detailed sampling is scheduled for mid-summer 1969-70 to determine the influence of ambient temperature on the rate of pyrite oxidation.

(iv) Phosphate Chemistry - Owing to pre-occupation with the Corin Dam investigation, the work on phosphates had to be put aside until late in the year. A suite of 93 samples representing three profiles in "C" grade material from Christmas Island was provided by the British Phosphate Commission for study of trace element distribution (including U and Th). Chemical analyses and mineralogical examinations have been completed on these samples. Future work includes an investigation of radioactivity and the nature of the iron content.

(v) Minor Activities - a Trace element analysis was completed on 470 plant samples from a geobotanical survey in the Woodcutters area, Rum Jungle. This work was carried out on behalf of Dr. W.F. Ridley, Geological Survey of Queensland.

- b A report on zinc pollution in the Molonglo River from past mining operations at Captains Flat was prepared and submitted to the Senate Select Committee on Water Pollution.

- c Some assistance was given to the Parks and Gardens Section of the Department of the Interior in their investigations of the effects of zinc pollution on parklands under irrigation by lake water, and possible effects of acid released by pyrite oxidation occurring in pyritic aggregate used around trees and gardens.

(vi) Miscellaneous Analyses - Routine analyses completed during the year included determination of P_2O_5 on samples from the Phosphate Group, analysis of various water and brine samples, spectrographic analysis of New Britain stream sediments and core samples from the Ringwood Dome, analysis of dolomites from Victoria River, and Cu determinations on samples from the Cloncurry area - a total of 300 samples.

GEOCHRONOLOGY

The age determination programme for the last year resulted in 146 K-Ar and Rb-Sr isotopic analyses, in addition to which about 40 analyses were duplicated. Samples worked on came from the West Kimberley (30 samples), Cape York (23), Antarctica (6), T.P.N.G. (80) and Victoria (7). Several calibrations of air argon and argon tracers were also carried out during the year. R.W. Page worked mainly on his investigation of the granitic and volcanic rocks of New Guinea, and on some Victorian rocks. Miss Bennett worked on the West Kimberley, Cape York, and Antarctica rocks using the Rb-Sr method. A summary of these projects is given below. Although some of the data from these areas have been duplicated, and are analytically reliable, the Rb-Sr ages obtained are not unequivocal, and several must be regarded as tentative. In many cases this is due to the poor quality of the samples and to inadequate collection in the field.

(i) West Kimberley Project: (a) In the previous annual report the Rb-Sr isochron age of the Kongorow Granite was given as 1776± 100 m.y. A bias correction of 5.5% (from XRF analysis) has now been applied, giving the age as 1870 ± 100 m.y., the initial ratio (I.R.) being 0.708 ± 0.002.

(b) The Whitewater Volcanics, Bickleys Porphyry, and Mount Disaster Porphyry, together with the Lennard, Larida, Long Hole, and Chayneys Granites (in all 14 samples) fit an isochron whose age is 1945 ± 90 m.y. (I.R. 0.706 ± 0.003).

Two muscovites from the Halls Creek Pegmatite (at Gusseys Mica Mine) were dated at 1465 m.y. and 1394 m.y.

(c) Rb-Sr total rock analyses from several other rock units do not give a firm isochron age, but tentative estimates are summarised below:

Noonkanbah Granite 1645 m.y. (I.R. 0.705)
Wetjulum Porphyry 1630 m.y.
Elgee Siltstone, Carson Volcanics, Elimberrie and Linesman Beds } Suggest a thermal event between 540 and 590 m.y.
Volcanics overlying Elimberrie Beds 350 m.y.
Pentecost Sandstone 1450 m.y. (I.R. 0.706)

(ii) Cape York Project: No clear picture of the age of granites or metamorphics has evolved from Rb-Sr analyses of the samples available from the Cape York area. The samples of Flyspeck Granodiorite and the Kintore Adamellite and its associated rocks were collected from localities which appear to have been too widespread, and the data scatter is too large to establish a Rb-Sr isochron.

Initial data from the metamorphic rocks of Cape York are also ambiguous. A tentative estimate of 800 to 1000 m.y. is made for the metamorphism.

(iii) Antarctica Project: Six Rb-Sr analyses on rocks from Antarctica were completed and regressed with other data obtained in previous years. It seems likely that there was a widespread metamorphic event between 588 and 744 m.y. The other total rock data indicate two pre-metamorphic ages of 1380 m.y. and 1940 m.y., but more samples would have to be analysed to confirm these events.

(iv) T.P.N.G. Project: The regional geochronological project in the Highlands and Sepik districts of New Guinea is nearing completion. Eighty K-Ar dates from the Maramuni Diorite, Bismarck Granodiorite, Akuna Dolerite, Aifunka Volcanics, Samari Volcanics, Mount Victor Granodiorite, Elendora Porphyry, and Chambri Diorite were completed. Reconnaissance work on Bougainville resulted in 16 K-Ar dates. Samples submitted by B.P. (Aust.) from the Lambo Volcanics (Southern Highlands) were dated as Pleistocene (1.1 $\pm$ 0.04 m.y.), and mid-Miocene ages of 14 m.y. were determined on granite samples from New Britain submitted by R.P. Macnab. Thirteen Ar extractions from the Frieda Porphyry and Mount Michael intrusives have been completed.

Dating of the Tertiary f-stage volcanics by K-Ar is complete, and all the age results were duplicated. These results suggest that several important adjustments to the presently accepted Tertiary geological time scale will be necessary. This work, which includes a review of world-wide isotopic age correlations in the Tertiary, is at present being written up.

Rb-Sr work will assume an increasingly important role in the New Guinea work. One hundred and fifty rough Rb-Sr analyses (X.R.F.) were completed on samples from the Kubor and Bismarck Granodiorites, Omung Metamorphics, and Kana Volcanics to determine their suitability for Rb-Sr dating. Ten isotopic analyses were done, but no Rb-Sr ages are as yet available.

(v) Victorian Project: Two basalt flows in Victoria, which are stratigraphically controlled by Lower Miocene foraminiferal stages, were sampled and dated. This was done to check and gain further control on the new proposed Tertiary time scale derived from the New Guinea data. Mean ages of 21.1 $\pm$ 0.4 m.y. and 25.6 $\pm$ 0.5 m.y. for the Maude Basalt and Aireys Inlet Basalt, respectively, are in accord with the new time-scale.

BAAS-BECKING GEOBIOLOGICAL RESEARCH LABORATORY

BIOLOGICAL GROUP

P.A. Trudinger, B. Bubela, D.P. Kelly, H. Jones, Miss L.A. Chambers

The research programme of the biological group has continued along the lines described in previous reports. The principal objectives have been to examine

(1) the physiology of organisms of geochemical interest, particularly those involved in sulphur metabolism;

(2) metal transformations by microorganisms; and

(3) mineralization reactions brought about by microorganisms.

Ecology and Physiology of Sulphate-Reducing Bacteria. (H. Jones)

The sulphate-reducing bacteria are considered to be major biological agents contributing to the formation of sulphides in nature. Their occurrence in a number of localities, including hot sulphur-springs, saline waters, and possibly mineral forming environments, is being examined. A number of strains have been isolated and purified; these include organisms capable of growing at high temperatures and in highly saline environments. Three of these organisms appear to represent new species, and are being examined in more detail.

Sulphate Reduction by Desulphotomaculum nigrificans. (P.A. Trudinger)

One of the unique features of the sulphate-reducing bacteria is their ability to reduce large quantities of sulphate to hydrogen sulphide. The mechanism of this reaction, however, is poorly understood. Over the past year, a pigmented protein from Desulphotomaculum nigrificans has been isolated and extensively purified. This protein has been shown to catalyse the reduction of sulphate to sulphide, and its properties and chemical constitution are being examined.

Concentration of Elements. (P.A. Trudinger, H. Jones)

The ability of sulphate-reducing bacteria to concentrate metal ions from dilute solutions is being investigated. It has been demonstrated that Desulphotomaculum can concentrate iron, copper, and zinc from solutions containing less than 0.5 ppm of these metals, and that concentration factors of up to 20,000 can be obtained. Preliminary work suggests that the metals are concentrated in the form of metal sulphides which remain closely associated with the bacterial structure.

Comparative Biochemistry of Organic Sulphur Metabolism. (L.A. Chambers)

The enzymes concerned with the synthesis of the essential sulphur amino-acid cysteine are being examined in a number of classes of microorganisms. It is hoped that results will help in establishing an evolutionary sequence for the development of sulphur metabolism. A new route for the incorporation of sulphur into organic compounds has been discovered, and a preliminary survey of sulphide-oxidizing bacteria, sulphate-reducing bacteria, photosynthetic organisms, and normal heterotrophic organisms indicates that there are two major groups with respect to organic sulphur metabolism.

Pyrite Synthesis by Microorganisms. (P.A. Trudinger)

The nature of the iron sulphide precipitates formed in biological systems containing sulphate-reducing bacteria and ferrous iron has been examined. The precipitates are initially in the form of regular spheres of one to two microns diameter, which are amorphous and are attached to organic material probably arising from the lysis of the bacterial cells. When subjected to mild temperatures and pressures, the small spheres aggregate into tight structures of 5 to 10 microns in diameter which exhibit a distinct framboidal appearance, and which show signs of an internal laminated structure.

Fractionation of Stable Sulphur Isotopes by Sulphide-Oxidizing Bacteria. (D.P. Kelly, L.A. Chambers)

The fractionation of sulphur isotopes during the oxidation of sulphide and thiosulphate by species of Thiobacillus have been studied in collaboration with Dr. A. Rafter (D.S.I.R., N.Z.). During the growth of Thiobacillus on thiosulphate, there is a general enrichment of ^{32}S in sulphate, and other products, such as polythionates, become highly enriched in ^{34}S. It has also been confirmed that sulphide oxidation by photosynthetic sulphur bacteria results in enrichment of ^{34}S in sulphur and, as a consequence, enrichment of ^{32}S in the residual sulphide. The results indicate that the sulphur-oxidizing bacteria could play an important role in modifying the distribution of sulphur isotopes in nature.

Formation of Mineral Bands. (I.B. Lambert, B. Bubela)

The work on the role of diffusion processes in the genesis of conformable sulphide bands in sediments has been continued, using supporting media such as quartz, tuffs, shales, dolomites, and limestones from natural sources. The materials were layered in various sequences. Diffusion of copper, lead, and zinc through media containing layers of limestone or dolomite resulted in the formation of metal carbonate bands which could subsequently be converted to sulphides without disturbing their structures. It has also been shown that precipitation and banding of metal sulphides may occur during slow sedimentation of the supporting material.

Copper Toxicity and Resistance in Microorganisms. (B. Bubela)

When the thermophilic bacterium Bacillus stearothermophilus is grown in the presence of copper its morphology is changed, and it accumulates a material absorbing at 800 cm^{-1} in the infrared. The latter has been considerably purified and examined by infrared, nuclear magnetic resonance, and mass spectroscopy. It appears to consist largely of an esterified phthalic acid.

MINERALOGICAL GROUP

W.M.B. Roberts, C.J. Downes, J. Ferguson, I.B. Lambert

Experimental Investigations

Sulphide synthesis and transformation. (W.M.B. Roberts)

An essential requirement for the understanding of the genesis of sulphide ores is a knowledge of the chemical mechanisms involved in the formation of sulphide minerals. During sedimentation these reactions take place in an aqueous medium, so the investigations being carried out are primarily concerned with the chemistry of formation and transformation of sulphide minerals in aqueous solutions.

Following the synthesis of pyrite from synthetic hydrated iron oxides, an investigation of the detailed chemical mechanisms involved in pyrite formation was commenced. This showed that pyrite forms by combination of a ferrous ion with a disulphide ion. The principal requirement for the disulphide ion to form is the presence of elemental sulphur, at a pH below 6.0. Pyrite has been formed in two types of experimental environment, one completely anaerobic, and the other where a limited amount of oxygen is available. In both cases the same basic mechanism for pyrite formation is involved, except that in the first case the necessary sulphur to form the disulphide ion is obtained by oxidation of H_2S by ferric iron; this method gives a large and rapid yield of pyrite.

In the second case an ageing period is necessary; FeS is precipitated in an aqueous H_2S solution in equilibrium with the atmosphere. The small amount of atmospheric oxygen which diffuses down through the column of liquid to the FeS layer oxidises the H_2S to elemental sulphur which combines with some of the sulphide ions present from the dissociation of FeS to form disulphide ions. These are fixed finally as the very stable form FeS_2. Experimental work has established that at pH above 6 different forms of FeS will precipitate, but not pyrite. Two papers describing the formation of pyrite and the chemistry of its formation have been published during the year.

Investigation of the system Fe-S-O is continuing with the study of the effects of temperature and pressure on transformations of FeS in aqueous solution. Starting with synthetic tetragonal FeS, experiments to date show that when some oxygen is present it will convert to $FeS_2 + Fe_3O_4$ at temperatures above about 150°C. However, in the total absence of oxygen, this transformation does not take place, but the tetragonal FeS converts to a perfectly crystalline hexagonal variety. An investigation of the exact temperature of these transformations is being carried out.

Work so far indicates that the only effect of pressure on the transformation of FeS to FeS_2 and iron oxide is that at pressures above 6kb the iron oxide phase is hematite, not magnetite.

Precipitation from Aqueous Solutions. (C.J. Downes)

By virtue of its influence on the activity of the sulphide ion, pH is probably more important than salinity in controlling precipitation of sulphides. For example, the activity of the sulphide ion can be changed by several orders of magnitude within the likely range of pH of natural waters. At the present time, the measurement of pH in solutions of moderate to high salinity is poorly understood, and experiments are being carried out to establish sources of error in present methods of measurement. The co-existence of dolomite and sulphides is very common in nature, and as pH plays an important part in carbonate deposition, the formation of dolomite is being investigated in the expectation that determination of the conditions under which it may form could throw light on the conditions under which co-existing sulphides have formed. In addition, the properties of solutions of various salinities containing concentrations of base metals are being studied; this work may assist in defining the conditions for precipitation of base-metal sulphides.

Experimental Metamorphism. (I.B. Lambert)

The majority of stratiform ore deposits occur in rocks that have been metamorphosed to some extent. A detailed experimental investigation of metamorphic effects has been started to provide more information concerning (i) stabilities of sulphide minerals in different physical and chemical environments; (ii) changes in chemical composition of sulphide minerals as conditions vary; (iii) ore textures; and (iv) metamorphic redistribution of sulphides.

Apparatus which can accurately maintain the range of pressures and temperatures attainable in the Earth's crust is nearing completion. Investigations are to be carried out on both synthetic materials and naturally occurring, unmetamorphosed sulphide deposits. The effects of the following variables are to be studied: pressure, temperature, time, nature of host rock, composition and amount of intergranular fluid, and sulphur and oxygen fugacities.

Field Studies

Pernatty Lagoon. (I.B. Lambert, C.J. Downes)

The Pernatty Lagoon-Mount Gunson area is about 250 miles N.N.W. of Adelaide, in arid salt-lake country. Copper mineralization and subordinate zinc mineralization occur at several places within late (?)Proterozoic sandstones and dolomites at the north-western corner of the lagoon. The known mineralization is restricted to two distinct levels; the westerly deposits (which are fairly oxidized) which are about 70 feet above the lagoon surface, and deposits closer to and in the lagoon (mainly sulphides) which are near lagoon level. It seems likely that groundwaters are dissolving copper from the higher deposits, transporting it "downstream", and re-depositing it as sulphides under anaerobic conditions in the lagoon environment, and especially in permeable zones of bedrock lying immediately beneath the lagoonal sediments; some of the mineralization in bedrock is of economic grade.

A geochemical study of the area has been carried out to obtain more information on the regime. Samples of groundwater were collected, and their pH and Eh measured immediately. pH ranged from 5.4 to 7.3, and Eh from aerobic to mildly reducing. The waters from drill holes and mine shafts to the west of the lagoon are not very saline, but those from bulldozer cuts and drillholes in the dry lagoon floor contain around 20-25% NaCl; sulphate is roughly proportional to chloride. Ca, Mg, Si, and to a lesser extent K, are much more abundant in the lagoon waters than in normal sea water. Cu and Zn are high in the lagoon water, ranging from 0.1 ppm to over 4 ppm, and there is no apparent relationship with pH or salinity; in groundwaters west of the lagoon Cu and Zn range from less than 0.1 ppm to 0.2 ppm. Sediments from the lagoon consist mainly of halite, gypsum, quartz, clay minerals, and carbonates. The Cu contents of those analysed range from 100 ppm to 13,000 ppm, and the zinc contents from 80 ppm to 300 ppm (both well above crustal average). Fe, Mn, Ni, and Pb are variable in the sediments, and locally are fairly high.

Sulphate-reducing bacteria have been isolated by H. Jones, of the Biological Group, from all the mud and water samples collected; the majority were mesophiles rather than thermophiles. Many of the bacteria failed to grow during subsequent procedures for the purification of crude cultures. However, thirty pure strains have been obtained, many of which can grow in media containing sodium chloride concentrations up to at least 8 percent; some can not grow without sodium chloride. These findings are in accord with the hypothesis that groundwater is transporting Cu and Zn from the topographically high mineralization down to the lagoon, where it is being precipitated by bacterial sulphide.

Matupi Harbour. (I.B. Lambert, J. Ferguson)

Matupi volcano lies on the eastern edge of Matupi Harbour, near Rabaul, New Britain. This is a typical active orogenic (island arc) region where new continental crust is being formed by eruption of vast quantities of calc-alkaline lavas generated in the mantle. The calc-alkaline volcanic suite is characterized by high water contents which cause explosive eruptions and hence high porosity and permeability and easy erosion of the resultant deposits. Meteoric water and sea water which may readily percolate down through these rocks will be heated, and should be capable of extensively leaching them. The metal-enriched waters which could be formed in this way may precipitate sulphides within the volcanic pile, if sulphide ions are available (such a process could give rise to some types of porphyry copper deposits). Alternatively, the waters may flow into marine basins, enriching the pyroclastic material and sedimentary detritus therein in the elements they have transported; such is the case in the vicinity of thermal springs at Matupi Harbour.

Preliminary sampling has been carried out in the Matupi area. The purpose of these investigations is to define the Eh-pH conditions of the environment, and find the nature and abundances of metals being added to the harbour sediments from the hot springs. The pH of the hot springs ranges from 2.5 to 6, and Eh values indicate an oxidized environment. H_2S is being expelled from numerous steam vents, and is rapidly oxidized to sulphur on contact with the air. The pH of harbour waters is about 8.3 (normal sea water), except within a few feet of the hot spring sources. Iron oxide is being precipitated from the spring waters, and causes a brown colouration in adjacent harbour waters. Bottom sediments in the vicinity contain up to 9% Fe and 1300 ppm Zn; Cu and Pb contents are similar to those of the nearby subaerially deposited volcanic rocks.

There appears to be a general lack of organic matter on the harbour floor which could maintain bacterial activity. Electron probe analyses indicate significant amounts of S in the harbour sediments, and this could later react with metals under mild metamorphic conditions, and give rise to stratiform sulphide deposits.

MISCELLANEOUS

VOLCANO SURVEILLANCE, CRUSTAL STUDIES, AND GENERAL VULCANOLOGY -

G.A.M. Taylor

Activities during the year have been concerned chiefly with the mounting of a crustal study project in the New Britain area, liaison with A.N.U. in the development of the Rabaul telemetered network, field work connected with petrological studies, and special investigations.

Crustal Study Project

Assistance was given in the organisation and execution of a second crustal study carried out in the New Britain area from March to May. Its objects were to check the findings of the 1967 survey, and extend the investigation to include:

(1) marine sections east of New Ireland

(2) marine sections west of Cape Lambert.

(3) crustal models in the volcanic and mountain root areas of central New Britain and the margins of the New Britain trench.

(4) a detailed model of the Rabaul caldera.

With the assistance of participants from the Universities of Hawaii and of Queensland, and from the Australian National University, 41 recording sites were occupied, and some 50 shots were fired over an area of 45,000 square miles. Sparker, magnetic, and gravity traverses were made where practicable as a supplement to the seismic refraction work, and the results will be interpreted against a background of revised geological mapping which is a concomitant activity of sections of the Geological Branch.

Power House Investigation

Power house noise as a source of interference to seismic recording was investigated in the Rabaul area, and a report prepared for the Administration. Recording stations in the northern sectors of the caldera, near the power house, are subject to at least double the noise level recorded at the more distant sites. Attention was drawn to the effects on the surveillance network of continued expansion of the power house on its present site.

Serious consideration is being given by the Administration to removal of the power house to a new site outside the caldera.

Instruments for Volcano Surveillance

Work on the Rabaul telemetered seismic network has included:

(a) the installation of an inexpensive drift-free amplifier as an experimental replacement for the Texas Instrument's RA2 amplifier.

(b) the design and installation of a voltage-regulated power supply for the radio link at Vulcan.

(c) the experimental installation of a filter system (1-10 Hz).

Dr. K. Muirhead, of the A.N.U., visited Rabaul to assist with these investigations. Promising results have been achieved with the amplifier and regulator tests: the filter system is being abandoned because of a lack of improvement in the signal to noise ratio.

Tests on a modified version of the standard bubble-type tiltmeter are being carried out in Canberra.

Fieldwork

Routine field investigations were carried out at Rabaul, at Manam, and at Wau where anomalous noises are still being heard by residents on the Wau-Mt Kaindi road.

Rock and thermal water samples were collected from the volcanic islands east of New Ireland for laboratory examination. It is hoped that study of these samples will provide information on deep-seated structure.

National Mapping have undertaken to produce a contour map of the Doma Peaks volcano. Relevant control was carried out by the Department of Lands, Surveys and Mines at the request of the Chief Resident Geologist.

STRANGWAYS RANGE CARBONATITE, N.T. - P.W. Crohn, D.C. Gellatly

Work on the Strangways Range carbonatite, 60 miles north-north-east of Alice Springs, was continued during the year, and a Record on the petrology and geochemistry of a preliminary collection of specimens was completed.

Further examination of the outcrop has been carried out, and an area of about 120 square miles in the vicinity of the carbonatite has been mapped. No further occurrences of alkaline rocks or carbonatite were found, but stream sediment samples from this area will be examined for the presence of alkaline rock minerals. New discoveries within the area of the known carbonatite occurrences include vermiculite and large masses of ilmenite.

A re-examination of core from the existing Geopeko deep diamond drill hole at the Enterprise 3 carbonatite lens has shown that, in addition to the previously recognised rock types (mainly foliated micaceous carbonate rocks and crystalline carbonate rocks with minor apatite, magnetite, phlogopite, and soda-amphibole), the carbonatite complex at this locality includes a number of rocks which contain plagioclase as well as carbonates. Some of these rocks consist of oligoclase-andesine and green-brown amphibole, subordinate clinopyroxene and brown biotite, and minor carbonates; others are characterised by porphyroblastic soda-amphibole, subordinate biotite, an excess of carbonates over plagioclase, and the presence of minor apatite and iron oxides.

Minor phases recognised in the drill core include pegmatites, veins of coarsely crystalline carbonates, and a 12-inch band composed almost entirely of serpentinised olivine crystals and minor phlogopite. This suggests a possible relationship of the carbonatite complex to rocks from Johannsen's Phlogopite Mine, some 20 miles to the south-west, from which a small quantity of phlogopite has been won from a composite zone of basic and ultramafic rocks. Carbonate veins at this locality have been sampled for trace element determinations, and other rock types have been collected for petrological examination.

A further diamond drilling programme at the Strangways Range carbonatite locality is currently being undertaken by the Mines Branch, Northern Territory Administration. Initial holes are designed to provide a complete cross-section through the Enterprise 3 carbonatite lens on the line of the existing Geopeko deep diamond drill hole. At the time of writing (October), one hole had been completed at a depth of 454 feet, and the second was drilling ahead below 300 feet. Detailed petrological and geochemical work will be carried out on these cores.

TECTONIC MAP OF AUSTRALIA AND NEW GUINEA - K.A. Plumb, (H.F. Doutch, R.G. Warren)

Plumb is convenor of the Commonwealth Territories Divisional Sub-Committee of the Tectonic Map Committee of the Geological Society of Australia. The committee is preparing a new Tectonic Map of Australia and New Guinea for publication in 1970 (see Geological Services Section). The local sub-committee, as well as being responsible for the compilation of Northern Territory, Kimberleys, and New Guinea, is also co-ordinating the other State contributions, and compiling the map of the whole continent. Plumb has personally compiled Northern Territory and the Kimberleys. Plumb, Doutch, and Dr. M.J. Rickard (A.N.U.) have been responsible for developing the legend and basic concepts of the map. Plumb attended a meeting of the Tectonic Map Committee in Adelaide in August.

CONFERENCES, SYMPOSIA, ETC.

AIMM - A conference on the "Future of the Mineral Industry in Australia" was held in Canberra on 21st and 22nd November, 1968. P.W. Crohn, P.R. Dunn, and A.G.L. Paine were delegates to the conference. Several other members of the Section attended various sessions.

"Phase Transformations and the Earth's Interior" was the title of an international symposium held at the A.N.U. between 6th and 10th January. W.B. Dallwitz and C.D. Branch were official delegates to the symposium, but many other members of the Section attended individual sessions of specific interest to themselves.

The 22nd Congress of the International Union of Pure and Applied Chemistry was held in Sydney from 20th to 27th August. Miss H.R. Lord attended as a delegate.

ANZAAS - D.C. Gellatly and P.A. Trudinger presented papers at the ANZAAS meeting held in Adelaide during August.

Dr. Gellatly presented a paper on "Palaeocurrents and lithofacies of the Kimberley Basin and their relation to the genesis of the Yampi iron ores" to the symposium on Basin Studies. Dr. Trudinger's paper was entitled "The biological factor in sulphide ore genesis", and was given at the symposium on "Experimental approaches to the study of ore genesis".

Papers on the metallogenic map of Australia were given by I.R. McLeod and Miss R.G. Warren (see Geological Services Section).

OVERSEAS VISITS

P.R. Dunn

P.R. Dunn left Australia on May 17th to attend a meeting of the Subcommission on Precambrian Stratigraphy in Stockholm. En route he visited areas of late Precambrian sediments and glacials in Scotland, and attended a pre-sessional excursion through central and southern Sweden. After the meeting he attended another excursion through south-western Finland, visited Precambrian glacials near Oslo, Norway, and returned through the U.S.A., visiting the copper deposits of the Keeweenaw Peninsula, Michigan, on the way. He returned to Australia on June 21st.

Before going to Scotland Dunn visited the Institute of Geological Sciences, the Geological Society of London, the Imperial College, and Reading University, at each of which he discussed various aspects of the glacial rocks on the Isle of Islay and the Torridonian sediments in the western Highlands. He also discussed isotopic age determination work with R.R. Harding, of the Institute of Geological Sciences, and F. Fitch, of the Robertson Research Company.

The visit to the Precambrian glacials in Scotland (Portaskaig Boulder Beds) and in Norway (Moelv Tillite) showed that they were much more indurated and less convincing than those we have in Australia. The Scottish deposits contain dolomitic boulders and dolomite interbeds similar to most Australian examples. At the meeting in Stockholm it was learnt that there are great thicknesses of well preserved Precambrian tillites on the east coast of Greenland.

The meeting in Stockholm lasted three days, during which time problems in the subdivision of the Precambrian in various parts of the world were discussed. No firm agreement was reached on how subdivisions should be made, but it was generally agreed that standard type sections for possible world-wide correlation should be set up. With this in mind it was decided to seek the financial support of the International Geological Correlation Programme to investigate likely type sections, starting with a world-wide survey of the late Precambrian glacials.

The pre- and post-sessional excursions were designed to see as much as possible of the Precambrian section of Sweden and Finland as the short time available would permit. The emphasis was on sediments and volcanics and the different degrees of metamorphism they had undergone, but some examples of classic igneous rocks were also visited. Recent isotopic age determinations have greatly modified thinking on Scandanavian Precambrian stratigraphy, and a much clearer picture of the order of events is now emerging.

The highlight of the trip was a visit to the copper-bearing district of the Keeweenaw Peninsula in Michigan, U.S.A. It was not possible to visit any localities of economic interest during the previous part of the trip, but this part made up for it. The Keeweenaw Peninsula forms the eastern margin of a late Precambrian basin which contains a thick sequence of basic volcanics overlain by sandstone and siltstone. The classic occurrences of copper are the native copper deposits within the volcanics and interbedded conglomerates. Over 5,000,000 tons of copper have been extracted since 1845, at first from vein-type deposits, but mainly from flow tops and conglomerates. The ore deposits are concentrated in rocks with the greatest permeability, and in the conglomerate appear to be controlled by old stream channels.

The White Pine Mine, where mining commenced in 1953, has reserves of 400 million tons of .1% copper. The ore is in black siltstone in the form of chalcocite; native copper is also present in interbedded sandstone, but is of lesser importance. The black siltstone overlies sandstone which in turn overlies the volcanics which contain the native copper. Although regarded by many as a syngenetic copper deposit, current thought is that it was formed through replacement of syngenetic pyrite by chalcocite, the copper being derived from the underlying volcanics by movement of mineralized waters. The occurrence of copper mineralization in sediments <u>overlying</u> copper-bearing basic volcanics is not uncommon - e.g., Mt. Isa and limestone above Antrim Plateau Volcanics, N.T.

A.G.L. Paine

A.G.L. Paine visited the United States, Peru, Chile, England, and Ireland between March and May, 1969, in order to study the geology of large copper and molybdenum deposits in U.S.A. and South America which are associated with igneous intrusions - the "porphyry coppers"; to study the geology of the tin mineralization in Cornwall; and to study and report on the geology of the base-metal mines in Ireland.

Paine arrived in San Francisco on 15th March. After talks with geologists of the United States Geological Survey and Professor Meyer at the University of California (Berkeley), he visited the copper mines at Yerington, Morenci, Ajo, Chino, Twin Buttes, and Bingham Canyon. These are all porphyry copper deposits which are mined by open-pit operations involving removal of between 25,000 (Yerington and Chino) and 100,000 (Bingham Canyon) tons of ore per day. The Yerington deposit differs from the others in that it is much older - 140 m.y. as against 65-70 m.y. - and in that the intrusion and orebody have been tilted through 60 degrees, making it a good subject for the study of the mineralization and hydrothermal alteration associated with a porphyry copper body. The Twin Buttes ore-body was discovered below 500 feet of alluvium; 200 million tons of alluvium had to be removed before mining of the orebody commenced.

After inspecting Bingham Canyon Paine visited the Climax and Urad molybdenum mines near Denver, and the U.S.G.S. offices in Denver. The Climax and Urad mines contain 400 million tons of 0.39% MoS_2 and 13 million tons of 0.42% MoS_2, respectively. A new orebody, Henderson, which is 3,000 feet below the Urad mine, contains 300 million tons of 0.49% MoS_2. The orebodies are associated with high-level acid intrusives of Oligocene age.

From U.S.A. to South America: after a brief visit to the Geological Survey of Peru in Lima, the Toquepala mine and Quellaveco and Cuajone deposits in Peru were visited, and the Chuquicamata, Exotica, and El Salvador mines in Chile. Although the geology of the South American porphyry copper deposits is fundamentally the same as that of the North American ones, the grade of ore is considerably higher - 1.2 to 1.8% Cu, as against about 0.7%. The localization of the Peruvian deposits is controlled by large breccia pipes. The Chuquicamata deposit is probably the world's largest single copper orebody; because of its arid environment many unusual species of soluble copper minerals have been preserved there. Two miles downslope from the Chuquicamata pit secondary copper mineralization occurs in cemented gravels; an orebody of several hundred millions of tons of 1.35% Cu has been proved, and has been named Exotica. The El Salvador is the only underground mine operation visited in South America; block-caving techniques are used.

After leaving South America Paine visited the geochemical laboratories of the Institute of Geological Sciences in London and all the active tin mines in Cornwall. The tin-mining industry in Cornwall is undergoing a revival, and current plans should increase production from 1800 tons to 5000 tons annually. Two existing mines, Geevor and South Crofty, are being expanded, and The Janes is being reopened. A new shaft in what is potentially a fourth mine has been sunk in relatively virgin country at Pendarves. The mines are all on lodes close to or within granites. A fascinating feature of the mineralization is the large difference in age between the tin lodes and the granites, as established by isotopic dating. Although the tin is obviously geologically related to the granite, most of the lodes were formed 70 million years after the granites were intruded.

The last phase of the overseas trip was a visit to the Geological Survey of Ireland and the three operating base metal mines in Ireland. The three mines, Tynagh (Pb-Zn-Cu-Ag), Gortdrum (Cu-Ag-Hg), and Mogul (Zn-Pb-Ag), lie on a north-trending line 40 miles long. Tynagh and Gortdrum are open-pit operations; Mogul is the largest underground lead-zinc mine in Western Europe with a throughput of 3000 tons of ore per day. Each of the three orebodies is in Carboniferous limestone adjacent to an east-trending fault which has downthrown the limestone to the north against Devonian sandstone and Silurian shale. The discovery of the three orebodies was a triumph for systematic geological, geochemical, and geophysical surveys. All the orebodies were concealed by glacial drift although mining had taken place at Silvermines, near Mogul, from time to time since the early 17th century.

Paine returned to Canberra on 27th May. He has collected representative suites of rocks and minerals from many of the mines, and intends to write a comprehensive illustrated Record summarizing the geology of the mines, and making comparisons with certain Australian geological situations.

H.L. Davies

H.L. Davies has held a Public Service Scholarship at Stanford University (U.S.A.) since September, 1968. He is completing the requirements for a PhD degree by writing a thesis on the Papuan Ultramafic Belt. Most of the year has been spent compiling information obtained in the field, and in studying the petrology of the rocks of the Belt. Writing of the thesis should be finished by the end of November.

In the course of compiling data from his field work Davies has produced three reports for the Record series, and has also written a comprehensive Record on his trip through Europe in 1968.

Davies attended the A.G.U. conference in Washington during April, and visited the Stillwater Igneous Complex in August-September. He is expected to return to Australia at the end of December.

TRAINING OF UNITED NATIONS AND COLOMBO PLAN FELLOWS

United Nations Fellow A. Annamalai, of India, completed his six months' training in Australia in December, 1968. From mid-October he spent most of his time in the chemical laboratory analysing samples collected in the Rum Jungle area by atomic absorption spectrophotometer, and learning something about the use of the direct-reading optical spectrograph and the X-ray fluorescence spectrograph. The remainder of his time was spent at the C.S.I.R.O. and A.M.D.L.

Colombo Plan Fellow J. Staim, of Sabah, arrived in Australia in February for a year's training in various aspects of geological and geochemical work and related laboratory operations. A large part of his work was carried out within the Metalliferous Section, and comprised visits to the Darwin Uranium Group and the Cloncurry Party, and instruction in various techniques in the petrological and chemical laboratories.

APPENDIX H. 1

PUBLICATIONS

Number		BULLETINS	
82	WALPOLE, B.P., DUNN, P.R., RANDAL, M.A., CROHN, P.W.	The geology of the Katherine-Darwin Region, Northern Territory.	Published
84	de KEYSER, F., LUCAS, K.G.	The geology of the Hodgkinson Basin, Queensland	In press.
106	DOW, D.B., GEMUTS, I.[2]	Precambrian geology of the Kimberley Region: East Kimberley.	Published
107	GEMUTS, I.[2]	Metamorphism and igneous activity in the Lamboo Complex, East Kimberley area, Western Australia.	In press.
	ROBERTS, H.G., PLUMB, K.A., DUNN, P.R.	Geology of the Carpentaria Proterozoic Province, N.T.: Arnhem Land.	Returned to authors for amendments.
	BLAKE, D.H.	Geology and mineral resources of the Herberton-Mount Garnet area, Herberton Tinfield, North Queensland.	With editor.
	DOW, D.B., SMIT, J.A.J., BAIN, J.H.C., RYBURN, R.J.	Geology of the South Sepik Region T.P.N.G.	With editor.
	DUNN, P.R., ROBERTS, H.G., SMITH, J.W., PLUMB, K.A.	Geology of the Carpentaria Proterozoic Province, N.T.: Roper River to the Queensland border.	In preparation
	BOFINGER, V.M.	Geochronology of the East Kimberley region, W.A.	With editors.
	WILLMOTT, W.F., PALFREYMAN, W.D., WHITAKER, W.G.[1]	Metamorphic and igneous rocks of the Cape York Peninsula and Torres Strait Islands.	In preparation.
	ENGLAND, R.N.	Kyanite - pyrophyllite - quartz assemblage from the Petermann Ranges, N.T.	Short papers to be issued in one Bulletin (in preparation)
	GLIKSON, A.Y.	Petrology and geochemistry of Archaean ophiolites near Kalgoorlie, W.A.	
	PLUMB, K.A., BROWN, M.C.	Revised correlations and stratigraphic nomenclature in the Proterozoic McArthur Group, N.T.	
	CROHN, P.W., WALKER, K.R.	Geochemical prospecting and research in the B.M.R., 1969.	
	RYBURN, R.J.	Glaucophane schists and eclogites from New Guinea.	
	SMITH, I.E.	Differentation in a suite of shoshonitic rocks from Eastern Papua.	

1. Geological Survey of Queensland
2. Geological Survey of Western Australia
3. Geological Survey of New South Wales
4. C.S.I.R.O. (Base Seeking Group)
5. A.N.U.
6. Elsewhere

Many authors have left the B.M.R. since their work was carried out; only those authors employed outside the B.M.R. at the time the work was done are indicated.

REPORTS

Number			
45	WHITE, D.A., SHIELDS, J.W., IVANAC, J.F.	The Union Reefs Goldfield, Northern Territory	Published
105	YATES, K.R., de FERRANTI, R.A.	The geology and mineral resources of the Port Moresby-Kimp Welch area, Papua	Published
114	DUNNET, D., HARDING, R.R.	Geology of the Mount Woodcock 1-mile Sheet area, Northern Territory	In press
117	HARDING, R.R.	Catalogue of isotopic age determinations on Australian rocks, 1962-65	Published
118	TRAIL, D.S., McLEOD, I.R., COOK, P.J., WALLIS, G.R.[3]	Geological investigations by the Australian National Antarctic Research Expedition, 1965	Published
126	PAINE, A.G., HARDING, R.R. CLARKE, D.E.[1]	The geology of the north-eastern part of the Hughenden 1:250,000 Sheet area, Queensland	With editor
127	WYATT, D.H.,[1] PAINE, A.G.L.,[1] HARDING, R.R., CLARKE, D.E.[1]	The geology of the Townsville 1:250,000 Sheet area, Queensland	In press
128	PAINE, A.G.L.,[1] GREGORY, C.M., CLARKE, D.E.[1]	The geology of the Ayr 1:250,000 Sheet area, Queensland	In press
135	TRAIL, D.S.	ANARE 1961 Geological traverses on the Mac-Robertson Land and Kemp Land coast	In press
137	WYATT, D.H.,[1] PAINE, A.G.L., CLARKE, D.E.,[1] GREGORY, C.M., HARDING, R.R.	The geology of the Charters Towers 1:250,000 Sheet area, Queensland	Ready for press
140	DOW, D.B.	Palaeozoic rocks of the Hardman, Rosewood, and Argle Basins, East Kimberley Region, Western Australia.	With editor
	CLARKE, D.E.,[1] PAINE, A.G.L., JENSEN, A.R.	The geology of the Prosperpine 1:250,000 Sheet area, Queensland	With editor
	PAINE, A.G.L., CLARKE, D.E.,[1] GREGORY, C.M.	The geology of the northern half of the Bowen 1:250,000 Sheet area, Queensland	In preparation
	CLARKE, D.E.[1]	Geology of the Ravenswood 1-mile Sheet area, Queensland	Writing complete

ROBERTS, H.G.[2], GEMUTS, I.[2], HALLIGAN, R.[2]	Adelaidean and Cambrian stratigraphy of the Mount Ramsay 1:250,000 Sheet area, Western Australia	With editor
PAGE, R.W.	Catalogue of isotopic age determinations carried out on Australian rocks in 1966	Ready for editor
PLUMB, K.A.	Petrography of the igneous and metamorphic basement rocks of Arnhem Land	In preparation
MIEZITIS, Y.	Compilation of geological and chemical information from the Hundred of Goyder, Rum Jungle district, N.T.	In preparation
PRICHARD, C.E., Geophysicist	Exploration of the Woodcutters area, near Rum Jungle, N.T. 1964-67	In preparation
SMITH , S.E., WALKER, K.R.	Primary element dispersions associated with mineralization at Mount Isa, Queensland	Being edited in Section
BENNETT, R. (Miss)	Catalogue of isotopic age determinations on Australian rocks in 1967-68	Being edited in Section
PONTIFEX, I.R., MORGAN, C.M., SWEET, I.P.	The geology of the Auvergne 1:250,000 Sheet area, N.T.	Writing complete
MORGAN, C.M., SWEET, I.P., MENDUM, J.R.	The geology of the northern part of the Victoria River Basin, N.T.	In preparation
MEDVECKY, A.	Permian sediments around Beaver Lake, Antarctica	In preparation
BAIN, J.H.C., McLEOD, I.R.	Geology of the eastern side of Prydz Bay, Antarctica	In preparation
MACNAB, R.P.	The geology of the Gazelle Peninsula, New Britain	In preparation

OUTSIDE PUBLICATIONS

AMOS, B.J.	The structure of the Palaeozoic sediments of the Mossman and Cooktown areas, North Queensland	J.Geol. Soc. Aust. 15(2) 195-208
BLAKE, D.H.	Post-Miocene volcanoes of Bougainville, Territory of Papua and New Guinea	Bulletin volcanologique, 32, 121-138
BRANCH, C.D.	Phanerozoic volcanic history of northern Queensland	Geol. Soc. Aust. Sp. Publ. 2, 177-182
CROHN, P.W., GELLATLY, D.C.	Probable carbonatites in the Strangways Range area, central Australia	Aust. J. Sci. 39(9), 335-336
DOW, D.B.	Post-Palaeozoic volcanism in New Guinea	Geol. Soc. Aust. Sp. Publ. 2, 203
DUNN, P.R., BROWN, M.C.	North Australian plateau volcanics	Geol. Soc. Aust. Sp. Publ., 2, 117-122
McDOUGALL, I.[5], WEBB, A.W.	Isotopic dating of Cainozoic volcanics of eastern Australia	Geol. Soc. Aust. Sp. Publ., 2, 203-204
PAINE, A.G.L.	Palaeovulcanology of central eastern Queensland	Geol. Soc. Aust. Sp. Publ., 2, 183-192
TAYLOR, G.A.M.	Post-Miocene volcanoes in Papua-New Guinea	Geol. Soc. Aust. Sp. Publ. 2, 205-208
TAYLOR, S.R.,[5] CAPP, A.C.,[5] GRAHAM, A.L.,[5] BLAKE, D.H.	Trace element abundances in andesites II - Saipan, Bougainville and Fiji.	Contr. Mineral Petrol, 23, 1-26
WALKER, K.R.	The Palisades Sill, New Jersey - a re-investigation	Geol. Soc. Am. Sp. Pap. 111
WALKER, K.R.	A mineralogical, petrological and geochemical investigation of the Palisades Sill, New Jersey	Geol. Soc. Am. Mem. 115 (Poldervaart Volume)
WEBB, A.W.	Isotopic age determinations in Queensland and their relation to the geochronological time-scale for the Permian.	Geol. Soc. Aust. Sp. Publ. 2, 113-116
WEBB, A.W.	Metallogenetic epochs in Eastern Queensland	Proc. Aust. Inst. Min. Metall. 230, 29-38.
WEBB, A.W., McDOUGALL, I.[5]	Geochronology of the igneous rocks of eastern Queensland	J. geol. Soc. Aust. 15(2), 313-346
WHITAKER, W.G.,[1] WILLMOTT, W.F.	The nomenclature of the igneous and metamorphic rocks of Cape York Peninsula, Queensland. Part 2 - The Coen-Iron Range area.	Qld Govt Min. Jour.., 70, 130-142
BUBELA, B.,[4] McDONALD, J.A.[4]	Formation of banded sulphides: metal ion separation and precipitation by inorganic and microbial sulphide sources	Nature, 221, 465-466

KELLY, D.P.,[4] CHAMBERS, L.A.,[4] TRUDINGER, P.A.[4]	Cyanolysis and colorimetric estimation of trithionate in mixture with thiosulphate and tetrathionate	Anal. Chem., 41,898-901
KELLY, D.P.[4]	Biochemistry of oxidation of inorganic sulphur compounds by microorganisms	Aust. J. Sci., 31(5), 165-173
ROBERTS, W.M.B.	The formation of pyrite from hydrated iron oxide in aqueous solution at 200°C	Mineralium Deposita, 3, 314-317
ROBERTS, W.M.B., WALKER, A.L.,[6] BUCHANAN, A.S.[6]	The chemistry of pyrite formation in aqueous solution and its relation to the depositional environment	Mineralium Deposita, 4, 18-29
ROY, A.B.,[5] TRUDINGER, P.A.,[4]	The biochemistry of inorganic compounds of sulphur	Monograph, Cambridge University Press, 1969
TRUDINGER, P.A.[4]	Assimilatory and dissimilatory metabolism of inorganic sulphur compounds by microorganisms	Adv. Microbiol. Physiol., 3, 111-158
TRUDINGER, P.A.[4]	Thiol reagents in Data for Biochemical Research, ed. by Dawson, R.M.C. Elliott, D.C., Elliott, W.H., and Jones, M.	O.U.P., 1969
GELLATLY, D.C.	Cross-bedded tidal megaripples from King Sound, Western Australia	Sedimentary Geol. (in press)
GELLATLY, D.C., DERRICK, G.M., PLUMB, K.A.	Proterozoic palaeocurrent directions in the Kimberley region, northwestern Australia	Geol. Mag. (in press)
GLIKSON, A.Y.	Geosynclinal evolution and geochemical affinities of early Precambrian systems	Tectonophysics (submitted)
JAKES, P.,[5] SMITH, I.E.	High potassium calc-alkaline rocks from Cape Nelson, Eastern Papua	In preparation
JOYCE, A.S.	Chemical variation in a pelitic hornfels	Chemical Geol. (submitted)
MILSOM, J., DAVIES, H.L.	Geology and gravity of Eastern Papua-progress results	Being edited
PAGE, R.W., McDOUGALL, I.[5]	Tertiary time-scale problems - K-Ar dating evidence from New Guinea	In preparation
TRAIL, D.S., McLEOD, I.R.	Enderby Land and Lambert Glacier	Am. geog. Soc. Folio Atlas Antarctica Sheets 11 and 12 (in prep.)
WHITAKER, W.G.,[1] WILLMOTT, W.F.	The nomenclature of the igneous rocks of Torres Strait	Qld Govt Min. Jour. (in press)
BUBELA, B.[4]	The chemical and morphological changes in Bacillus stearothermophilus induced by copper	In preparation

DOWNES, C.J.[4]	Activity coefficients of hydrochloric acid in brines	In preparation
FERGUSON, J., LAMBERT, I.B.[4]	A geochemical study of a sedimentary exhalative environment, and its relation to ore deposition	In preparation
KELLY, D.P.[4]	Regulation of the chemoautotrophic metabolism. I. Phenylalanine toxicity to thiobacilli	In preparation
KELLY, D.P.[4]	Regulation of the chemoautotrophic metabolism II. Competition between amino acids for incorporation into Thiobacillus neapolitanus	In preparation
KELLY, D.P.[4]	Regulation of the chemoautotrophic metabolism III DAHP synthetase in Thiobacillus neapolitanus, a putatively allosteric enzyme subject to competitive inhibition by phenylalanine	In preparation
LAMBERT, I.B.,[4] BUBELA, B.[4]	On the genesis of conformable metal sulphide bands in sediments	In preparation
LAMBERT, I.B.[4] DOWNES, C.J.[4] JONES, H.A.	Precipitation of copper from ground waters at Pernatty Lagoon, S. Aust.	In preparation
McDONALD, J.A.[4]	Some effects of deformation on sulphide-rich bands in lead-zinc ore-bodies, Mount Isa, Queensland	Econ. Geol. (in press)
TRUDINGER, P.A.[4]	On the absorbancy of reduced methyl viologen	Anal. Biochem. (submitted)
TRUDINGER, P.A.[4]	A carbon monoxide binding pigment with sulphite reductase activity from Desulfotomaculum nigrificans	In preparation

RECORDS

ISSUED

1965/118	The igneous petrology of the Cooktown 1:250,000 Sheet area, north Queensland	W.R. MORGAN
1966/179	The geology of New Ireland	D.J. FRENCH
1968/66	Eastern Papua reconnaissance geology	H.L. DAVIES, I.E. SMITH, G. CIFALI, D.J. BELFORD
1968/80	The geology of the South Sepik region	D.B. DOW, J.A.J. SMIT, J.H.C. BAIN, R.J. RYBURN
1968/101	Resident geological section, Tennant Creek, minor investigations: Bishops Creek area; Three Keys Goldmine; Skipper Extended Goldmine; Comet Reserve; Hopeful Star Extended; and Cu prospect 21m S.W. of Banka Banka Homestead	B.A. TAPP, A. TAUBE
1968/102	Summary of B.M.R. exploration - Rum Jungle, 1968	P.W. CROHN, C.E. PRICHARD, J.E.F. GARDENER
1968/121	Annual Summary of Activities, Geological Branch, 1968	
1968/124	Cross-bedded tidal megaripples from King Sound, Western Australia	D.C. GELLATLY
1968/126	The older Precambrian geology of the Lennard River 1:250,000 Sheet area, SE 51-8, Western Australia	D.C. GELLATLY, J. SOFOULIS,[2] G.M. DERRICK, C.M. MORGAN
1968/133	Geochemical orientation survey, Wau, New Guinea	R.G. HORNE
1968/141	Proterozoic palaeocurrent directions in the Kimberley region, Western Australia	D.C. GELLATLY, G.M. DERRICK, K.A. PLUMB
1968/144	The Pillara Range Precambrian inlier, Noonkanbah Sheet area, Western Australia	J. SOFOULIS,[2] D.C. GELLATLY
1968/145	Miscellaneous chemical investigations carried out in the Geological Laboratory, January-December, 1968	H. LORD, P. REW
1969/9	Reconnaissance in the Mary Kathleen - Cloncurry area, July-August, 1968	G.M. DERRICK

1969/10	Programme for the New Britain CrustalStudy	G.A.M. TAYLOR, W.A. WIEBENGA, A.S. RENWICK
1969/12	Notes on the volcanoes Mount Bagana and Mount Victory, T.P.N.G.	I.E. SMITH
1969/17	B.M.R. rotary percussion drilling, Rum Jungle district, N.T., 1967/68 (Woodcutters, Area 44 Extended, Waterhouse No 2 Prospect and Rum Jungle Creek South)	A. TAUBE
1969/18	Geochemical study on part of the Manton Grid, Rum Jungle area, N.T.	A. ANNAMALAI
1969/25	Compilation of part of the Embayment area, Rum Jungle district	Y. MIEZITIS
1969/35	Geochemical and radiometric investigations, Manton area, N.T., 1968	J.L. WILLIS
1969/36	Geochemical and radiometric investigations, Rum Jungle East, N.T. (Coomalie Creek and Huandot areas)	J.L. WILLIS
1969/46	Normanby Island, T.P.N.G. - reconnaissance petrography	H.L. DAVIES
1969/47	Ultramafics and ophiolites; record of a visit to the Alps, Cyprus, France, and England	H.L. DAVIES
1969/64	The igneous and metamorphic rocks of the Coen and Cape Weymouth 1:250,000 Sheet areas, Cape York Peninsula, Queensland	D.S.TRAIL, W.F. WILLMOTT, W.D. PALFREYMAN, R.F. SPARK, W.G. WHITAKER[1]
1969/67	Notes on the Papuan Ultramafic Belt mineral prospects, T.P.N.G.	H.L. DAVIES
1969/77	Probable carbonatites in the Strangways Range area, Alice Springs 1:250,000 Sheet area, SF53/14: petrography and geochemistry	D.C. GELLATLY
1969/93	The geology of the Louisiade Archipelago, T.P.N.G., excluding Misima Island	I.E. SMITH, P.E. PIETERS
1969/97	Notes on the geology of Medusa Banks 1:250,000 geological sheet, SD52-10	K.A. PLUMB, W.J. PERRY

IN PREPARATION

1968/117	The geology of the Auvergne 1:250,000 Sheet area (Victoria River Basin), N.T.	I.R. PONTIFEX C.M.MORGAN I.P.SWEET
1969/37	B.M.R. diamond drilling results, Rum Jungle East, N.T., 1966-1968 (Woodcutters L1, L2, L3 and L6 anomalies)	C.E. PRICHARD
1969/90	Minor metalliferous investigations, Northern Territory Resident Geological Section: Katherine - Darwin area	

1969/91	Minor metalliferous investigations, Northern Territory Resident Geological Section: Iron ore	
1969/92	Minor metalliferous investigations, Northern Territory Resident Geological Section: Central Australia	
1969/115	Notes on the thermal fields at Talasea, Pangalu, and Kasolol!, New Britian, T.P.N.G.	R.F. HEMING, I.E. SMITH
1969/117	Geology of the Ravenswood 1-mile Sheet area, Queensland	D.E.CLARKE[1]
1969/119	The igneous rocks of Torres Strait, Queensland and Papua	W.F. WILLMOTT, W.D. PALFREYMAN, D.S. TRAIL, W.G. WHITAKER[1]
1969/123	Annual Summary of Activities, Geological Branch, 1968	
1969/133	The geology of the Charnley 1:250,000 Sheet area, Western Australia	G.M. DERRICK, D.C. GELLATLY, J. SOFOULIS[2], R. HALLIGAN[2]
	The Precambrian geology of the Oscar Range inlier, Lennard River Sheet area, Western Australia	D.C. GELLATLY, G.M. DERRICK
	Chromiferous ultrabasic rocks near Eastman's Bore, Mount Ramsay 1:250,000 Sheet area, Western Australia	D.C. GELLATLY J. SOFOULIS[2]
	A note on textures and genesis of the Narlarla lead-zinc ores, Kimberley a region, Western Australia	D.C. GELLATLY
	The geology of the southern part of the Victoria River Basin, N.T.	C.M. MORGAN, I.P. SWEET, J.R. MENDUM, R.J. BULTITUDE
	Stratigraphy and sedimentology of the Barneys Creek Formation, McArthur River, N.T.	M.C. BROWN
	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, D.E. CLARKE[1]
	The geology of the area around the Strangways Range carbonatite, Alice Springs 1:250,000 Sheet area, SF 53/14	D.C. GELLATLY
	Geology of the Kubor Range, New Guinea	J.H.C. BAIN, R.J. RYBURN, D.E. MacKENZIE
	Geology of Eastern Papua, including the offshore islands	I.E. SMITH, H.L. DAVIES, P.E. PIETERS, P.D. HOHNEN
	Geology of New Britain, T.P.N.G.	R.J. RYBURN R.W. JOHNSON, R.P. MACNAB, D.E. MACKENZIE

GAPS AND EXPLANATORY NOTES

(1969 progress indicated by underlining)

1:250,000 Sheet area	Map: Field Work	Map: Prelim. Edit.	Map: Coloured Edit.	Explanatory Notes: Authors	Explanatory Notes: Record	Explanatory Notes: Publication
Gordon Downs	1962	1963	Issued	Smith, J.W., Geouts, L.[2]	1963/120	Issued
Dixon Range	1962/63	1964	Issued	Doe, D.B., Geouts, L.[2]	1964/56	Issued
Lissadell	1963	1964	Issued	Dunnet, D., Plumb, K.A.	1964/70	Issued
Cambridge Gulf	1963	1966	Ready for printer	Plumb, K.A., Veevers, J.J.	1965/174	Ready for press
Lansdowne	1964	1965	Printed	Gellatly, D.C., Derrick; G.M.	1965/210	Returned to printer
Mount Ramsay	1964	1966	Issued	Roberts, H.G.,[2] Halligan, R.A., Playford, P.E.[2]	1965/156	Issued
Mount Elizabeth	1965	1967	Dye proof returned	Roberts, H.G., Perry, W.J.	1966/136	Printed
Ashton	1965	1967	Dye proof returned	Derrick, G.M.	1966/81	Printed
Drysdale-Londonderry	1965	1966	Dye proof returned	Gellatly, D.C., Sofoulis, J.[2]	1966/55	Printed
Medusa Banks	1965	1969	Being fair drawn	Plumb, K.A., Perry, W.J.	1969/97	With editor

Montague Sound	1965	1967	Corrections in progress	Allen, A.D.[2]	1966/201	Being edited by author
Prince Regent-Camden Sound	1965	1967	Ready for printer	Williams, I.[2]	1967/38	With editor
Charnley	1965/67	1969	Being prepared for fair drawing	Gellatly, D.C., Halligan, R.A.[2]	1969/133	With editor
Lennard River	1965/67	1969		Derrick, G.M., Playford, P.E.[2]	1968/126	
Yampi	1966/67	Being compiled		Sofoulis, J.,[2] Gellatly, D.C.	Being written	
Townsville	1960-63	1966	Issued	Wyatt, D.H.[1]	1965/159	Issued
Hughenden	1963	1964		Paine, A.G.L., Vine, R.R.	1965/93	
Charters Towers	1963-64	1966	Ready for printer	Clarke, D.E.[1]	1967/104	With editor
Ayr	1964	1966	Issued	Gregory, C.M.	1966/68	Issued
Bowen	1961 and 1964/65	1967		Paine, A.G.L.	Being written	
Proserpine	1962 and 1965	1968	Being corrected	Paine, A.G.L.	1968/22	Being compiled
Coen (part)	1967	1969				Not planned at this stage
Cape Weymouth (part)	1967	1969		Trail, D.S., et al.	1969/64	

Torres Strait (part)	1968	With printer	Willmott, W.F., Palfreyman, W.D. Trail, D.S. Whitaker, W.G.[1]	1969/119
Daru-Maer Island	1968	Being corrected		1969/119
Auvergne, N.T.	1967	Ready for printer	Pontifex, I.R., Morgan, C.M., Sweet, I.P.	1968/117
Port Keats	1967-68	Compilation complete		
Fergusson River (2nd Ed.)	1957, 1968	Being compiled	Morgan, C.M. Sweet, I.P. Mendum J.R.	Being compiled
Cape Scott	1968	Being compiled		
Delamere	1966, 1968	Being compiled		
Victoria River Downs	1966, 1969			
Wave Hill	1966, 1969			
Waterloo	1969			
Limbunya	1969			
Wabag, N.G. (part)	1963, 1966	1969		
Ramu, N.G.	1956,1962 1967,1968	Being compiled		
Karamui, N.G.	1968	Being compiled		

Wau, N.G.	to 1968	Being compiled	Smit, J.A.J.	Being edited
Tufi	1968, 1969			
Abau	1968, 1969			
Samarai	1968, 1969			
Rossel	1969			
Fergusson Island	1961, 1968, 1969			
Gazelle Peninsula	1968	Being compiled		
Pomio	1969			
Talasea	1969			
Gasmata	1969			
Arawe	1969			
Cape Raoult	1969			

OTHER MAPS

1 inch to 1 mile

Herberton Mount Garnet	Being fair drawn
Ravenswood	Preliminary Edition with printer

1:100,000 Scale

Yampi Leopold Downs	Being compiled to illustrate Bulletin
Marraba Cloncurry	Fieldwork completed 1969

1:500,000 Scale

South Sepik area	With drawing office
Cape York area	Compilation well advanced
West Kimberley Eastern Papua Louisiade Archipelago Papuan Ultramafic Belt Burdekin River Region	Compilation started
Kimberley Basin Victoria River New Britain Central Highlands	Programmed

GEOLOGICAL SERVICES SECTION

Contents

GEOLOGICAL SERVICES SECTION

The Geological Services Section was constituted in the reorganization of November 1968. It includes the Engineering Geology and Phosphate groups, the Resident Geologists Sections, Computer Application, Mineral Reports (including Museum), Map Editing and Compilation, Editing, and Geological Drawing Office.

Of these the Northern Territory Resident Geologists' Section is to be transferred early in 1970 to Department of the Interior, and the editing and computer functions and the drawing office are likely to be transferred to the Operations Branch shortly.

The professional staff of the Section over the year has been:

Geologist in charge:		K.A. Townley
Engineering Group:	Geologist Class 4 :	Dr E.K. Carter
	Geologists Class 3 :	G.M. Burton
		D.E. Gardner
	Geologists Class 1 :	R. Thieme
		M.J. Jackson
		G.A. Henderson
		A. Saltet (from 18.7.69)
		D.C. Purcell (from 4.8.69)
Phosphate Group:	Geologist Class 4 :	Dr H.A. Jones
	Geologists Class 3:	F. de Keyser
		D.S. Trail
	Geologist Class 2 :	Dr P.J. Cook
	Geologists Class 1:	R. Geyshes
		D. Jongsma
		F. Walraven (resigned March 1969)
Resident Geologists, P.N.G.	Geologist Class 4 :	A. Renwick
	Geologists Class 3:	I.S. Cumming
		G. d'Addario
	Geologists Class 2:	P.R. MacNab (to Mar.1969)
		J.C. Braybrooke (to 5.12.69)
		J.A.J. Smit (to April)
		D.J. Grainger (from April)
		D. Palfreyman (from 17.11.69)
	Geologists Class 1:	P.D. Hohnen
		R.F. Heming (to Oct.1969)
		P..E. Pieters
		R.F. Tingey
		Dr R.A. Davies (from 17.11.69)
	Geophysicist Class 1:	I.M. Mancini

Resident Geologists, N.T.	Geologist A/Cl.4 :	Dr R.G. Dodson
	Geologists Cl. 2 :	M.R. Daly (A/g)
		I.G. Faulks (resigned July)
		O. Fruzetti(A/g)
		J.W. Shields (resigned July)
	Geologists Cl. 1 :	J. Watts
		D.J. Grainger (to April)
		A.T. Laws (resigned August)
		B.A. Tapp (resigned early in 1969)
Mineral Reports:	Geologist Class 3 :	I.R. McLeod (to 2.5.1969)
	Geologists Class 1:	Miss E. Rosenberg
		Mrs P.E. Thieme
		Mrs L. Walraven (to March)
		Miss P. Simpson (to May)
		T. Nicholas (Museum Curator)
Map Editing and Compilation	Geologist Class 3 :	Dr G.E. Wilford
	Geologist Class 2 :	Miss R.G. Warren
	Geologist Class 1 :	Miss R.L. Cameron
Editing	Geologist Class 4 :	I.R. McLeod (A/g from 2.5.69)
	Geologist Class 2 :	Dr R.R.E. Jacobson
Computer Applications	Geologist Class 3 :	T. Quinlan.

ENGINEERING GEOLOGY AND HYDROLOGY

The new structuring of the Section under the reorganization proposals, under which map editing, map compilation and indexing were transferred to a separate group, became effective about the beginning of 1969 and the Engineering Geology Group was organized into two field parties, designated A.C.T. Engineering Geology No.1 Party, under D.E. Gardner and A.C.T. Engineering Geology No.2 Party, under G.M. Burton. E.K. Carter supervised the group, and also privided technical supervision of major engineering geology projects in Papua-New Guinea and worked with the Australian Atomic Energy Commission in connection with possible Plowshare experiments.

In November all Canberra positions, except the Technical Officer Grade 1 position, are occupied, but Class 1 geologists are temporarily replacing the two Geologist Class 2 positions.

Although there is a shortage of experienced staff, all services required have been provided, including an inspection of the Nancar damsite, Daly River, N.T., and the initiation of the detailed design investigation for the No.1 power station and appurtenant structures for the Upper Ramu hydro-electric scheme, P.N.G.

Close co-operation has again been achieved between the Engineering Geophysics and Engineering Geology groups in the investigation of A.C.T. engineering projects, including those at Jervis Bay. Closer consultation between the two groups has further developed in the present year.

PROGRAMME FULFILMENT (See Figs. GS1 & 2)

The work performed during the year by the group differs considerably from that programmed for, but the departures are, for the most part, due to changes in requirements of clients. For example, although extensive investigation was done on the North Molonglo outfall sewer tunnel, the National Capital Development Commission is now reviewing Canberra's comprehensive long-term requirements for sewerage services and has asked the Bureau to examine (in varying detail) five alternative arrangements of the city's sewerage system before completing the work on the North Molonglo outfall sewer tunnel.

To the end of October no request had been received for work on the Belconnen Lake damsite or the East Lake bridge and other structures (see 1969 programme); road works, building site investigations, and urban development work were done as required, but a number of reports are still outstanding. Some but not all of the outstanding reports should be complete by the end of the year.

Early in the year it had been hoped to begin a systematic, multi-discipline, study of Lake George and its environs as the lake had continued to recede. Some geological mapping was done and the study of the lake hydrology was intensified but it proved impossible to implement the larger programme because of lack of resources.

With the agreement between the U.S. and Australian Governments to examine the feasibility of creating a harbour at Cape Keraudren, W.A., by nuclear explosives, provision was made in the final 1969 programme for a substantial effort by the Bureau. The need for substantial work ceased when the project was abandoned, but the Supervising Geologist, with assistance from other Sections and Branches, spent a considerable amount of time on Plowshare studies.

An effort in excess of programme expectations was made to several projects, e.g. assessment of Jervis Bay resources, including groundwater (which was added to by the decision of the Government to examine the feasibility of building a nuclear power station at Jervis Bay), investigation of sewerage works for Canberra (see above), and the current servicing from Canberra of the Upper Ramu hydro-electric scheme design investigation in P.N.G.

RESUME OF ACTIVITIES NOVEMBER-DECEMBER, 1968.

A study of the geology and resources of the Commonwealth Territory, Jervis Bay (See Fig GS1), was started in November. The initial geological mapping was completed by the end of the year and several piezometers to observe groundwater levels were installed.

The final draft of the Corin Dam (Fig GS2, locality 1) completion report was finished. Investigations of the origin of the leak from Corin Dam and the character of the emerging waters were continued.

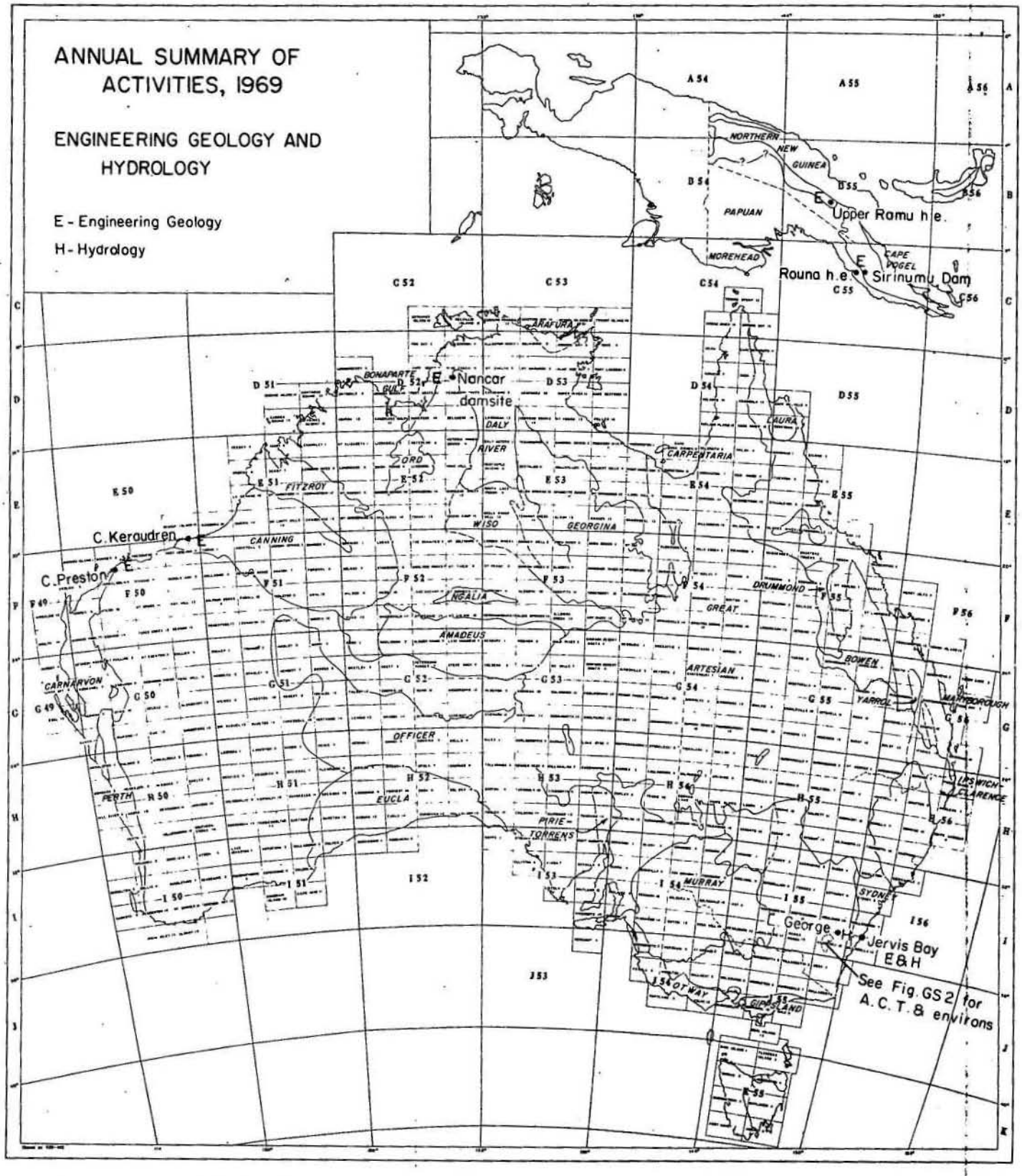
Development area mapping and report-writing covered parts of Belconnen, Woden, and Weston Creek districts (Fig. GS2). Vacation students began mapping an area between Belconnen and Weston Creek to provide continuity in geological knowledge between the two areas. Some trenches in the Yarralumla area were mapped.

A report on the engineering geology of the Central (Parliamentary) area of Canberra was completed and a compilation of geological information on other parts of the Capital Hill and adjoining areas was started (Fig. GS2, locations 2 & 3).

Enquiries about construction materials were answered.

Routine groundwater observations were maintained; one bore was sited and advice given to several landholders. Close observations were maintained on the level and salinity of Lake George (Fig. GS1); a public warning was issued about the danger to stock arising from the high salt content of the lake.

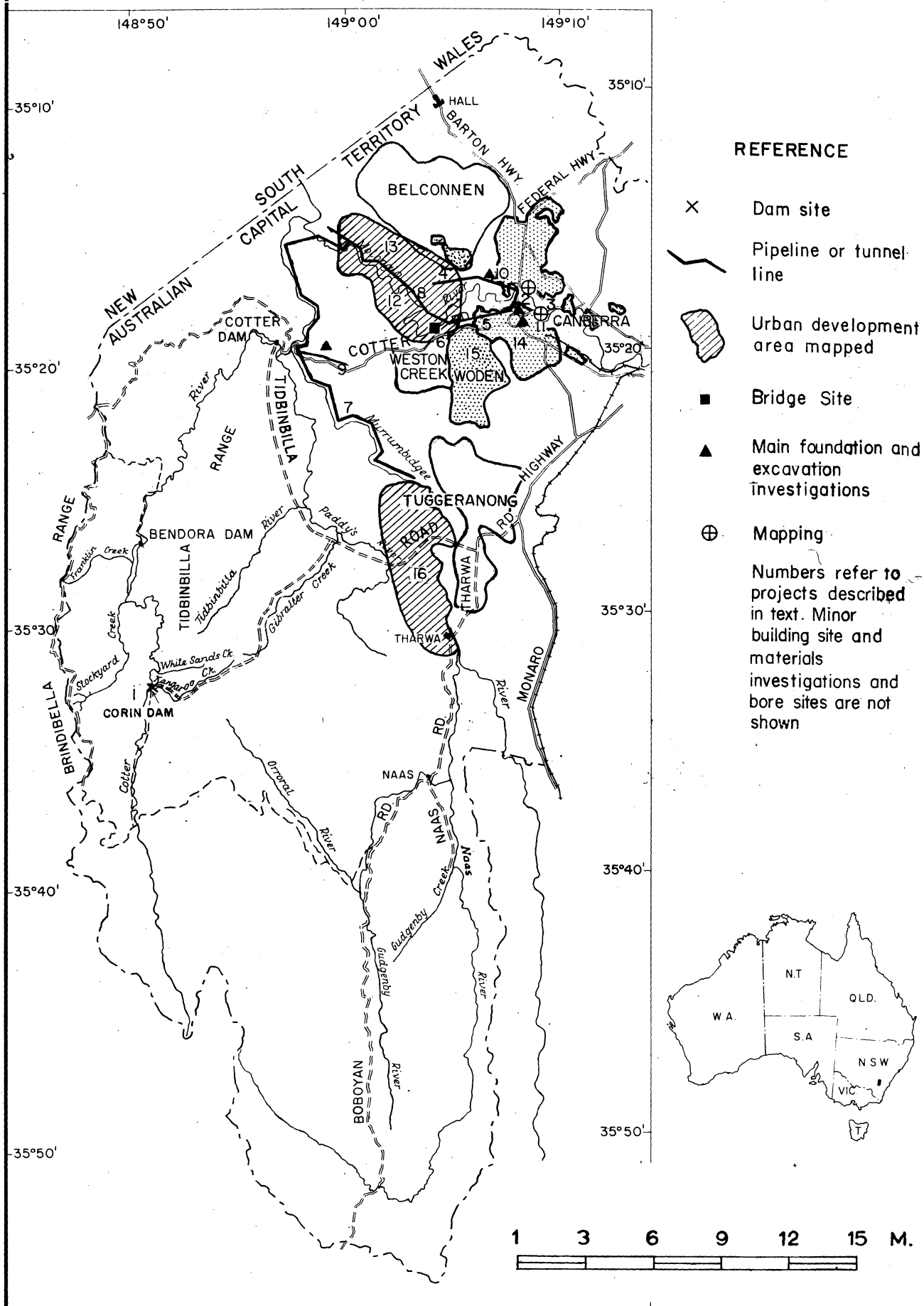
Fig. GS 1



To accompany Record 1969/123

AUS 2/120

A.C.T. ENGINEERING GEOLOGY INVESTIGATIONS, 1969



REFERENCE

- Dam site
- Pipeline or tunnel line
- Urban development area mapped
- Bridge Site
- Main foundation and excavation investigations
- Mapping

Numbers refer to projects described in text. Minor building site and materials investigations and bore sites are not shown

155/A16/604 J.W.C.

Bureau of Mineral Resources, Geology and Geophysics. March, 1964.

To accompany Record 1969/123

During the two months the map editing group completed the final edit of six, and the preliminary edit of two, 1:250,000 map sheets, and edited the reference for the morpho-lithological map of Australia being produced by Land Research Division of C.S.I.R.O. for A.W.R.C.

Further work was done of Sheet 15 of the geological map of Australia and Oceania and on the metallogenic and tectonic maps of Australia.

The indexing group maintained the stratigraphic index and technical files. Some progress was made with Fascicule 5H - Australia, General - of the International Stratigraphic Lexicon.

ACTIVITIES DURING 1969

The Supervising Geologist's main activities during the year, other than normal supervising and administrative duties, may be summarised as follows:

1. Plowshare. He was a member of the Cape Keraudren (later renamed Plowshare) Interdepartmental Committee and of the technical committee subsequently set up. In this capacity he was engaged on the collection and study of geological and geophysical data relating to Cape Keraudren, Cape Preston (See Fig. GS1), and a number of other possible sites for nuclear excavation experiments examined by the Committee. He was a joint author of a 'scoping' report on Cape Preston, prepared by the Australian Atomic Energy Commission. On 15 October he gave a lecture on mining and engineering applications of Plowshare to senior students and staff of the Department of Mining, University of Melbourne.

2. Papua-New Guinea hydro-electric schemes (See Fig. GS1). One visit was made to P.N.G. during the year and another is planned for November 1969. Advice was given to C.D.W. engineers in the preparation of aspects of the tender documents for Sirinumu Dam (Stage 2), on the Laloki River, Papua, and the detailed design investigation for the Upper Ramu hydro-electric scheme was planned and initiated. An alternative site for the Rouna No.3 hydro-electric power station was inspected. Three reports were written for the Record series, two of them jointly with Port Moresby resident geologists (see list of Records). A collection of all available information on the Upper Ramu scheme is in progress.

3. A.C.T. engineering projects. Particular attention was paid to the detailed investigation of the North Molonglo outfall sewer tunnel (Fig. GS2, locality 4), the leak from Corin Dam (see elsewhere), and the issue of E.J. Best's Corin Dam completion report.

4. Advice was given to the Director on various matters, e.g. the need for seismic instrumentation and geodetic levelling to record the crustal response to the filling of the proposed Dartmouth Reservoir, on the Mitta Mitta River, Victoria.

No work was done during the year on the Standards Association of Australia's "Code of Practice for Site Investigation" but the draft code has now been issued for public comment.

A.C.T. ENGINEERING GEOLOGY, NO.1 PARTY

The work undertaken included preliminary and detailed investigations of proposed construction projects such as tunnels for sewers, investigation of routes of pipelines (water and sewer mains) to ascertain the depth to which trenching can be done without blasting, site investigations and site inspections, mapping in areas of proposed and current urban development, and minor investigations of materials for construction purposes. No work was done by the party outside the A.C.T.

Construction Projects

North Molonglo Outfall Sewer (G.A.M. Henderson - Fig. GS2, locality 4)

A proposed scheme for an outfall sewer for the northern suburbs of Canberra involves driving a tunnel 4½ miles long. The tunnel would pass along the northern side of Lake Burley Griffin, below Black Mountain from Commonwealth Avenue to near Coppins Crossing. A proposal was drawn up for detailed investigation of the route by geological mapping, seismic refraction surveys, augering, and diamond drilling, following a preliminary investigation in 1967. The work was completed and a report was written, which is being processed as a Record.

South Molonglo Outfall Sewer (D.E. Gardner - Fig. GS2, locality 5)

An alternative proposal has been made to route the Canberra northern suburbs outfall sewer parallel to and west of Commonwealth Avenue, as far as Forster Crescent, and thence parallel to the existing sewer. The geology of the route in relation to trenching and tunnelling conditions was discussed with Works Department engineers.

Molonglo River Bridge (D.C. Purcell, R. Thieme - Fig. GS2, locality 6)

A seismic refraction survey was carried out at the site of a bridge where the Tuggeranong Freeway will cross the Molonglo River, a short distance downstream from Scrivener Dam. A geological report was started during October.

Corin Dam (R.L. Craven)

Groundwater levels in boreholes designed to give information on the effect of Corin Dam on the local groundwater regime were recorded periodically until May, when the task was taken over by No.2 Party (which see for further details).

Thickness of Soil

(including highly weathered bedrock)

Investigations are carried out along the routes of proposed roads, and proposed trenches for pipelines, to ascertain the depth to which excavations can be taken without the need for blasting.

Murrumbidgee Valley Outfall Sewer (D.E. Gardner - Fig. GS2, locality 7)

A traverse was made along a possible route for an outfall sewer from Tuggeranong Creek, along the right bank of the Murrumbidgee River, to the Molonglo River.

Molonglo Valley Outfall Sewer (D.C. Purcell, G.A.M. Henderson, D.E. Gardner - Fig. GS2, locality 8)

A proposed route for an outfall sewer starts at a locality on the southern side of the Molonglo River, a short distance downstream from Scrivener Dam; it crosses to the northern side of the river and follows the valley nearly to the junction with the Murrumbidgee. The scheme would involve a number of short tunnels. A reconnaissance traverse was made along the route. Sites were selected for seismic refraction traverses to be carried out by party members; by the end of October four of the traverses had been finished. Recommendations were also made to the Commonwealth Department of Works for more extensive seismic work by contract.

Murrumbidgee-Stromlo Gravity Main Extension (D.C. Purcell - Fig. GS2, locality 9)

A gravity main from Bendora Dam is to be extended from the Murrumbidgee River to Mount Stromlo Reservoir. Seismic refraction traverses were conducted at selected sites by B.M.R. engineering geophysicists. A report relating the results of the seismic surveys to the engineering geology of the sites was completed.

Barry Drive, O'Connor (D.C. Purcell, R. Thieme - Fig. GS2, locality 10)

Barry Drive is a proposed expressway along the eastern side of Black Mountain, linking Boldrewood Street, Turner, with Belconnen Way. A geophysical survey was carried out at localities where cuttings would be needed. A geological report was written, relating seismic results to geology.

Site Investigations

The site investigations are intended to provide information, to assist in foundation design, on the depth to bedrock, the nature and strength of the bedrock, and any unfavourable features such as faults.

Sections 16 and 22, Barton (D.C. Purcell - Fig. GS2, locality 11)

A seismic refraction survey was conducted by the engineering geophysicists, and the results were interpreted on the basis of the engineering geology of the site. A geological report was started in October.

Secretariat Building Site (G.A.M. Henderson - Within locality 2, Fig. GS2)

Data obtained during construction, on rock conditions, was analysed.

Urban Development

Geological mapping was carried out in areas that were about to be developed for urban purposes. The information was supplemented, after development had started, by inspection and mapping of trenches. Excavations were mapped in some of the older developed areas. Standard map sheets (A.C.T. Detail Series, 1 inch:200 feet) of the Survey Section, Department of the Interior, are used as base maps.

Belconnen (G.A.M. Henderson)

Geological mapping was completed in the area covered by three standard map sheets (G3C, G6B and H6A) and additional mapping was done for four other sheets (G4B, H3C, H3D, J4A). The results of trench mapping necessitated slight alterations to the geology of four sheets (G4A, G4B, G4C, G4D). A record was completed on an area that covers sheets G4C, G4D, G5A, G5B, G5C and G5D in the western part of Belconnen.

A Record was started on an area in the east that covers sheets H4B, J4A, H4D, J4C, H5B and J5A.

Between Belconnen and Woden-Weston Creek (R. Thieme, students - Fig. GS2, locality 12)

Geological mapping was completed on seven map sheets (H7A, H7B, H7C, H7D, G7B, G7C, G7D) and started on two others (G6A and G7A). Compilation and drafting was finished on sheets H7B, H7C and H7D and is in progress on sheets G7A and H7A.

South-West of Belconnen (D.C. Purcell - Fig. GS2, locality 13)

Geological mapping is in progress on map sheets F5D and F6B; compilation and drafting has been started.

Woden and Weston Creek (R. Thieme)

A small amount of trench mapping was carried out in the suburb of Phillip (Woden Town Centre) and in the area of map sheet H8D, Weston Creek.

Canberra City (D.E. Gardner)

Geological information that has been gathered in numerous investigations over a number of years was presented in a Record on the Central Area of Canberra. A summary record was prepared on a wider area, 'the Extended Central Area', and a more detailed record started.

Site Inspections

(D.E. Gardner, R. Thieme)

Several construction sites (mainly building sites) were inspected, in some cases to record the geological information that was, temporarily, exposed to view, and in others to advise the contractors or others on the classification, for excavation purposes, of the material excavated, stability of excavation, and suitability of rock for foundations. Seven sites were inspected in Canberra City and in the areas that are being developed.

Materials Resources

(D.E. Gardner)

Information was made available on resources of sand, aggregate, and building stone; deposits were briefly inspected.

Materials Testing

(R. Thieme, D.E. Gardner)

The services of Australian Mineral Development Laboratories were utilized in routine testing of materials such as building stone. Minor laboratory work carried out by party members included simple soil testing, such as size grading.

A.C.T. ENGINEERING GEOLOGY NO.2 PARTY

Activities

Groundwater (G.M. Burton, J. Saltet, and M.J. Jackson)

The autumn and winter of 1969 provided suitable rains for groundwater recharge; groundwater storage has now returned to the average experienced before the drought of 1965-68. The recovery stages required regular close observation, and considerable effort was devoted to this. Two additional observation bores were sited, drilled and logged in the Cullarin Horst, east of Canberra; they provided a useful increase in data during the winter recharge.

The piezometer net established at Jervis Bay (Fig. GS1) was serviced and provided the first records of recharge. Most readings were taken for the Bureau by a resident officer of the Department of the Interior.

Sixteen farm supply bores were sited but only two of them were drilled, probably because of the improvement in surface supplies after the drought. It is noticeable, however, that siting is occurring well ahead of drilling now. This is desirable because the location of bores is needed early in the water planning for the modern, efficiently-run, farm.

G.M. Burton participated in a symposium on "Drought in the A.C.T." conducted by the Hydrological Society. The contribution was distributed as a Bureau Record (1969/73).

The Senate Select Committee on Water Pollution took evidence in the A.C.T. in May from officers of the Department of National Development. Burton prepared a submission on groundwater (issued as a Bureau Record 1969/74) and gave evidence before the Committee at its sitting.

A.C.T. Groundwater drainage (G.M. Burton, M.J. Jackson, J. Saltet)

The end of the drought brought a resurgence of several of the major groundwater problems in the Manuka-Red Hill area (Fig. GS2, locality 14) and the Woden valley (locality 15). Jackson and Saltet reported on several of them and commenced a general survey of the Flinders Way catchment to observe the degree to which recent development has affected the area through artificial summer recharge arising from lawn watering. Data were provided to the Department of Works for an investigation into the infiltration of groundwater into the city's sewerage system and consequent overloading.

Lake George (G.M. Burton, J. Saltet - Fig. GS1)

Studies at Lake George were incresed to observe the sharp decline in the level of the lake. The lake fell to a minimum level of 4.1 feet in February, the lowest level since the field party took over observations in January, 1958. A supplementary gauging station was established at Kenny's Point to increase the accuracy of readings at very low stages. Chemical and hydrological data were analysed; they revealed deposition from solution of large quantities of salt during the 1965-68 drought and provided data on the major elements of the water balance. An average January loss of water due to evaporation was revealed for the last twelve years of approximately 5,000 million gallons. A small aluminium boat has been obtained and equipped to permit more detailed sampling and measurements of the lake. Shore features were photographed vertically in 70 mm colour film from BMR aircraft VH-BMR while the lake level was low and oblique photographs were taken of the scarp at the Lake George Fault. The oblique photographs revealed features not readily observable in the vertical photos and will provide a basis for further field mapping of geomorphological features. R. Hill, assisted by two students, mapped part of the southwest margin of the lake (Record, in manuscript, "The geology of the Geary's Gap-Sutton-Gundaroo Area") as part of the Bureau's plan to remap the geology of the margin of the lake.

Australian Water Resources Council and Miscellaneous (G.M. Burton)

There was a noticeable increase in the general demand for both ground and surface water data by farmers, developers, landholders, graduate, undergraduate and secondary school students as well as from the various committees of the A.W.R.C. The demand ran at the rate of about one major and one or two minor enquiries per week. A significant feature of the enquiries was the approach of major drillers, screen manufacturers, instrument makers, groundwater consultants, and desalination firms to acquaint themselves better with groundwater resources data and field workers. This signifies a welcome and overdue improvement in the technology associated with groundwater. Two radio interviews were given and several news releases made to press and radio dealing with local hydrology, including that of Lake George.

Burton attended meetings and performed duties in connection with A.W.R.C. sub-committees on the Groundwater Maps of Australia, Extraction of Water from Unconsolidated Sediments, Forward Assessment of Water Resources, and Management of Representative Basins. He also attended a two-day symposium on groundwater resources, held at the University of New South Wales.

Engineering Geology, Jervis Bay (M.J. Jackson - Fig. GS1.)

Jackson completed the detailed engineering geological survey of Jervis Bay and prepared the report (issued October, as Record 1969/88). Considerable information and assistance was provided for the N.S.W. Electricity Commission and Australian Atomic Energy Commission to aid the search for a suitable atomic power station site within the territory. Two stratigraphic bores were sited and the drilling supervised; a completion report was prepared by Jackson (Being edited and to be issued as a Record, "Stratigraphic bores B.M.R.Ulladulla 1 and 2, and consequent implications on engineering geology, Jervis Bay, A.C.T."). Investigations of leakage from Lake Windermere are continuing.

A.C.T. Urban Geology: (M.J. Jackson).

The urban geological survey of the proposed Tuggeranong development area west of the Murrumbidgee River (Fig. GS2, locality 16) was completed. All plans were drawn and the report is being written (to be issued as a Record January, 1970).

Upper Ramu Hydro-Electric Scheme, P.N.G. (E.K. Carter, M.J. Jackson -Fig.GS1).

M.J. Jackson started the detailed design investigation for the No.1 power station in mid-October, under the supervision of E.K. Carter. He is expected to continue the work until mid-February, when it is hopes that staff will be available from the Port Moresby Resident Staff. Design investigation will continue through most of 1970 and will conssist of drill core logging, including relogging of existing core, and detailed geological mapping, including some re-mapping. Tenders are expected to be called for the construction of the power station and allied structures at the end of 1970 and construction should start about mid-1971.

Leakage from Corin Dam (E.K. Carter, G.M. Burton- Fig.GS2, locality 1).

G.M. Burton participated in the investigation of acid and other waters emerging downstream from, and into the outlet tunnel of, Corin Dam. The study has involved chemists and geologists of the Bureau (see report by A.D. Haldane), engineers of the Commonwealth Department of Works, and others. The acid appears to be forming mainly by bacteria-stimulated oxidation of pyrite in the rockfill of the dam. Groundwater observations have been maintained by A. Schuett and F. Simonis, and chemical studies are continuing.

Materials (G.M. Burton).

Enquiries were answered regarding possible sources of brock shale and clay, and marble for sculpturing, in or near the A.C.T. Two detailed enquiries about Australian coal resources were also answered.

Nancar Damsite, Daly River, N.T. (G.M. Burton- Fig.GS.1).

A five-day inspection was made of the site and environs for the Water Resources Section, N.T.A. The abutments are formed by folded and faulted Upper Proterozoic sandstone; extensive limestone occurs in the storage area. A report is being prepared.

General (G.M. Burton).

A member of the New Zealand Geological Survey and an officer of the United Kingdom Institute of Geological Sciences visited the group during study tours. Assistance was given to the Department of External Affairs in planning a training visit for an Indian U.N. groundwater fellow.

The question of establishing the palaeoseismicity of Australia from geological evidence was discussed with H.A. Doyle of the Australian National University. The possibility of establishing bench marks in the Collector and Lake George area is also being investigated.

Burton prepared sections of his report on his study visit to the U.S.A. and delivered a staff lecture on the visit.

A record is being prepared to assist the preparation and editing of engineering and hydrological Records of the group ('Brief guide to the checking and editing of engineering geology manuscripts for B.M.R. Record Series').

During the year the conversion of all hydrological and chemical records of the party to A.D.P. form was completed. Programmes are now complete and flexible enough to permit the processing of all data into critical factors and to permit the automatic plotting of all data.

Technical Assistants

The work performed by technical staff in the party includes field surveying and measurements, modification, installation and maintenance of all hydrological records on A.D.P. cards, manipulation of routine Fortran programmes and some simple intitial programming; also liaison with officers of the Department of Works, Bureau of Meteorology and C.S.I.R.O. to maintain and exchange full hydrological records.

RECORDS OF INVESTIGATION

Eighteen Records were processed, in whole or part, in the period 1/11/1968 to 31/10/69; in addition, three Records processed last year were issued, and two Records prepared by the Photogeology Group for the Engineering Geology Sub-section were checked. Fifteen Records are awaiting edit and four have been partly processed. Of the reports awaiting edit three deal with P.N.G. village water supply surveys; it has been decided not to issue reports of this type as Bureau Records in future as the Resident Office Note on Investigation adequately records the survey observations and recommendations.

The following Records produced within the sub-section were issued, or allotted numbers, during the last twelve months. Records numbered 1968/108, 1968/110, and 1968/111 were allotted numbers before 1st November 1968, but not issued until after that date. Ten other reports written by members of the Sub-section are either awaiting edit or are being processed.

Rec. No.	Author	Title
1968/108	H.F. Doutch	The Ninth International Congress of Soil Science, Adelaide, August, 1968.
1968/110	G.A.M.Henderson	Preliminary geological report on proposed North Molonglo outfall sewer, A.C.T. 1967.
1968/111	E.J. Best and G.A.M. Henderson	Geology and foundation conditions at the Secretariat building site, Canberra.
1968/139	G.M. Burton	Preliminary groundwater reading list and key references
1969/11	D.E. Gardner	Geology of the central area of Canberra, A.C.T. (with a section on groundwater by G.M. Burton).
1969/28	D.E. Gardner	Inspection of white clay deposit, Jervis Bay, A.C.T. 1968.
1969/38	D.E. Gardner	Summary note on the geology of the central and Capital Hill areas of Canberra.
1969/41	G.A.M. Henderson	Geology of the Camp Hill area, Parkes, A.C.T.
1969/45	G.A.M. Henderson	Geological investigations of proposed C.S.I.R.O. site, Campbell, A.C.T., 1968.
1969/73	G.M. Burton	Drought and groundwater in the A.C.T.
1969/74	G.M. Burton	The pollution of groundwater. (A submission prepared for the Senate Select Committee on Water Pollution, April, 1969).
*1969/76	I.S.Cumming and E.K. Carter	Appraisal of the geology of the Musa River hydro-electric scheme, Papua, 1969.
1969/88	M.J. Jackson	Engineering geology and economic resources of the Commonwealth Territory, Jervis Bay.
ø*1969/105	J.C. Braybrooke and E.K. Carter	Upper Ramu hydro-electric scheme; possible leakage from No.1 reservoir.
ø1969/111	E.J. Best	Geological report on the site investigation and construction of Corin Dam, Cotter River A.C.T.
ø1969/127	E.K. Carter	Upper Ramu hydro-electricity scheme: geology of possible dam sites near the proposed intake area for No.1 power station.

* Senior author is a member of the Port Moresby Resident Geological staff.
ø Record number allotted but Record not issued by 31st October, 1969.

MAP EDITING AND COMPILATION

Editing

Twenty seven First Edition maps and their accompanying Explanatory Notes were edited during the year (23 at 1:250,000; 2 at 1:500,000; and 2 at 1 mile to 1 inch).

Geological Map of Australia and Oceania, 1:5,000,000 (Miss B.K. Graham).

The compilations and colour guides for Sheets 9 and 13 were checked. These are being published by the New Zealand Geological Survey. Sheet 1 showing the title and general reference will now be compiled.

International Geological Atlas: Sheet 15 - Australia and Oceania 1:10,000,000 (Miss B.K. Graham).

Fair drawing was well advanced by the end of the year. Only the Tasmania and Officer Basin areas need adding to complete the map.

Groundwater maps of Australia 1:5,000,000 (G.M. Burton, G.E. Wilford).

A start was made with the preparation of the first of four groundwater maps of Australia. The series is being compiled by officers of States and Commonwealth water authorities under the direction of the Technical Committee on Underground water of A.W.R.C., convener, G.M.Burton.

Tectonic map of Australia 1:5,000,000 (H.F. Doutch, K.A. Plumb, Miss R.G. Warren, M.J. Rickard (A.N.U.)

The new Tectonic Map of Australia and New Guinea, at 1:5,000,000 scale, which the Geological Society of Australia is to publish, is nearing completion; publication is hoped for during 1970. The Commonwealth Territories Divisional Sub-Committee of the Tectonic Map Committee (listed above) is responsible for compilation of the Northern Territory, Kimberleys, Papua - New Guinea, and most of Queensland, but is also responsible for coordinating all the other State Sub-Committees, drafts and compiling the final map of the whole continent. They have been mainly responsible for determining the basic concepts of the map and designing the legend and colour scheme. Close liaison is being maintained with the compilers of the Metallogenic Map of Australia.

During the year the preliminary draft of the final map was compiled from the various state drafts; a hand-coloured copy of this draft was exhibited at A.N.Z.A.A.S. at Adelaide in August, 1969. The map is now undergoing final checking and corrections before fair-drawing. Explanatory notes will be produced later.

Metallogenic map of Australia and Papua - New Guinea 1:5,000,000.
(I.R. McLeod, Miss R.G.Warren).

The map is being compiled and will be published on behalf of the Subcommission for the Metallogenic Map of the World of the Commission for the Geological Map of the World.

The first, hand-coloured, draft of the map has been completed; a draft legend, which is partly diagrammatic, has been drawn up, and notes on the principles used in compiling the map prepared - these notes will be included in the explanatory commentary on the map. State Geological Surveys, several companies, and interested individuals have been asked for comments on the map and notes.

The draft map was displayed at the ANZAAS congress in Adelaide, and Miss Warren and I.R. McLeod each presented papers on topics related to the map.

Close co-operation and interchange of ideas with the Tectonic Map Committee of the Geological Society of Australia continued; the tectonofacies base of the metallogenic map is adapted from the draft Tectonic Map of Australia.

Geology of Northern Territory 1:2,500,000. (G.E. Wilford).

A start was made reducing data from 1:250,000 sheets, preparing a base map and drafting a legend.

Geology and Minerals Map, Burdekin, Queensland, 1:1,000,000.
(A.G.L. Paine, Miss R.L. Cameron)

A start was made reducing data from 1:250,000 sheets and preparing a legend. The map will be published by the Geographic Section of the Water, Power and Geography Branch, Natdev.

CONFERENCES

I.R. McLeod and R.G. Warren attended the ANZAAS Conference in Adelaide, August 17-22.

G.E. Wilford attended the Annual Conference of the A.I.M.M. in Sydney, 10-15 August.

PHOSPHATE SEARCH SUB-SECTION

MARINE GEOLOGY

Two marine geological surveys in the Arafura Sea have been undertaken during 1969; the first took place during May, when the Japanese vessels Yamato and the submersible Yomiuri were used, and the second started in September from Newcastle in the chartered vessel San Pedro Sound.

The approximate boundaries of the area being examined are shown in Figure GS3.

The Yamato cruise

The Yomiuri submersible and its mother ship, the motor vessel Yamato, were used for a number of geological and biological investigations in Queensland waters during the 4 months preceding the B.M.R.'s expedition in May. These vessels are owned and operated by the Japanese Yomiuri newspaper organization and the participation of Australian marine scientists in the various research projects was arranged and funded by the B.M.R. The Bureau's own operation in the Arafura Sea took place between the 2nd and 25th May in the western part of the area outlined in Figure 1. During the first part of the cruise the 3-man B.M.R. party carried out bottom sampling and shallow seismic profiling from the mother ship Yamato. Although the vessel was not well suited for this type of work, 63 bottom sample stations were occupied and about 500 miles of sparker traverses run. North of the belt of quartz sand fringing Bathurst and Melville Islands a zone of mud broadens eastwards to become 70 miles wide at the 131°E meridian, the eastern limit of the area sampled. The mud grades northwards through a zone of very muddy shell sand 10 miles wide to a wide zone of shell sand with little mud. These unconsolidated Recent sediments usually form only a thin cover on older rocks.

Morphologically it was found that the shallow banks of the Van Diemen Rise to the west do not extend far to the east of the 130° meridian. A number of breaks in slope in water depths of 80 to 180 metres can be related to ancient shorelines.

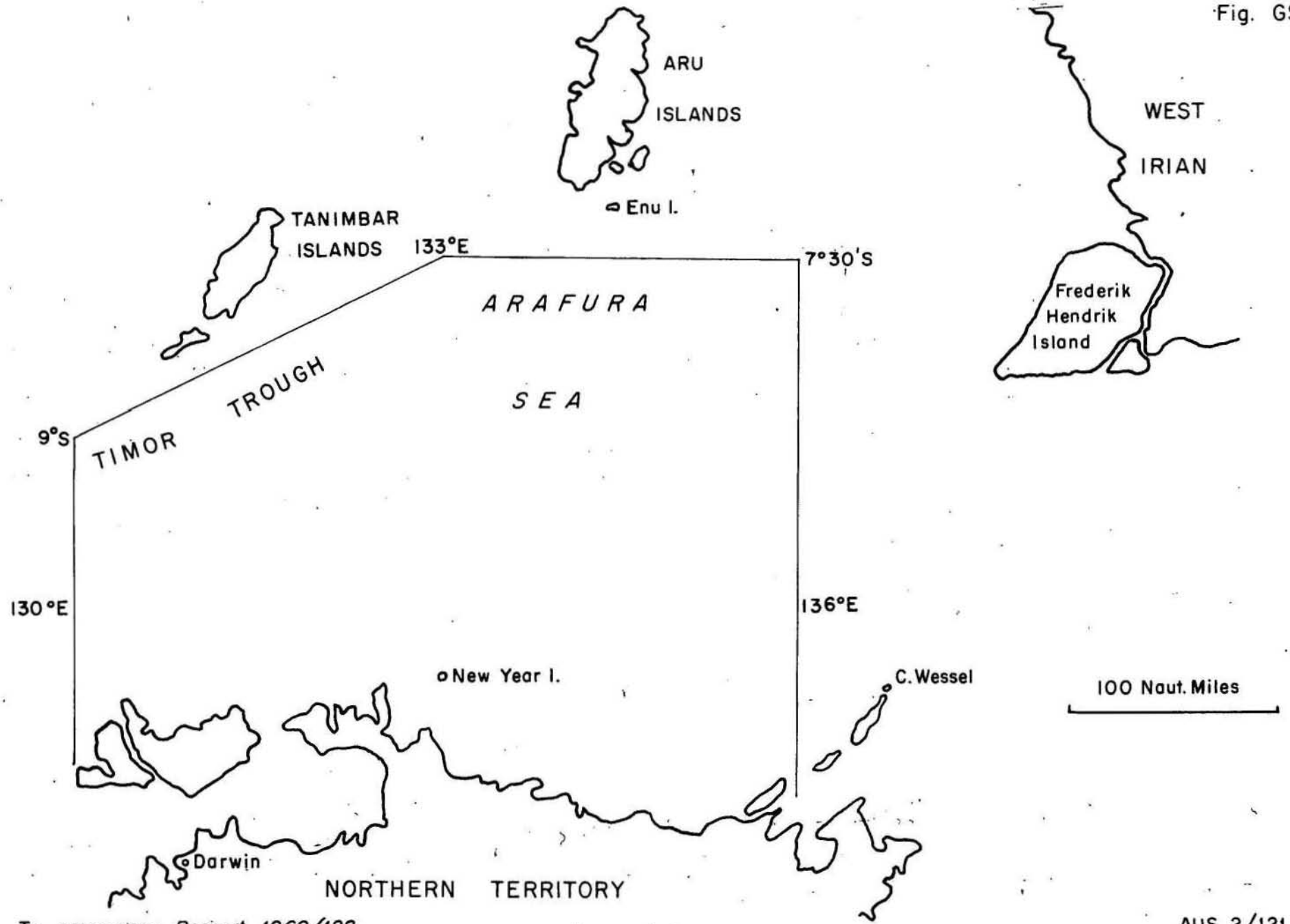
The sparker traverses indicated that the submerged plateau topography of the western margin of the area is essentially a drowned subaerial erosion surface which has been little modified by Recent sedimentation. Recent sediments fill small pockets here and there and smooth out minor irregularities, but by and large the surface has been little altered since its submergence. To the east, however, Recent sedimentation has been active and the seismic profiles have indicated as much as 300 feet of post-Pleistocene fill locally.

Three dives in the submersible Yomiuri were made during the second half of the cruise and drowned reef structures were identified in each instance. These reefs, which occur at depths of 180 to 200 metres, are a persistent feature along the southern margin of the Timor Trough and point to a lower sea level stand in this area during

The San Pedro Sound Cruise

The oil rig supply vessel San Pedro Sound was taken on charter by B.M.R. on 18th September and sailed from Newcastle with an eight-man party on board on 20th September. The survey of the Arafura Sea started on 1st October on the 136°E meridian near Cape Wessel. By the end of October, 172 bottom sample stations had been occupied and nine sparker traverses, averaging about 80 miles each, had been run. The cruise is scheduled to end at Darwin in mid-December and it is expected that about 300 bottom samples and a series of gravity cores will be collected. These, together with the sparker traverses, continuous sounding runs, and underwater photography, will provide adequate basic data for a comprehensive marine geological interpretation of the region between the Gulf of Carpentaria and the Sahul Shelf.

Fig. GS 3



To accompany Record 1969/123.

AUS 2/121

CONTINENTAL PHOSPHATE

Summary

The biostratigraphic mapping of the Georgina Basin phosphate province was completed during the 1969 field season. The field work is being supplemented by laboratory studies including investigations into the petrology, geochemistry, clay mineralogy, and crystal chemistry of the phosphorites.

The cores and cuttings obtained during the 1968 drilling program in the Northern Territory were examined by L.V. Bastian, who also correlated the lithological intersections in these drill holes.

A number of phosphate occurrences of various type were visited in New South Wales, Victoria, and South Australia.

Three unpublished Records and three outside publications were prepared during the year.

Company representatives interested in the search for phosphate (and other commodities) continued to visit the Phosphate Group to discuss various geological problems and to exchange information.

Georgina Basin

The biostratigraphic mapping of the Georgina Basin phosphate province, initiated in 1967, was completed during the year. The field work was carried out from 13th May to 26th July and covered the middle Cambrian deposits along the eastern margin of the Georgina Basin, in parts of Mount Isa, Urandangi, and Glenormiston 1:250,000 Sheet areas (Fig. GS4). Fossils collected were determined by J. Shergold. Clay samples were taken from the Beetle Creek Formation and its equivalents in many parts of the phosphate province. At the completion of the field work, a reconnaissance traverse was made along the southern margin of the Georgina Basin, between Urandangi and Alice Springs, in order to decide on the question whether the survey should be extended to these areas.

The conclusions reached as a result of the 1967 investigations have not been essentially changed by work in 1969 (see Annual Summary for 1968). In short, the Georgina Basin was a very shallow area of deposition, characterized by an irregular coastline with embayments, lagoons, estuaries, shallows, and banks. The mainland bordering the Georgina Basin was morphologically mature - hence the almost complete lack of coarse detritus except during the initial transgressive stage when basal sandstone and conglomerate were laid down. During the Middle Cambrian, the marginal areas close to the old shoreline were characterized mainly by biochemical and fine detrital sedimentation (chert, silt-shale, phosphorite, biopelsparite), whereas towards the open sea the proportion of micritic limestone strongly increased. Evidence of local short time breaks in the marginal lower Middle Cambrian is provided by the presence of ferruginous and manganese-stained breccia horizons which commonly have a phosphorite matrix. Towards the late Middle Cambrian and Upper Cambrian, sandstone and siltstone units were deposited close to the old shorelines, probably as a result of a rise of the Mount Isa High and the Smoky Anticline. These clastic deposits appear to interfinger with the carbonate deposits, and to wedge our basinwards.

The much-discussed Camooweal Dolomite is a dolomitic lateral facies of the Middle and Upper Cambrian formations; its depositional environment was characterized by very extensive intertidal and supratidal mud flats, probably with high salinity and evaporation. This environment appears to have acted as an effective barrier between the Northern Territory and Queensland parts of the Georgina Basin, which would explain the faunal differences between the two regions.

Phosphate deposits - Upwelling currents, commonly considered to be a major factor in the formation of phosphate deposits, could not have played a role in the formation of the Georgina Basin phosphorites, which are now thought to have an origin similar to that of the deposits in Florida and the U.S. Atlantic coast, where concentration by reworking, and deposition in a shallow-water estuarine environment were the most likely processes.

Three types of phosphorite may be distinguished in the Georgina Basin deposits:

1. Primary biogenic pelletal deposits, in which the pellets are largely the phosphatized remnants of originally calcareous fossils, much worn and rounded. A proportion of the pellets represents the comminuted and rounded flakes of reworked thin phosphate laminae which have been precipitated probably as a result of biochemical processes. Other pellets may be phosphatized faecal pellets. The matrix in the pelletal phosphorites is either calcite or silica.

2. 'Microsphorite' (a term used by the B.H.S. geologists), consisting of fine-grained siltstone with a collophane matrix. Its origin is not clear - the phosphate matrix may have been chemically or biochemically precipitated; it may represent a clay-like residue of leached slightly phosphatic Thorntonia Limestone; or the phosphate matrix may be the cemented flour of the pulverized remnants of phosphatized carbonate particles. At present the second possibility seems to be the more likely, as the 'microsphorite' in the Lady Annie, for example, is typically associated with a karst development in and over Thorntonia Limestone, in which the P_2O_5 values are commonly in the vicinity of 0.5 to 1.0 percent.
   The effects of reprecipitation of the phosphate are occasionally noticeable in thin section.

3. 'Phoscrete' (a term coined by P.J.Cook), a hard, dense, usually brown or cream-coloured phosphate rock of secondary origin, commonly cementing breccia fragments, and generally associated with ferruginous-manganiferous weathering horizons, old as well as Recent. P_2O_5 values are high, but the distribution is patchy, erratic, and superficial. In thin section, effects of chemical reprecipitation and of replacement of original carbonate rock are clearly recognizable.

The pelletal phosphorites are common in the southern regions (Burke River Outlier, Ardmore, Quita Creek area). Towards the north, the microsphorite facies becomes predominant. The pelletal phosphorite is perhaps indicative of a relatively slightly deeper or more off-shore marine environment than the microsphorite. Phoscrete is ubiquitous, but seems

Fig. GS 4

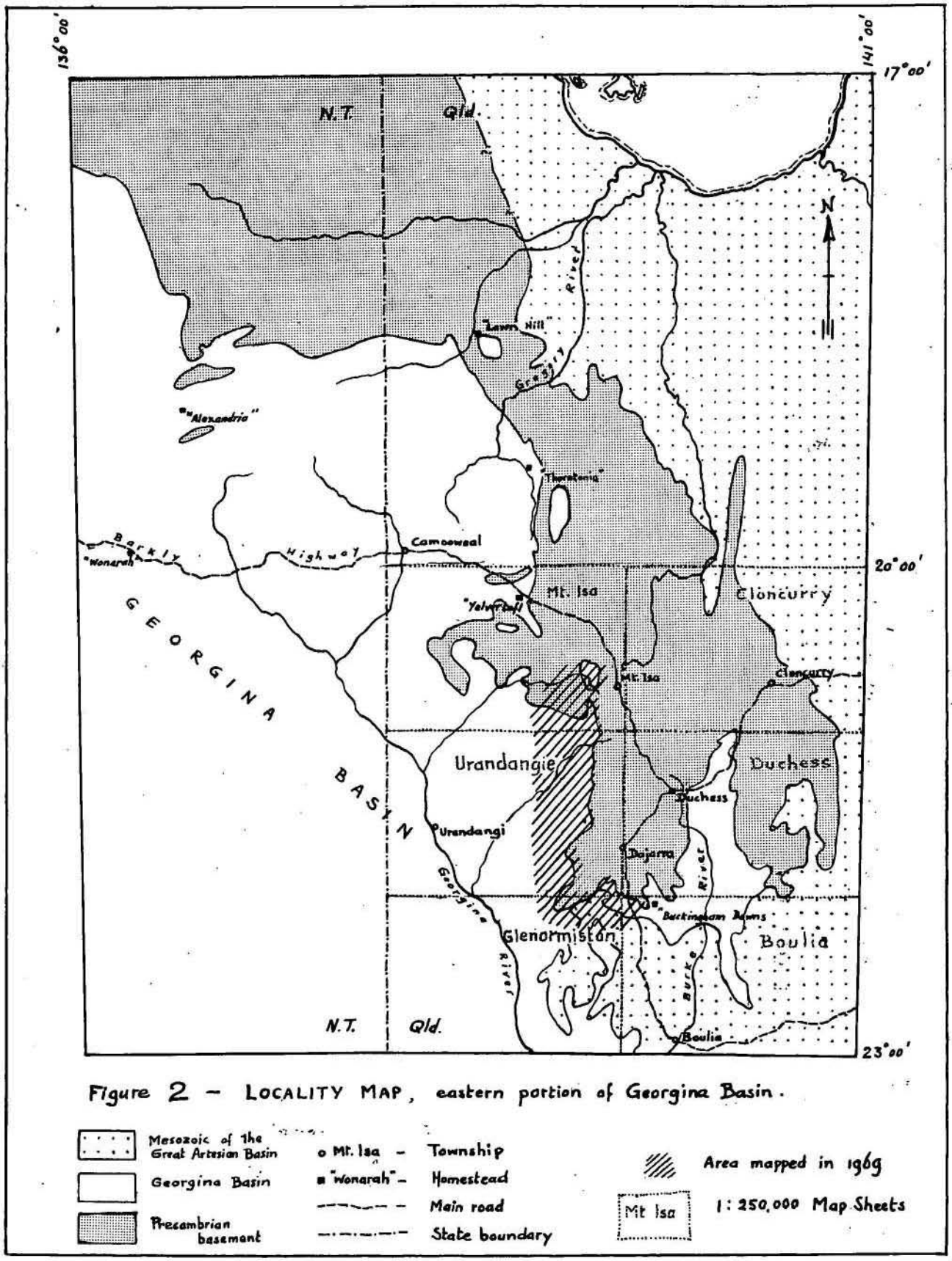


Figure 2 – LOCALITY MAP, eastern portion of Georgina Basin.

To accompany Record 1969/123

AUS 2/122

most readily developed over deposits of the microsphorite type, possibly because of the porosity and fine grain-size of the latter. Also, the fossil weathering profiles (with which the phoscretes are associated) as well as the supposedly very shallow-water environment of the microsphorites, are both most probably found in the old near-shore regions.

Tasman Geosyncline

Brief field trips were made by P.J.Cook to New South Wales and Victoria to examine the mode of occurrence of diverse types of phosphorite. The localities visited were:

1. Narooma/Bateman's Bay area, N.S.W. : the Wagonga Beds (with F. de Keyser).

2. Wellington/Molong area, N.S.W. - cave and karst deposits.

3. Mansfield area, Victoria - lower Palaeozoic marine.

4. Waratah Bay area, Victoria - lower Palaeozoic marine.

5. Geelong area, Victoria - Tertiary lag deposits.

Other Areas

1. The Kapunda phosphate deposits in South Australia were visited by F. de Keyser in December 1968, in the company of Mr K. Johns (Mines Department) and Mr R. Russell (B.H.S.). Problems relating to the genesis of the phosphate deposits in the Georgina Basin were discussed with Dr N.A.Trueman (AMDL) and R.Russell (B.H.S.).

2. The apatite-rich carbonatites about 60 miles northeast of Alice Springs were briefly visited in July.

Laboratory Investigations

1. Petrology - F. de Keyser continued the examination of more than a hundred thin sections of phosphorites and associated rocks from the Georgina Basin. This work contributed considerably to the assessment of the palaeo-environment and genesis of the Cambrian sedimentary and phosphate deposits, and to the understanding of diagenetic processes and their effects on the concentration of the phosphorites. In addition a number of unusual phosphate minerals were studied by means of X-ray diffractometer and electron micro-probe analysis. P.J. Cook examined a great number of thin sections of overseas phosphorites including those of the Phosphoria Formation. L.V. Bastian studied the cores and cuttings obtained during the 1968 drilling programme in the Alexandria/Wonarah region, Northern Territory, and correlated the intervals in these drill holes.

2. Geochemistry - Suites of representative samples were submitted to the BMR chemical laboratory as well as to AMDL for the determination of P_2O_5 and trace element content. Results have not yet come to hand. Previous data have been transferred to punch cards in preparation for computerized handling.

3. Crystal chemistry (P.J.Cook) - A large number of cell dimension determinations on various carbonate-fluorapatites is being made. This work is expected to be of value in the determination of the depositional environment of the various types of phosphorites.

4. Clay mineralogy (P.J.Cook) - Work is proceeding on the semi-quantitative determination of the clay minerals of phosphorites and associated sediments. To date, more than 100 determinations have been made.

RECORDS OF INVESTIGATIONS

The following BMR Records were issued between November 1968 and October 1969.

1969/15 A preliminary account of the distribution of Recent foraminifera on part of the N.W. Australian continental shelf, by A.D. Albani and R. Geijskes.

1969/30 The marine geology of the Huon Gulf region New Guinea, by C.C. von der Borch.

1969/79 On the genesis of the Georgina Basin phosphorites, by F. de Keyser.

1969/82 Report on the Australian - Japanese marine geological cruise in the Arafura Sea, May 1969, by D.S. Trail and H.A. Jones.

1969/113 Echo-sounding and facies delineation, by H.A. Jones.

RESIDENT GEOLOGICAL SECTION

The Resident Geologists, Northern Territory, are officers of the Bureau of Mineral Resources, seconded to the Northern Territory Administration to provide geological services to Government Departments, the mining industry, and to the general public. For the second year the position of Resident Geologist, Tennant Creek, has remained vacant. As far as possible Tennant Creek is served by Darwin based staff. Work has also been curtailed by the shortage of staff at Darwin and Alice Springs.

Transfer of the positions of the Resident Geological staff from the Bureau of Mineral Resources to Mines and Water Resources Branch, Northern Territory Administration is scheduled for 1970.

STAFF

On 31st December, the Resident Geologists consisted of the following professional staff:

Darwin

R.G. Dodson	Senior Resident Geologist
M.R. Daly	Geologist Class II (Acting)
J. Watts	Geologist Class I
2 positions vacant	

Tennant Creek

Position vacant

Alice Springs

O. Fruzzetti	Geologist Class II (Acting)
3 positions vacant	

A clerical assistant and typist at the Darwin office and a clerical assistant at the Alice Springs office are provided by the Northern Territory Administration.

WATER SUPPLY INVESTIGATIONS

Water supply investigations account for a considerable proportion of the work done by the Resident Geologists. The investigations include selection of bore sites for pastoral purposes and as sources of domestic water supply, and hydro-geological surveys of sedimentary basins. The upsurge in agricultural activity throughout the Northern Territory during the past year is reflected in the sharp increase in demand for the selection of bore sites. Investigations of water supplies for domestic or industrial purposes were made at Alice Springs, Croker Island, Cape Crawford Beef Road, Groote Eylandt and Warrego Mine.

Water supply investigations were undertaken at the request of the Director, Mines and Water Resources Branch, Northern Territory Administration.

Selection of Bore Sites

One hundred and thirty nine pastoral bore sites were selected. In addition advice against drilling at 17 sites was given as they were considered unlikely to yield the required quantities of water. The bore sites are described in minor reports which are made available to the Director, Mines and Water Resources Branch, for use in the issue of bore construction advices to pastoral and agricultural leaseholders, and to facilitate the planning of Government bore holes. The reports include a brief description of hydrogeological and geological data and where available, a summary of information on the past history of drilling in the area investigated.

The following is a list of localities for which pastoral bore sites were selected:

Station Name	No.of Boresites	Station Name	No.of Boresites
Wave Hill	7	Humbert River	3
Mount Bundey	3	Auvergne	5
Kirkimbie	1	Dungawar	1
Wallhallow	10	Murangi	4
Kildurk	9	Birrindudu	4
Cresswell Downs	5	Dry River	3
Block 286 Hundred of Bagot	1	Roper River	3
Lot 76-77 Hundred of Bagot	1	Cape Crawford (Beef Road)	1
Benrock	5	Indiana	3
Mountain Valley	26	Elkedra	1
Eva Valley	3	Phillip Creek	2
Kumbidgee	2	Nawietcoma	5
McArthur River	4	Tarlton Downs	1
Michell's Block	1	Mittiebah	1
Marrakai	2	Amburla	1
Innesvale	3	Muckitty	2
Fitzroy	10	White Gums	1
		Owen Springs	1

Soil and rock cutting samples from 136 bores were logged. Samples are collected at 5 feet intervals as each bore hole is drilled. The samples are washed, microscopically examined, and qualitatively tested for phosphate. Samples considered worth further testing are submitted for detailed chemical analysis. Data obtained from examination of the borehole cuttings are recorded, indexed, and made available to the Bureau of Mineral Resources, Canberra, the Water Resources Section, N.T.A., and other Government Departments, and to mining companies holding authority to prospect on leases over the areas in which boreholes are located. A representative specimen of each of the bore cutting samples is retained at the Darwin or Alice Springs office.

Town Water Supply Investigations

No major investigations of town water supplies were made. Assessment of available water supplies for Alice Springs town has continued as further research is undertaken to estimate the resources of the Mereenie Basin. Minor surveys were made at certain Welfare Settlements and mining townships.

Alice Springs Water Supply. As part of the continued investigation of the Alice Springs Water Supply, two bores, P7 and P8, were sited to intersect Mereenie Sandstone west of the present production area. The bores each yielded over 15,000 gph.

Finke Water Supply. An opinion was prepared on the prospects of groundwater suitable for a town supply at Finke.

Croker Island Settlement. A survey was made of Croker Island. Three sites were chosen for bores planned to increase the domestic water supply; two sites were selected as pastoral bores.

Warrego Mine Water Supply. An appraisal was made of the groundwater resources of the area around Warrego Mine, Tennant Creek. An adequate quantity of groundwater is believed to be available from the carbonate rocks of the Wiso Basin immediately west of the mine. A systematic drilling programme is recommended to allow final assessment of the groundwater resources of the carbonate rock formations.

Groote Eylandt. Three bore sites were selected to provide a water supply for the Kaulis Prawning Company establishment on Groote Eylandt.

Hermansburg Mission Settlement. In the light of the data from the geological succession intersected in Palm Valley No.1 oilwell, a bore was sited to supply water for Hermansburg Mission. The bore was planned for a depth of 2,500 feet, but due to drilling difficulties was abandoned at 1,597 feet.

IRRIGATION PROJECTS

Daly Basin Survey

Work continued on the Daly Basin Hydrogeological survey. By the end of the year four more bores were completed. Another bore is nearing completion. Detailed tests have been carried out on the bores drilled the previous year to allow an accurate assessment to be made of the total safe yield and the quality of available water from each bore.

The following is a summary of this year's drilling results:

Bore Number	Location	Results
DB 6	5 miles S.S.E. of Tipperary Homestead	Total depth: 1420 feet. Yield (from one of two aquifers): 2000 gph. Standing level: 25 feet. Aquifer Upper: (cased off); Tindall Limestone. Lower: Waterbag Creek Formation.
DB 10	9 miles north of Daly River crossing at Collee.	Total depth: 2000 feet. Yield: 17,000 gph Flowing at 5,000 gph.
DB 9	11 miles from Stuart Highway on the Daly River Road.	Total depth: 397 feet. Yield: (from two aquifers) 30,000 gph. Aquifers: Mullaman Beds, Tindall Limestone.
DB 8	7 miles from Stuart Highway on the Daly River Road.	Total Depth: 441 feet. Yield: 6,700 gph. Aquifers: Tindall Limestone Waterbag Creek Sandstone.

Tennant Creek

A discussion was held with personnel of the Agricultural Section, Primary Industries Branch, regarding the possibility of using shallow groundwater from the Cabbage Gum and Kelly Well Reserves, for irrigation purposes. Data available for bores in the areas indicate there is little likelihood that water is present in sufficient quantity to be utilized for irrigation.

Moyle Plains

A brief report was completed summarizing the availability of groundwater in the Moyle Plain area, Port Keats district, as the area has been considered as a site for an irrigation scheme.

The report dealt with both the plains area and the upper reaches of the Moyle Valley within the Aboriginal Reserve.

Wycliffe Well Area

Following recommendations contained in the report Preliminary Report on the Availability of Groundwater in the Wycliffe Well Area, five shallow investigation boreholes totalling 370 feet were drilled by Mines and Water Resources Branch drilling rigs in the Wycliffe Area. Samples from the drill cuttings were

examined and the bores pump tested. Two of the bores yielded over 3000 gph each while a deeper hole, about 108 feet, gave an estimated supply of 8000 gph.

East Emily Plain

An investigation of the groundwater potential of the Mereenie Sandstone in the East Emily Plain was started. Two bore holes have been completed: EE1A to a depth of 225 feet to be used as an observation bore for the pump testing of EE1, a deeper bore at 1,175 feet. Pump tests at EE1 are disappointing, the yield being approximately 1,500 gph for a 9 foot drawdown. There appears to be a possibility, however, that the drilling mud used was of inferior quality and has therefore partially sealed the aquifers. Further drilling is necessary before the potential water yield can be evaluated.

ENGINEERING GEOLOGY

In the absence of suitably qualified staff, minor engineering geological projects are normally dealt with by members of the Resident Staff. Major projects are usually undertaken by staff of the Engineering Geological Section, Bureau of Mineral Resources, Canberra.

Darwin Harbour Investigation

As part of a feasibility study of the Darwin Harbour area, conducted by a firm of consultant engineers, staff from the Resident Geologists Section supervised a foundation testing programme and made a survey of available gravel reserves in the East Arm area.

Drilling in the bay off-shore of East Arm indicated that the harbour sediments consist of between twenty and thirty feet of superficial calcareous mud, with a basal layer of ill-consolidated but well sorted boulders, capping a foundation of rocks of the Noltenius and possibly Golden Dyke Formations.

Darwin River Damsite

A reconnaissance ground survey followed by a more detailed survey by helicopter was made of the catchment area of the proposed Darwin River Damsite. The survey was made to identify the surface outcrops of rock in the catchment, and as far as possible to predict the solid geology beneath the covering of soils.

The survey included the mapping of "Beetsons" iron ore prospect to ascertain the extent of pollution to the dam if the prospect is mined.

Quarry Sites, North Australian Railways

Minor investigations of proposed quarry sites were made at Darwin River, Howley Siding and Pine Creek.

The investigations were planned to discover sources of rock suitable for use as ballast for the North Australian railway line between Darwin and Pine Creek.

Darwin River Bridge Site

Foundation test drill hole cores from the proposed re-aligned site of the Darwin River railway bridge were examined and described in detail. Realignment of the bridge is necessary to divert the railway line from the Darwin River dam site.

Cullen River Bridge Site

Cores from six diamond drillholes sited to test the bedrock foundations of the Cullen River crossing were logged. Construction of a bridge at the crossing is planned for 1970.

Foundation Tests, Gove

At the request of the engineer-in-charge, Nabalco, a programme of test drilling was planned to investigate rock foundations at the site of future processing plant. Data obtained by the drilling will be used in the design of buildings requiring a high degree of stability.

Nancar Dam Site

A reconnaissance survey was made of a proposed dam site on the Daly River by Canberra-based staff of the Bureau of Mineral Resources. Further detailed investigation is scheduled for the future. Assistance and collaboration was given by Resident Staff.

MINES AND MINERAL PROSPECTS

Mineral exploration in the Northern Territory has continued at the high level of the past few years. At the close of the year geological staff representing seven mining companies were resident in the Northern Territory. Additional personnel were temporarily resident in the Territory from time to time while engaged in geological and geophysical surveys during the winter months field season. The Tennant Creek mineral field has attracted renewed attention from both companies established at Tennant Creek and from companies based elsewhere. Further exploratory and proving work has continued at most of the proven mines, particularly at the Francis Creek iron ore mine.

Considerable assistance in the form of technical advice and mineral identification was given to company officials and individual prospectors. This work includes the appraisal of mineralization at Mt. Hardy on behalf of the Yuendumu Welfare Settlement Village Council. Related surveys are in progress at the Mt. Clark copper prospect and the Mt. Allan Tin Prospect.

COPPER AND GOLD

Katherine-Darwin Area

Granite Copper Mine

A partly exposed copper bearing lode known as the Granite Copper Mine was mapped in detail. The lode is a mineralized pegmatite in the Cullen Granite. Where exposed the lode is 4 to 5 feet wide and pitting has proved a length of 950 feet. Further investigation is recommended.

Wave Hill Copper Prospect

At the request of the Director, Welfare Branch, a short visit was made to a reported copper prospect in the Wave Hill area. The prospect was discovered by aboriginals and brought to notice by the journalist Mr S. Smith. A detailed search of the prospect revealed the presence of rare small patches of malachite staining in chert. The country rock is flaggy sandstone, with minor intercalations of chert. Systematic search of the surrounding area failed to reveal more mineralization. No further work is recommended.

As this investigation was made by Darwin-based staff, for convenience it is included in the Darwin-Katherine Section.

Tennant Creek Field

Jubilee Reserve (No.306)

Four magnetic anomalies in the Jubilee Reserve were located by detailed ground magnetometer survey conducted by staff of the Bureau of Mineral Resources Geophysics Section. The area is blanketed by fine textured soils which effectively cover the underlying solid geology. All four of the anomalies have been partly tested by diamond drilling.

Anomaly C6. By the end of the year two drill holes put down to test anomaly C6 had been completed. In the first drill hole massive ironstone was intersected between 211 feet and 459 feet. Drillhole No.2, planned to test the inferred width of the lode, intersected 80 feet, corrected width, of quartz hematite ore. Assays of the ore from the first drillhole varied from a trace of gold to a maximum of 4.6 dwts/ton in the downhole interval 337-342 feet. Further drilling is planned to outline the extent and shape of the ore, and to test the mineralization.

Anomaly C12. Drillhole No.1 sited to test anomaly C12 was completed to a depth of 802 feet. Thin veinlets and patches of disseminated magnetite with some hematite were intersected at three intervals in the section. The highest copper values were up to 1% for the interval 380-385 feet. Gold assay results have not been received so far.

Anomaly C13. A test diamond drillhole sited on anomaly 13 intersected quartz-hematite lode with sparse copper mineralization at between 450-475 feet. Gold assay results are awaited. Further drilling is required to test the mineralization.

New Comet Reserve (No.163)

Anomaly 6. A diamond drillhole designed to test anomaly 6, Aeromagnetic Ridge, located by Bureau of Mineral Resources Aeromagnetic survey, was terminated at 840 feet. No ironstone was intersected. The anomaly will be resurveyed next year to decide whether further test drilling is warranted.

Great Western Extended Reserve (No.287)

A drillhole has been completed and a second started to test a magnetic anomaly on the Great Western Extended Reserve. The first drillhole, No.7, was terminated at 740 feet, having passed through a succession of Warramunga Group sandstones and shales. The lower part of the succession consisted of just over 400 feet of chloritic slate with finely disseminated magnetite, accounting for up to 5% of the total composition. A second drillhole, No.7A, is being drilled to test for the possible presence of massive iron ore.

New Hope (A.P. 2236)

Drilling of the Authority to Prospect area, New Hope, continued during the year. A second drillhole was stopped at 1,300 feet by June, having passed through a succession of silicified sandstones and siltstones. Dolerite was intersected at approximately 230 feet.

Central Australia

Mt. Skinner Copper Prospect

The survey of the copper mineralization at Mt. Skinner was completed during the year. Four diamond drill holes, totalling 1,986 feet, were drilled by Mines and Water Resources Branch. The drilling provided a clear picture of the stratigraphy and type of mineralization.

The copper mineralization occurs in grey sandstone and siltstone horizons usually less than 15 feet thick, in gently dipping lithic sandstone and siltstone of the Central Mt. Stuart Beds. The mineralization occurs over an area of over 50 square miles. Analysis values seldom exceed 0.2% copper for the mineralized intervals but isolated 1-foot core samples have yielded

up to 0.65% copper. At depth the mineralization consists of chalcopyrite with associated pyrite. At the surface it has been altered to malachite, azurite, and chalcocite.

Clarke Copper Mine

A detailed survey was made of the copper prospects at and near the Clark Mine. Six diamond drill holes, totalling 927 feet, were completed. A report on the investigation is in preparation.

Yambah Copper Prospect

A small copper prospect 2½ miles north-northeast of Yambah Station was examined and a brief report prepared. The copper mineralization is present as carbonates contained in a lens of amphibolite about 150 feet long.

Sitzlers Copper Prospect

Sitzler's Copper Prospect, 8 miles southeast of Mud Tank, was briefly investigated. Copper mineralization, mainly chalcopyrite, occurs in quartz veins infilling shears cutting amphibolite.

Pinnacles Copper Prospect

A detailed investigation was made of the copper mineralization in the Pinnacles area. The report incorporates details of previous investigations made by mining company personnel, with a review of the results of a geophysical survey made by Geophysical Branch, Bureau of Mineral Resources.

LEAD/ZINC

Katherine-Darwin Area

McKinley Silver/Lead Mine

Two diamond drillholes were put down to test the ore at the abandoned McKinley Mine, just south of Burrundie Siding.

The mine was abandoned in 1891 when water inflow made mining methods in operation uneconomic. At the surface the much oxidized orebody appears to be about 2-3 feet thick, a figure corresponding with records of the thickness of ore at depth. The ore is characterized by an unusually high silver content, production figures recording values varying from 47 to 3,740 oz. of silver per ton.

The two drillholes intersected ore almost directly below the surface outcrops of mineralization. Unfortunately at depth the ore narrows sharply with a corresponding lowering of ore grade. At a true depth of about 170 feet the ore is approximately 1 foot wide, with assay figures of: Lead 2.35%, Zinc 3.0%, Silver 2.3 oz/ton, Gold, trace. Detailed prospecting may reveal the presence of better concentrations of ore but the prospect appears to have little scope for even a medium sized mining operation.

Pine Creek Lead Mine

A brief visit was paid to the Pine Creek lead mine. The ore is contained in narrow veins contained in siltstone country rock. No further work is recommended.

TIN

Katherine-Darwin Area

Tin Mines, Middle Arm Area

At the request of the leaseholder, the Bella Mona Mine and two other small prospects were briefly examined. The cassiterite is present as finely disseminated grains in quartz-muscovite pegmatite. As the prospect is obscured by superficial deposits, systematic pitting is recommended to expose sections of the lode to allow detailed examination.

BAUXITE

Umbakumba, Groote Eylandt

A detailed survey by helicopter was made of the Umbakumba area, Groote Eylandt, and the neighbouring islands of Bickerton, Winchelsea, and Connexion to assess the economic significance of reported bauxite. The Umbakumba bauxite is low grade, analyses of representative specimens ranging from 22% to 28% Al_2O_3. The silica and iron content is high. Exposed sections of bauxite up to 15 feet thick were measured. Typically the succession consists of silty bauxite to clay containing fragments of weathered siltstone or claystone, followed by 2-4 feet of tubular bauxite, which in turn is capped by 1-3 feet of pisolitic bauxite.

The islands of Bickerton, Winchelsea and Connexion do not contain bauxite deposits. Thin layers of reddish argillaceous silt and clay are exposed on the southwestern corner of Bickerton. Manganiferous laterite is patchily exposed in the southern and central parts of both Bickerton and Winchelsea.

ASPHALT DEPOSIT

Gunn Point

Following the reported discovery at Gunn Point of an asphalt deposit, a brief investigation was made of the country rock (Mullaman Beds of Creataceous Age) in the area. The bituminous hydrocarbon was reported as a seepage from the exposed rock. Careful examination failed to prove a relationship between the country rock and the asphalt.

The presence of such material along the Australian coastline has been repeatedly reported. The asphalt probably originates from submarine sources. A specimen has been submitted to the Bureau of Mineral Resources, Canberra, for analysis.

BERYL

Kulgera Area

Soil and rock samples were collected from a locality 4 miles northeast of Kulgera, where beryl, with monazite, was detected in a trench dug by personnel from C.S.I.R.O. Beryl was not identified by microscopic examination in samples collected. The samples have been submitted for detailed geochemical analyses.

GEOCHEMICAL SURVEYS

Mary River Reserve

Following the establishment of roughly coinciding but unclosed geochemical and self-potential geophysical anomalies on the edge of the Mary River Reserve grid during the previous season's fieldwork, the grid has been extended. Further auger drilling was completed to allow closure of the geochemical anomaly. Diamond drilling is planned for the 1970 season to test the anomalies of lead and zinc established during this year's survey.

Work has been hampered by the difficulty of access and the density of vegetation around the original grid.

Mary Lane Shear Zone

Work continued on the Mary Lane Shear Zone Geochemical Survey. Auger drilling was completed and about three-quarters of the assay results received. Three small copper/bismuth anomalies have been identified, but further detailed work is required to assess their significance.

Search for Oil

During the year drilling for oil started at three sites, two on land and one off shore. Two further offshore wells are due to be drilled in the near future. Tyler No.1 was continued to completion, plugged, and abandoned. West Waterhouse and North West Mereenie were both completed, the latter left as a water well.

Petrel No.1, an offshore well, struck gas at great pressure at a depth of 13,052 feet, suffering serious damage as a result of gas pressure blow back and subsequent ignition.

Numerous discussions were held with staff from companies engaged in the search for oil. When possible, officers of the Resident Geological staff visited operation oil rigs.

Miscellaneous

During the year the number of visitors calling at the offices of the Resident Geologists increased slightly. The visitors included company personnel, government officers, and individual members of the public.

Assistance and advice is given on exploration methods, prospecting, the availability of materials for building and engineering projects, and the identification of minerals.

Final arrangements have been made for the transfer of the Resident Geologists positions from the Bureau of Mineral Resources to the Northern Territory Administration.

Meetings and Conferences

The senior Resident Geologist attended the 9th Commonwealth Mining and Metallurgical Congress held in London.

The acting Senior Resident Geologist attended the Technical Committee on Underground Water held this year in Hobart.

D.J. Grainger attended the 9th International Congress of Soil Science held in Adelaide.

I.G. Faulks attended the Arid Zone Conference held in Canberra.

Reports

The more important reports prepared by officers of the Resident Geological Staff during the year are as follows:

Iron Ore Reconnaissance by Helicopter in the Areas Covered by the Tipperary, Burnside, Mount Bundey and Narrakai One Mile Sheet Areas, N.T.	R.G. Dodson J.W. Shields M.R. Daly
Preliminary Survey - Acacia Gap Iron Ore Prospect	B.A. Tapp
An appraisal of Available Sources of Rail Ballast, Darwin River to Rum Jungle	J. Watts
An Appraisal of Cleo's Gift Gold Mine, Bishop Creek Area	J. Watts
Geological Interpretation of Diamond Drill Cores for Bridge Foundations, Roper River Road	J. Watts
Diamond Drilling at White Point Yuendumu, N.T.	D.J. Grainger
The Granite Mine Copper Prospect	J. Watts
A Brief Inspection of an Occurrence of Copper Mineralization at Wattle Creek, Wave Hill	J. Watts
A Geological Interpretation of Diamond Drill Cores from the proposed New Darwin River railway bridge foundations	A.T. Laws J.A. Watts
Helicopter Reconnaissance of the Batchelor Group Proposed Darwin River Damsite Area	J. Watts
Iron Occurrence Near Daly River Road Turnoff	M.R. Daly

An Inspection of Red Mud and Drimmie Head Quarry Sites - Gove.	J. Watts
Report on a Visit to the Precambrian "Fossil" Localities at Georges Creek and Tumbling Waters, N.T.	B.A. Tapp
An investigation of Copper Mineralization at Mt. Skinner, N.T.	D.J. Grainger
Investigation Made in the Red Bluff Area, Tennant Creek, N.T.	B.A. Tapp
The Geology of the Princess Louise Goldmine Gove Hill Area, N.T.	J.W. Shields M.R. Daly
A Reconnaissance Survey of part of the Cox Peninsula Tinfield	J. Watts
Petrographic & Geological Notes on Rocks from Two Proposed Sites for Rail Ballast, Pine Creek, N.T.	J. Watts
Anomaly C13 Diamond Drill Hole	M.R. Daly
Summary of Investigations Carried out at the Gigantic Goldmine, Tennant Creek, N.T.	B.A. Tapp
Geology of the McKinley Silver/Lead Prospect	R.G. Dodson
Diamond and Fergusson Drilling - Lone Star Area - Tennant Creek	M.R. Daly
Wagon Drilling at Millers Iron-Manganese Prospect, Frances Creek North, N.T. 1967	J.W. Shields

RESIDENT GEOLOGISTS

TERRITORY OF PAPUA AND NEW GUINEA

There are at present 12 Resident Geologist positions in the Territory and the Administration has made financial provision for an additional three in the current financial year. However, at no one time have all the positions been filled. Services have been provided to the Administration in the fields of Regional Mapping and Mineral Investigation; Engineering Geology; and Volcanology. These services are also extended to Commonwealth Departments in the Territory and to mining companies, prospectors and members of the public.

HEADQUARTERS AND ADMINISTRATION

The Chief Resident Geologist (A. Renwick) visited the B.M.R. New Britain Field Party in February and the Markham Field Party in September. He visited the Central Observatory at Rabaul in September and plans to do so again in December. A visit planned for February was aborted by bad weather. He was on recreation leave from 21st March to 20th July, apart from a two-week period in May when he resumed duty to attend the Ninth Commonwealth Mining and Metallurgical Congress in London. Two visits were made to Canberra, one in February and the second in October. Mr I.S. Cumming acted as Chief Resident Geologist throughout all these periods of absence.

Construction of the major extensions to the Central Volcanological Observatory at Rabaul began in February and, although behind schedule, is expected to be completed by the end of the year.

Excavation of the site for the new block in Port Moresby began in October and completion of buildings is scheduled for 21st April, 1970.

The number of visitors, principally from mineral and petroleum exploration companies, increased considerably this year. In addition to dealing with these, the Chief Resident Geologist was engaged in the supervision of Branch activities and administration and also with the preparations for the 1970 meeting of ANZAAS in Port Moresby. He continued membership of the Mining Advisory Board, the Petroleum Advisory Board, the Science Faculty of the University of Papua and New Guinea, the Council of the Scientific Society of Papua and New Guinea (of which he became President), and remained Chairman of the Advisory Committee on Seismology and Earthquake Engineering.

REGIONAL MAPPING & MINERAL INVESTIGATION SECTION

INTRODUCTION

STAFF AND MOVEMENTS

J.A.J. Smit	-	On leave from 26th March prior to resignation from Public Service.
R.P. Macnab	-	Transferred to Canberra 2nd March.
D.J. Grainger	-	Assumed duty 29th April.
R.J. Tingey	-	On leave until 9th January.
P.D. Hohnen	-	On local leave from 25th April until 9th May. Duty tour in Canberra from 18th July to 17th August.

REGIONAL MAPPING

PROJECTS AND INVESTIGATIONS

B.M.R. New Britain Party

Macnab spent parts of January and February, and Tingey February and part of March, with the B.M.R. New Britain field party. In October P.E. Pieters (Engineering Geologist) took part in field work with a second B.M.R. New Britain party.

Wau 1:250,000 Sheet (65104)

Smit completed the preliminary map compilation and draft Explanatory Notes prior to his resignation from the Public Service. Editing of the Explanatory Notes is in progress in Canberra.

Kratka Range (69202)

A helicopter-supported geological reconnaissance of the Kratke Range area of the Markham 1:250,000 Sheet was made by Smit and Tingey in January. The work involved 25 hours helicopter flying. Further field work by Tingey, Grainger, Hohnen, J.C. Braybrooke and P.E. Pieters (the last two Engineering Geologists) took place during May when 45 hours of helicopter time were utilised.

The achieved objective of the survey was to link up previously mapped areas in the Wau, Kainantu and Menyamya areas. Several units of volcanically derived sediments were mapped. Limestone lenses within the sediments were sampled for palaeontological age determination.

The work is being written up in conjunction with the Markham area survey carried out later in the year.

Markham Area (69204)

During September, Grainger, Tingey (Hohnen for one week) and P.G. Flood (on temporary attachment from Canberra) mapped the area of the Markham 1:250,000 Sheet north of the Markham Valley and completed the link-up with previously mapped areas to the South. 51 hours of helicopter time were used.

Sandstones, pebbly sandstones and conglomerates form a unit in the foothills on the northern side of the Markham valley. Northwards, the sediments contain progressively more volcanically derived material. Well-bedded, sub-horizontal limestone forms cappings over 1000 feet thick on the highest parts of the Saruwaged Range. Rivers have eroded deep gorges through the limestone and have exposed underlying basic volcanics on the northern fall of the Range.

South of the Markham River a series of intrusions ranging from acid to basic extend from Gusap to west of Kainantu. Limestone unconformably overlies the intrusions and was traced south to Wasiang Mountain. At the mouth of the Wanton River an unconformity between limestone and quartz sandstone was observed.

Traverses were made in the Wasiang Mountain and Waffa River areas to complete work begun by the Kratke Range Survey.

Kaindi Metamorphics and Morobe Granodiorite were mapped along the Lae-Bulolo road.

The mapping of the Markham 1:250,000 Sheet is now complete except for a few small isolated areas which can be investigated in 1970.

Writing up of the September field work and the Kratko Range Survey, and compilation of previous work by Resident Staff and mining company personnel is in progress.

New Ireland

Hohnen (four weeks) and Macnab (one week) mapped part of New Ireland during January and February.

Hohnen completed the mapping of New Ireland in September and October. Compilation of field data and a Note on the investigation are in hand.

Dayman Dome, S.E. Papua

Hohnen and Pieters (Engineering Geologists) spent one week of July completing field work in the Dayman Dome area of S.E. Papua. The Dayman Dome work forms part of the B.M.R. S.E. Papua regional mapping project.

Hohnen and Pieters completed the writing up of the Dayman Dome field work during a four-week duty tour in Canberra in July and August. Their work is to be issued as a B.M.R. Record.

Mount Yule area (68202(b))

Hohnen made a photo-interpretation of the Mt. Yule area and completed a 1:250,000 scale geological map of the Akaifu-Mt. Yule-Kunimaipa area of the Central District.

Kemp Welch (68204)

A preliminary note on the geology of the Kemp Welch area, mapped during 1968, was completed.

MINERAL INVESTIGATIONS

Mt. Lawes

Hohnen, Tingey and Grainger visited the Mt. Lawes copper prospect near Port Moresby on several occasions at the request of the lease holder. Weak sulphide and carbonate mineralization is present in sediments near the contact with a gabbroic intrusive. The drilling section of the Department of Lands, Surveys and Mines drilled two subsidized diamond drill holes (317 feet and 160 feet). No mineralization was intersected and it is unlikely that the copper occurrence has any economic potential. The exposed mineralization is probably surface enrichment occurring as isolated pods.

MISCELLANEOUS

Bougainville Village Water Supply (68420)

Tingey spent four weeks on a survey for the Engineering Geology Section of village water supplies in Bougainville.

Coal Occurrences in Papua and New Guinea (69201)

Grainger compiled data on coal occurrences of the Territory following several requests for information.

Many occurrences of low-grade Tertiary coals are known but, because of their location, thickness and grade, none has been exploited commercially. Most of the deposits are in the Gulf District. Coal seams near the navigable lower Purari and Vailala rivers are of potential interest.

Miscellaneous

Grainger completed a Northern Territory report begun before his transfer from Alice Springs to Port Moresby and spent some time editing part of the draft report of the B.M.R. 1969 Antarctic field work.

During October and part of November, Grainger lectured at the University of Papua and New Guinea in the absence, due to illness, of the Earth Science lecturer.

Many mineral exploration companies have consulted the data files which contain all the unclassified unpublished information on the geology of the Territory. Discussion with company personnel is an important, but time-consuming aspect, of the work of the Section.

A large number of specimens and samples were identified and submitted, where appropriate, for chemical determination, for prospectors and members of the public.

ENGINEERING GEOLOGY SECTION

INTRODUCTION

STAFF AND MOVEMENTS

I.S. Cumming - In charge of the Section during most of the year. He acted as Senior Resident Geologist during the absence of A. Renwick on leave from 21st March to 20th July and was absent on recreation leave on 11th-22nd August.

J.C. Braybrooke - Absent on recreation leave from 15th September to 4th December, the effective date of his resignation from the Bureau of Mineral Resources.

P.E. Pieters - Absent on duty in Canberra from 18th July to 18th August.

Officers of the Section were engaged on 33 projects and investigations. Notes on Investigation for 17 of these were issued and drafts of 4 others were completed. Work on the remaining 12 projects and investigations continues.

Bureau of Mineral Resources Records on work of the Section were issued during the year.

To meet the lack of geologists in regional mapping projects, Braybrooke worked for two weeks in the Kratko Range and Pieters spent the total of twenty weeks with field parties in South East Papua, West New Britain and the Kratka Range and in drafting the record in Canberra. The position for a fourth geologist in the Section was not filled. As a result, much of the scheduled programme had to be abandoned and the available manpower resources devoted to providing services urgently required by the Government Departments and their consultants.

HYDRO-ELECTRIC SCHEMES

Upper Ramu Hydro-Electric Scheme

Investigation (68404) into the possible leakage from the proposed reservoir continued. In collaboration with Dr E.K. Carter, Bureau of Mineral Resources, Canberra, Braybrooke drafted a review of the geological inferences to be drawn from a seismic survey carried out by geophysicists of the Commonwealth Department of Works.

Following the decision of the P.M.G. Electricity Commission to go ahead with Stage 1 of the Scheme a party of engineers and geologists of the Commonwealth Department of Works, the Snowy Mountains Hydro-Electric Authority and the Bureau of Mineral Resources visited the site in August to determine the specifications for the design investigation (69412). Mr M.J. Jackson, of B.M.R. Canberra, commenced geological work on 20th October. Diamond drilling to obtain more information about the siltstone-marble succession below the intake commenced in November. Construction is expected to begin early in 1971.

Sirinumu Dam Stage 2 Construction (69401)

Construction work commenced in September to increase the storage of the Sirinumu reservoir in order to meet future electricity requirements in the Port Moresby area. The work includes raising the crests of the main dam and five existing saddle dams by 22 feet, the construction of three new saddle dams and a new spillway. Geological services were provided by Cumming, whose report on the design investigation (67410) has been issued as B.M.R. Record No. 1969/1.

Nebilyer River Hydro-Electric Scheme (68402)

Investigations into various aspects of the scheme to provide power for the Mount Hagen area continued into the early part of the year. The project has been abandoned. The investigation Note was compiled by Cumming.

Musa Gorge Hydro-Electric Scheme (68405)

In collaboration with Dr E.K. Carter, Cumming completed the geological report for the Commonwealth Department of Works feasibility study. The scheme includes the construction of a 450 feet high dam in the Musa Gorge, 54 miles S.W. of Tufi, Northern District; the impounded water would form a lake of about 125 square miles in area.

Lake Hargy Hydro-Electric Scheme (68419)

The proposed scheme is to use the water stored in Lake Hargy, a crater lake near Mt. Gallosento on the east side of Kimbe Bay, West New Britain. The lake is drained by the north flowing Lobu River. The scheme would be located on this river about three miles downstream from the lake. The geological investigation was carried out by Braybrooke late in 1968 and the Investigation Note has been issued.

Rouna No.3 Power Station and Sogeri Regulating Pond (68422)

This scheme will complete the development of the Laloki River for generating power for the Port Moresby area. Cumming completed the preliminary investigations of two possible sites for the power station; one is near to the existing No.1 Power Station and the other is one mile further downstream.

Mendi Hydro-Electric Schemes (69407)

Braybrooke visited the Administration and United Church Mission scheme in operation at Mendi, Southern Highlands District.

He investigated the leakages from a race-line and a storage pond by way of cracks which have developed in the volcanic soil of the area. He has attributed the cause of the cracking to soil properties like those found in similar terrain in New Zealand. Further soil testing is required in order to reach a firm conclusion.

WATER SUPPLIES

Village Water Supply Surveys, New Britain

Pieters completed the writing and distribution of reports on three surveys carried out in 1968, namely N.E. Gazelle Peninsula (67417A), North Coast (67417B) and South Coast (67417C).

In this work a total of 235 sources of supply were examined.

Village Water Supply Surveys, Bougainville (68420)

Pieters visited 61 villages in South Bougainville during 22nd January-12th February and Tingey visited 50 villages in the northern part during 20th June-15th July. The report combining the work of both surveys is in preparation.

Agricultural Projects, Central District, Groundwater Resources

The Department of Agriculture, Stock and Fisheries requested advice on groundwater developments for market gardening projects in the basins of the Vanapa and Kemp Welch Rivers (69410) and for a rubber project in the Bailebo Sub-division near Margarida, Amazon Bay, Central District (69406). Shortage of staff has hindered progress in these investigations.

Rigo Sub-District Water Supply (69409)

The recent long dry season has emphasized the lack of reliable water resources in the Sub-District, located south east of Port Moresby. There are very few perennial creeks and the bedrock, mainly of gabbro and siltstone, is not a good aquifer. Most of the groundwater comes from buried drainage channels. The Local Government Council has requested boreholes to supply villages and schools as well as Kwikila township, where the demand for water is steadily increasing. It is felt that Kwikila cannot be supplied from boreholes much longer and that the Kemp Welch River should be developed as a source in the near future.

Local Government Council Water Boreholes - Kaiapit (68421)

Several water boreholes near Kaiapit in the Markham Valley ran dry in the later part of 1968. Deepening of the boreholes has been beneficial. At present, very little is known about the Markham Valley aquifers and investigation will continue.

ROAD SURVEYS

Geological studies of the routes for new and improved roads is an increasingly important activity of the Section and close liaison with the Works Departments and their consulting engineers continues during design and construction.

Braybrooke completed Investigation Notes on the Middle Watut Road, Morobe District (68313), the Yalu-Boana Road, Morobe District (68414), part of Mendi-Ialibu road, Southern Highlands District (68417) and the Nantambu Passage road, West New Britain (68419). The Mendi-Ialibu road poses considerable problems of construction in an area of regular high rainfall.

Proposed Gulf-Southern Highlands Road (68423)

Braybrooke visited parts of the southern section of the route by helicopter.

Usino-Cogol River Road, Madang District

Braybrooke inspected the proposed route in March and completed Investigation Note 69403. Pieters walked the cleared alignment in September (Investigation Note 69403A). The watershed of the Buru River is difficult terrain due to the presence of numerous faults in shale and mudstone.

Minj-Kundiawa Road, Chimbu District (69404)

Braybrooke inspected possible bridge sites on the Kerowagi, Kanigi and Wahgi Rivers and completed the Investigation Note.

MISCELLANEOUS ENGINEERING INVESTIGATIONS

Cement Industry - Port Moresby (68412)

Braybrooke inspected outcrops of limestone in the Port Moresby area throughout the year and collected samples for chemical analysis. Field assistance and information was given to representatives of companies interested in cement manufacture.

Ru River Gravels, Gigo-West New Britain (68415)

Braybrooke completed the Investigation Note on further work on these deposits as a source of concrete aggregate.

Mission Point Wharf, Wewak, East Sepik District (69402)

Braybrooke examined possible sources of rock to be used as fill and rip-rap for the new wharf. It was estimated that sufficient quantities of reef limestone are available in the Kreer Sub-Division.

The Investigation Note was issued.

Slope Stability, Kundiawa, Chimbu District (69405 and 69411)

Much of the township of Kundiawa is on slopes where landslips have occurred. Braybrooke visited the area twice at the request of the Department of Public Works. Most of the slips occur in weathered mudstone. Damage to buildings in the high covenant housing area was however found to have been caused by factors which do not indicate an imminent landslip.

Advisory Committee on Seismology and Earthquake Engineering

Four ordinary meetings and one special meeting were held by the Committee. The special meeting, on 26th March, was to meet Dr Robert A. Eppley, U.S. Coast and and Geodetic Survey and Lt. Gerald Ward, U.S.N. of Pacific Tide Party of the U.S.N. The detection of tsunamis in Territory waters was discussed.

VOLCANOLOGICAL SECTION

INTRODUCTION

STAFF AND MOVEMENTS

G.W. D'Addario - On leave from 29th May to 27th August. He attended to administrative duties and routine activities throughout the year and supervised preparation of the Observatory fixed and mobile stations for the New Britain Crustal Study Project 1969. He visited Fergusson and Normanby islands in April and Manam Volcano in October.

R.F. Heming - On leave from 9th September to carry out research at the University of California, Berkeley, U.S.A. He occupied the seismic station at Pakia, Central New Britain from 16th March to 20th April during the Stages 1 and 2 of the Crustal Study investigation. Between 24th April and 2nd May he operated the station at Toma, Gazelle Peninsula for Stages 3 and 4. He acted as Senior Geologist during G.W. D'Addario's absence on leave.

M.G. Mancini - Stationed in Rabaul throughout the year. He occupied the seismic station at Au'una from 16th March to 20th April for Stages 1 and 2 of the Crustal Study investigation. Between 24th April and 2nd May he operated a station near Mt. Varzin in the Gazelle Peninsula for Stages 3 and 4.

VOLCANIC ACTIVITY

Manam Volcano

Activity began in May when thin dust falls occurred between Yassa and Kaluguma. Similar mild activity continued through June with dust falls at Tabele and a number of explosions. The level of activity increased during July and reached a peak early in August, decreasing later that month.

In September a further increase in activity occurred and a large number of explosions were heard, followed by emissions of ash laden vapour to heights of up to 900 feet. A similar level of activity continued throughout October.

Langila Volcano

Two phreatic explosions occurred on 29th September with dust laden vapour clouds rising to 1500 feet.

Other Activity

No other volcanic activity was reported in the Territory.

SPECIAL PROJECTS AND INVESTIGATIONS

Mechanism of Epicentral Location Using only Rabaul Seismological Data (66501)

2200 earthquakes for the period December 1968 to July 1969 have been entered on the Rabaul Index Cards.

Epicentral maps, including information on depth body wave magnitude from data provided by the U.S.C.G.S., for the periods January 1962-December 1962 and June 1968 to August 1969, have been completed.

Epicentral maps, including depth information provided by the I.S.R.C. for the period 1964-1969 have been completed.

Revision of New Guinea Earthquake Epicentres (66502)

Near regional and large local earthquakes from 3rd August 1966 to 31st June 1967 have been revised and Mark Sense Cards and Phase Epicentre Data Forms despatched to the International Seismological Research Centre for final processing.

Structure and Geology of Blanche Bay and adjacent Areas (66509)

During the year the west slopes of the South Daughter and the Caldera Wall to Rabalanakaia were mapped. A number of traverses were made on the slopes of the North Daughter and a road traverse from Vunckanau to Kokopo via Tapipipi was completed. A brief visit to Latlat village, west of Vulcan, confirmed the presence of a lava flow which outcrops to the south of Taviliu and extends for one and a quarter miles from Taviliu to Latlat as a low cliff. The rock type is obsidian. The Caldera Sequence was re-examined and a large number of sites were correlated.

Short-Period Telemetry System (69501)

A single channel telemetry system comprising an amplifier and a modulator for the remote unit and a pulse shaping amplifier and de-modulator for the recording unit has been designed and tests, so far very encouraging, are in progress. Construction of prototype units is being completed to enable more detailed tests to be carried out, including operation under field conditions.

This short-period monitoring system should finally consist of a remote portable unit and a smoked paper recorder linked by radio or land line, and it is hoped that, except for the seismometer, the system could be entirely constructed at the Central Observatory workshop at very low cost.

Rabaul Crustal Model for Harbour Warning Network (69502)

Computed distances between shot points and stations were received from the Bureau of Mineral Resources. D'Addario and Mancini checked the analytical method for the location of hypocentres to be used with the harbour network stations. Results obtained during the last New Britain Crustal Study were used.

Analytical Method for Location of Regional Earthquake (69503)

Graphical and analytical methods for location of regional epicentres were reviewed. A table to facilitate the body wave magnitude determination was prepared. A suitable analytical method for rapid location of regional earthquakes was selected and the solution of the resulting equation forwarded to the Computer Application and Data Storage Centre, B.M.R., Canberra for computation.

Investigation of GARBUNA and PAGO (69504)

The preliminary investigation will consist of tests on suitable foundations for seismometers between Lollo and Pago volcanoes and between Garbuna and Wali Plantation; radio link tests between each suitable site and Cape Hoskins; and selection of the central station site in Hoskins. It will be carried out before the end of 1969.

Rabaul Crustal Study Project (67101)

Two field stations were operational during the N.D.C.S. in March-May, 1969. Preliminary analysis of seismogram records from the Harbour Network, W.W.S.S., and field stations was completed.

ROUTINE ACTIVITIES

SEISMOLOGICAL

About 28 seismogram records per day, obtained from the regional network of stations (including the C.R.A. station at Kobuan, Bougainville Island, which commenced operation in January, have been analysed at the Central Observatory in Rabaul. The Preliminary Earthquake Analysis was regularly produced every week. Daily telegrams with main information on earthquakes have been forwarded to the Washington Centre of the U.S.C.G.S. for the Preliminary Computation of the World-Wide Standard System Network Records.

Planning for the temporary installation at Rabaul of a Willmore mobile network of 10 stations, radio linked to a central recording station (records on magnetic tape), by the Institute of Geological Science, London, is completed. It is hoped that installation will be carried out in December 1969. Comments and suggestions about the geometry of the network and the position of the stations were forwarded to the Geophysical Laboratory, I.G.C., Edinburgh. The mobile network will be integrated with the existing fixed array of stations. Results will be analysed with a view to locating events deeper than 100 km. and of magnitude greater than 4.8, and small volcanic tremors; and to the acquisition of data on focal mechanism and the progression of seismicity in the region.

Seismic Activity During 1969

2301 earthquakes were recorded in Rabaul (RAB) between January and September 1969.

Local magnitude calculated at Rabaul for shocks with clear S-P intervals indicated that between January and September, 701 earthquakes had magnitude from 2.0 to 4.9, and 129 shocks had magnitude greater than 5.0.

Regional seismicity was at a low level for the first six months of the year with isolated peaks of only 16, 17-19 and 16 earthquakes per day in January, April and June respectively. Since July peaks of 15 earthquakes in one day were reached every week, with a maximum of 24 on 8th August.

Numerous earthquakes shook Esa'ala on Normanby Island and the eastern coast of Fergusson Island early in April. 5-7 shocks per day were felt with intensity I-III(MM). Felt shocks were accompanied by noise. This shallow seismic activity caused unrest among the local population of Oiau Peninsula and Dobu Island, and

villagers evacuated themselves from the coasts around Gomwa Bay and Dobu Island. A slight increase in temperature in the Fergusson Island thermal area was noticed during the ground inspection. Seismic records of the Esa'ala Observatory showed 7 types of tremors with S-P intervals from 1.0 to 1.4 sec., possibly originating below Gomwa Bay and Dobu Passage. On 15th April D'Addario recommended that villagers be returned to their homes.

A swarm type of seismic activity was again reported from Esa'ala in July. The largest earthquake occurred on 11th July and was felt with Intensity IV(MM) in Fergusson, Normanby and Dobu Islands. A few of the earthquakes which followed in the next few days were felt with an Intensity of II(MM). A Willmore portable seismograph was installed at Budoia between 20th to 29th July. Epicentre locations determined independently from Esa'ala and Budoia records and the results showed that they lay in two areas, one near the Dobu Passage and the other between Cape Dawson and Bomwa Bay. These two areas coincide with the two previous locations indicated during the April storm.

Pile driving equipment in operation at the new Rabaul wharf was clearly recorded at Rabaul WAN and SUL with a period T = 0.3-0.5 sec. and amplitude A = 2mm.

On 5th January at 2328 hrs (LT) a main earthquake, Local Magnitude 7.4 and body wave magnitude 7.2 was recorded at Rabaul but no felt report received. The epicentre was located 540 miles south-east of Rabaul in the Solomon Islands Region with co-ordinates 8.5°S., 159.0°E.

On 8th May at 0817 hrs (LT) an earthquake M_L= 5.1 was felt at Kavieng with Intensity V(MM), Lassul Bay III(MM) and Rabaul I-II (MM). On 22nd May shocks were felt at Rabaul at 0305 hrs (LT) and 0307 hrs (LT), the first with Intensity IV(MM) and the second with Intensity II(MM). Epicentres were placed 85 miles east of Rabaul between Feni Island and New Ireland.

On 24th June at 1330 hrs (LT) a large earthquake M_L = 6.2 was felt at Kailapi with intensity IV(MM), Lae, Popondetta and Kikeri with Intensity III(MM). Approximate co-ordinates of the epicentre were 5°40'S., 147°10'E., 380 km. W, SW of Rabaul in the Vitiaz Strait. Depth to the focus was in excess of 100 km.

On 16th July at 2339 hrs (LT) a main earthquake was felt at Rabaul with Intensity IV-V(MM), at Barapmang (Kieta) III(MM). The epicentre was provisionally located in the area midway between New Ireland and Bougainville Island.

A major earthquake was felt in East New Britain, New Ireland and Bougainville Island at 1022 hrs (LT) on 3rd August. Felt Intensities ranged from Intensity V(MM) at Rabaul, through IV(MM) on the Warangoi, to III(MM) at Kieta. Several after-shocks occurred within 26 hours of the major event. Five of these were felt in Rabaul with Intensities from II(MM) to IV(MM), M_L= 4.2-4.9. The epicentral area for this swarm of earthquakes was located 57 miles S.E. of Rabaul with approximate co-ordinates 05°00'S., 153°00'E.

On 6th August at 0232 hrs (LT) a large earthquake M_L = 5.8 was felt at Buka with Intensity IV-V(MM), Kieta V(MM), Rabaul IV(MM) and Warangei III(MM). Several after-shocks with M_L less than 4.5 followed it. Epicentres were located 180 miles south-east of Rabaul with approximate co-ordinates 0.6°S., 154°E.

Another large earthquake M_L=5.8 on 7th August was felt at 1150 hrs (LT) with Intensity III(MM) at Rabaul and V(MM) at Kieta. The epicentre was located just west of Bougainville Island, with co-ordinates 05°40'S., 154°10'E.

An earthquake on 20th August M_L=5.9 was felt at Talasea with Intensity VI(MM). The epicentre was located by the Rabaul Observatory just west of the Willaumez Peninsula with co-ordinates 05°20'S., 149°40'E. The U.S.C.G.S. determination gave the following computed epicentre co-ordinates 5.3°S., 149.7°E. This epicentre coincides with the one given by the Rabaul Observatory.

On 7th September at 1840 hrs (LT) an earthquake M_L=5.9 was felt at Wakunai, Bougainville Island with Intensity III-IV(MM). The epicentre was located in the Solomon Islands Region with approximate co-ordinates 5°15'S., 155°10'E.

STATIONS AND EQUIPMENT

Central Observatory, Rabaul

The air-conditioning plant was non operational from 10th to 16th September. During that period the temperature in the Equipment Room rose to 98°F causing malfunctioning of the trigger amplifier and secondary chronometer.

The construction of the new building commenced in February. The extension of the Equipment Room and Underground Water Tank was completed by the end of August, and the whole construction programme, which is behind schedule, should be completed by the end of the year.

W.W.S.S. Equipment

A new clock meter was fitted to the programming unit in January. Secondary time was introduced on 6th January when the streboscope developed a fault. The unit was repaired and primary time reinstated on 27th February.

Backlash on all recorders was checked and adjusted in June. Calibration tests were carried out in August.

New Britain Crustal Project

The broadcasting time system was repaired in February. Installation of a transmitter for the broadcasting of the signals and communications was carried out and the equipment for two field stations overhauled in time for the survey. The technical staff potential was completely absorbed by the project, which had top priority between 23rd March and 2nd May.

Rabaul Harbour Network

Good seismogram records were obtained throughout the year.

A day-time/night-time gain change system was introduced in January to increase magnification at WAN, SUL and VUL stations at night. Amplifiers at TAV and VUL were repaired in February. A horizontal component was installed at Tavurvur on 4th April.

RA-2 amplifiers were checked and adjusted and a faulty modulator at SUL replaced July.

The equipment was closed down between 22nd-29th July during the construction of the extension of the Equipment Room. Mr R. Muirhead A.N.U., Canberra, visited Rabaul between 15th and 21st August to test a set of filters and an amplifier of his construction to replace one of the RA-2 amplifiers. The new amplifier was installed on trial at WAN station.

The VHF equipment for TAV was overhauled in September.

Keravat Station

KRT station at Karavat High School was closed on 18th December 1968.

A new site was selected at the rear of the chemistry laboratory at L.A.E.S., Keravat. A vertical variable-reluctance seismometer was installed on 21st March and operated throughout the Crustal Study Project.

The three Benioff seismometers were overhauled in the Central Observatory workshop. The vertical seismometer coil was rewound and the horizontals adjusted. The seismometers were installed in the new station between 14th and 17th June.

Ulamona Field Station (The Father)

Tiltmeter readings were carried out regularly by the part-time observer.

Piva Field Station (Mt. Bagana)

Regular tiltmeter readings were received throughout the year from the part-time observer.

Agenahambo Station

The seismograph was operational only from 2nd to 23rd February, and from 22nd May to 27th July. Records were very poor in July and it appears that the part-time observer was relying on main charger to keep the battery charged. This resulted in great variation of light intensity with loss of part of each day's seismic record. The seismograph was again non-operational from August until 14th October when J. Mathison (T.O.) visited the station to effect a major overhaul.

Manam Island

Tabele Observatory

In January the equipment was serviced and a new Mercer clock fitted. Water-tube tiltmeter pots were also cleaned. Daily information was received regularly.

Waris Station

Telegrams with information on Main Vent and Tiltmeter readings were received regularly from the part-time observer, although it was established that some of these were unreliable and steps were taken to improve the service.

Esa'ala Observatory

The SP film recorded and LF-Z photographic paper recorder were non-operational till 19th February.

Seismic equipment operated reasonably well until July, when a major overhaul including replacement of parts was carried out.

In May the air-conditioning plant was overhauled and since then has been working more satisfactorily.

Technical Developments

The standard installations of two interchangeable crystal chronometers to out stations was planned and the first pair established at Esa'ala. In the event of failure of the working unit the stand-by unit is automatically switched on.

The construction of equipment for 3 portable Willmore field stations was completed.

A single channel telemetry SP System was designed and constructed in the workshop.

EDITING AND PUBLICATION

The editing process in the Geological Branch was thrown into some confusion as a result of the partial reorganization of the Bureau in November 1968: the principal editor was promoted to another position, and because of the intention to transfer the function to another Branch the editing position was held vacant for several months, until the pressure of work grew so great that a temporary appointment to the position had to be made.

As a result, the throughput has been considerably less than usual. The lag has been aggravated by the receipt of sevefal recalcitrant papers, whose processing has taken far longer than was expected, and by the overloading of the Drawing Office with illustrations, which has imposed a considerable delay in the submission of manuscripts to press.

The following publications have been sent to press during 1969:

Bulletin 56 : Devonian and early Carboniferous Brachiopods from Western and Northern Australia, by G.A. Thomas.

Bulletin 84 : Geology of the Hodgkinson and Laura Basins, Queensland, by F. de Keyser and K.G. Lucas.

Bulletin 106 : Precambrian Geology of the Kimberley Region: The East Kimberley, by D.B. Dow and I. Gemuts.

Bulletin 109 : Sedimentology of the Upper Devonian and Carboniferous Platform Sequence of the Bonaparte Gulf Basin, by J.J.Veevers.

Bulletin 110 : Cambro-Ordovician Conodonts from the Burke River Structural Belt, Queensland, by E.C. Druce and P.J. Jones.

Bulletin 112 : Late Upper Cambrian Trilobites from the Gola Beds, Western Queensland, by J.H. Shergold.

Bulletin 113 : Nepeid Trilobites of the Middle Cambrian of Northern Australia, by A.A. Öpik.

Bulletin 114 : Redlichia of the Ordian (Cambrian) of Northern Australia and New South Wales, by A.A. Öpik.

Bulletin 115 : Lower Carboniferous spores from the Bonaparte Gulf Basin, Western Australia and Northern Territory, by G.E. Playford.

Bulletin 116 : Palaeontological Papers, 1968, by Various authors.

Report 127 : Geology of the Townsville 1:250,000 Sheet area,Queensland, by D.H. Wyatt and others.

Report 128 : Geology of the Ayr 1:250,000 Sheet area, Queensland, by A.G.L. Paine and others.

1:250,000 Series Explanatory Notes: Ayr, Mount Liebig, Mount Elizabeth, Alice Springs, Finke, Mount Coolon, Durham Downs, Illogwa Creek, Buchanan, Canterbury, Connemara, Daly Waters, Helen Springs, Jundah, Windorah, Cambridge Gulf, St. Lawrence, Richmond, Charters Towers, Adavale. (20).

Publications in an advanced state, which may well go to press before the end of 1969, included:

Bulletin 100 : Geology of the Amadeus Basin, N.T., by A.T. Wells and others.

Bulletin 107 : The Lamboo Complex, by I. Gemuts.

Bulletin 117 : Conodonts from the Lower Palaeozoic of the Bonaparte Gulf Basin and the Daly River Basin, by P.J. Jones.

Report 135 : ANARE 1961, Geological Traverses on the Mac.Robertson Land and Kemp Land Coast, by D.S. Trail.

Report 137 : Geology of the Charters Towers 1:250,000 Sheet area, by D.H. Wyatt and others.

Report : Geology of the Taroom, Eddystone, and Western Mundubbera 1:250,000 Sheet areas, Queensland, by R.G. Mollan and others.

Report : Geology of the Tambo and Augathella 1:250,000 Sheet areas, Queensland, by N.F. Exon and others.

Explanatory Notes: 16 volumes in the explanatory notes series are ready for press except for their illustrations. Five or six will probably go to press in 1969.

The success of the annual volume of palaeontological papers, of which four are now issued or in press, has prompted the initiation of a similar series of geological papers, of which the first volume will go to press early in 1970. The editorial group is also encouraging the compilation for publication of bibliographies of various facets of Australian earth sciences.

MINERAL REPORTS GROUP

As a result of the re-organization of the Branch late in 1968, the work of stratigraphic indexing, mineral indexing and preparation of mineral deposit reports, and maintenance of technical files were onsolidated in this group.

Stratigraphic Index:

The Stratigraphic Index received a small but steady stream of visitors and enquiries through the year, both from B.M.R. personnel and from outside geologists in State surveys, Universities, and companies.

The Index of Stratigraphic Names of Australia and T.P.N.G. was maintained through a continuous search of published literature reaching the B.M.R. Library. Some duplication of names is still occurring; however, the index of names reserved and awaiting publication continued to be useful as shown by the decline in the number of invalid names from 33 in 1967 to 18 in 1968.

Issue of bimonthly variations lists by the Index to State Surveys, Universities, and interested companies continued. These record new proposed names and first publication of stratigraphic names.

A bibliographic reference card is prepared for each paper indexed. This contains an alphabetical list of any stratigraphic names in the paper. Duplicates of these cards are sent to appropriate State Geological Surveys. Similar cards, containing only the bibliographic reference, are sent to the B.M.R. Library for filing under the heading Author, Subject, and 1:250,000 Sheet areas; the indexing of papers according to subject and sheet areas is done by the stratigraphic indexer.

All the State Surveys were asked for a list of coal seam names used in their State. Although coal seams are not in the scope of the stratigraphic code at present, these names, especially the well known ones, will be taken accountof when proposed stratigraphic names are checked for availability.

A preliminary survey was made of the feasibility of applying computer storage methods to parts of the index.

Work on Fasicule 5(h) of the index to the Lexicons of Stratigraphic Names has been suspended since December 1968 due to staff shortages.

Mineral indexing and mineral reports: Numerous enquiries about Australian mineral resources were received during the year, and the occurrence and possible occurrence of various commodities was discussed with company representatives.

The simple index to literature on Australian mineral deposits was maintained; the proposed information retrieval system for data on Australian mineral deposits could not be put into effect for lack of staff. The desirability of adapting the proposed system to computer handling will be investigated because of the envisaged development of other computer-based information systems in B.M.R.

The 'Phosphate' and 'Aluminium' chapters of Bulletin 72 were revised and a short note written on oil shale occurrences in Queensland. At the request of the Water, Power and Geographic Branch of the Department, important new mineral localities were added to the Mineral Deposits map of the map, and the commentary on the map was revised. Supervision of compilation of the Metallogenic Map of Australia continued.

Technical Files: Recording and indexing of unpublished data in the technical file system continued. The files now keep one copy of Amdel reports, which previously were stored in diverse places. Use of the files by staff of the Branch and of other Branches is increasing.

COMPUTER APPLICATIONS

The development and adaption of computer programs to assist in the analysis and interpretations of geological data was continued. In addition a considerable amount of time was spent on the maintenance and revision of existing programs, gaining experience in their use, and assisting other geologists to use them.

A report describing the geochemical variation of the Fountain Formation was completed. Work is in progress to determine the geochemical variation in siltstones of Upper Proterozoic age in the Kimberley Region of Western Australia, based on a set of 180 samples which were collected by a nested sample design. The concentrations of the major oxides and trace elements were determined at A.M.D.L. and in the B.M.R. Laboratories. X-Ray diffraction charts for each sample were prepared by G. Berryman, and methods for their quantitative interpretation are being investigated.

A project to demonstrate the use of the C.D.C. Software package INFOL for the storage and retrieval of palaeontological references was completed. An investigation was begun on the use of this system to index B.M.R. Publications.

TRANSIT ROOM AND SAMPLE SUBMISSION

One function of the transit room is to send on to the appropriate contractor or group in B.M.R. samples submitted for thin-sectioning or detailed laboratory work, and to arrange, where necessary, the appropriate financial documentation. An average of about 1000 samples are handled each month.

Plans were made some years ago to store sample information on punch cards, but were only partly implemented. The system proposed was reviewed during the year, with the object of using computer storage and retrieval methods for sample data. The sample submission form has been re-designed as a first step towards use of these techniques, and card-punching of data on samples will begin when the re-designed form comes into use. The transit room officer will be responsible for this work.

GEOLOGICAL DRAFTING

1. Sheet Maps

(a) 1:250,000 Series

14 sheets published (including 1 reprint)
14 sheets in press (including 1 reprint)
18 sheets fair drawing in progress.

(b) 1:63,360 Series

2 sheets, fair drawing in progress.

(c) 1:500,000 Scale

Amadeus Basin (2 sheets), fair drawing in progress
Cape York - Maer (1 sheet) fair drawing in progress
Tambo - Augathella (1 sheet), fair drawing in progress

(d) Australia and Oceania 1:5,000,000 Series

Sheets 6, 7, 11 and 12, reprinting.

(e) Metallogenic Map of Australia & New Guinea, compilation in progress
Tectonic Map of Australia & New Guinea, compilation in progress
World Geological Map (Australia only) compilation in progress.

2. Preliminary Maps

(a) 1:250,000 Scale

16 sheets (plus "layout sheet") published
2 sheets in press
14 sheets in progress

(b) 1:500,000 Scale

1 sheet printed

(c) 1:1,000,000 Scale

1 sheet published

3. Photogeological Maps, 1:250,000 Scale

3 sheets completed
2 sheets in progress

4. Drawings for Records, Reports, Explanatory Notes and Bulletins.

570 drawings completed
52 drawings in progress

5. Staff

Chief Draftsman Grade 2	-	1
Chief Draftsman Grade 1	-	1
Supervising Draftsmen	-	4
Senior Draftsmen	-	5
Draftsmen Grade 2	-	6 (plus 1 acting as Senior with Petroleum Exploration Branch)
Draftsmen Grade 1	-	5 (plus 1 National Service (plus 1 Leave without pay)
Drafting Assistants Grade 2	-	4
Drafting Assistants Grade 1	-	3
Trainees ..		4