DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/174

GEOLOGICAL BRANCH

SUMMARY OF ACTIVITIES

1973

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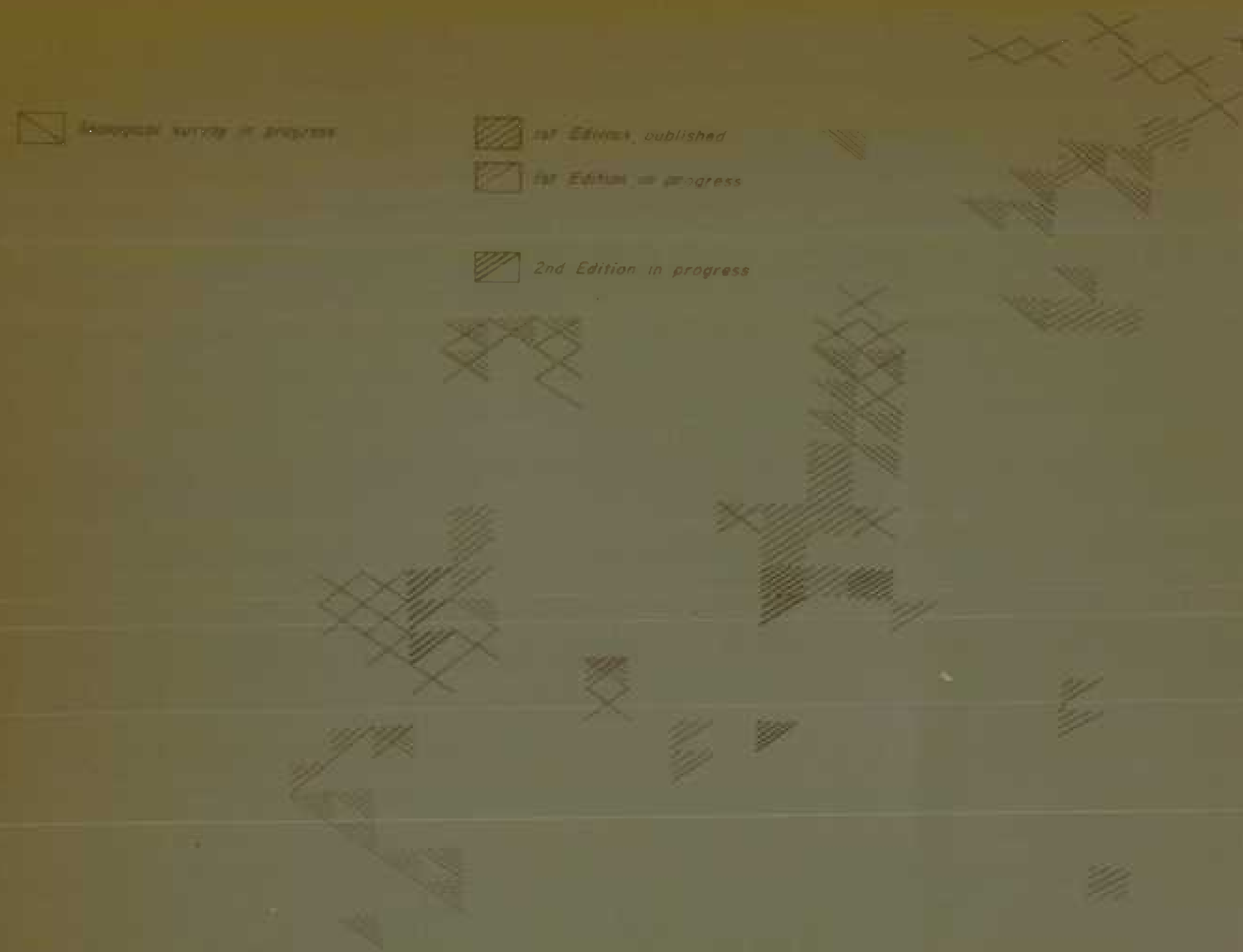


Progress in geological field mapping and series map production in the year ended 31 Oct 1973

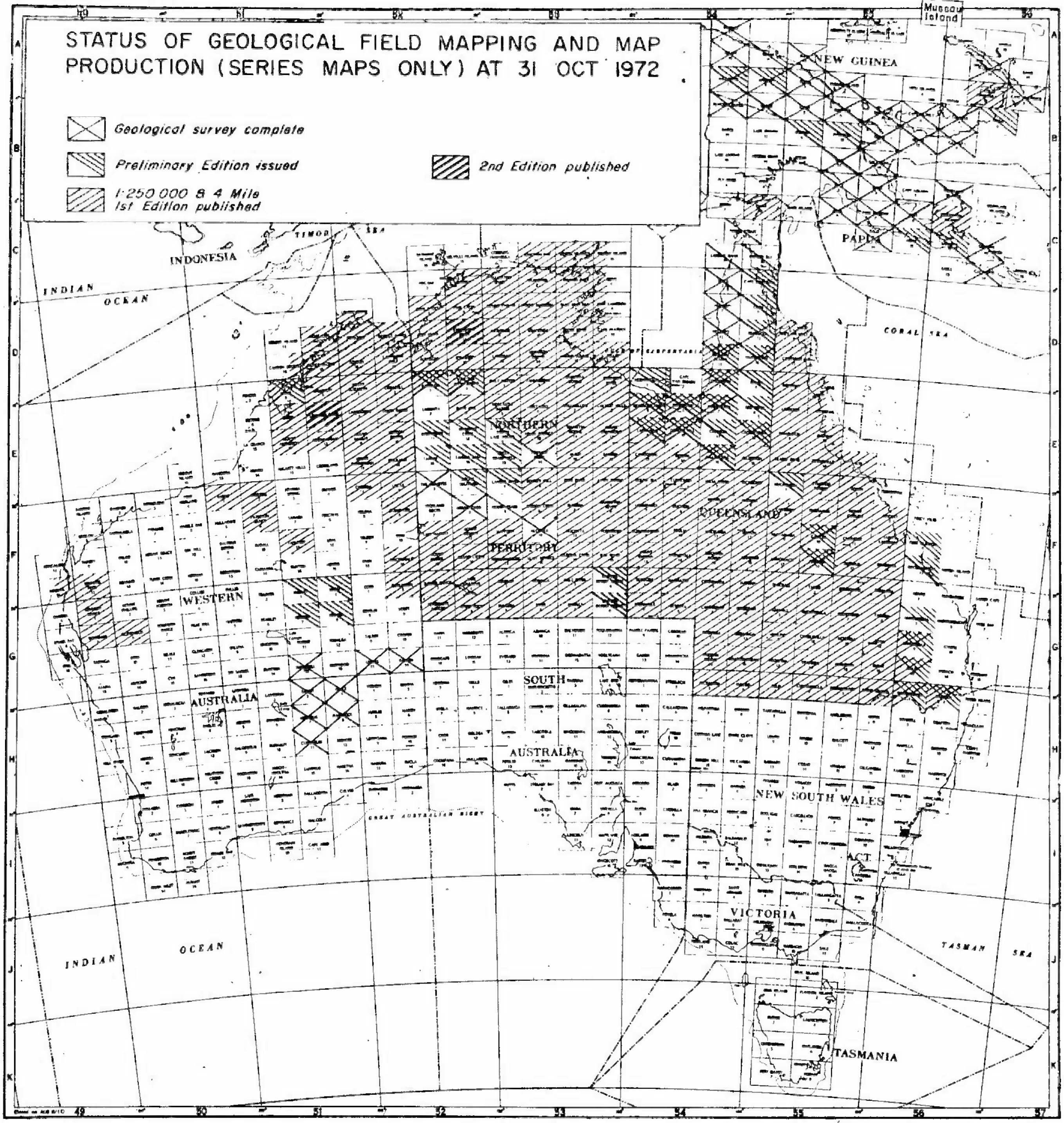
CUMPSTON MASSIF	MAWSON ESCARPMENT NORTH	MOUNT MENZIES	WILSON BLUFF
GOODSPEED NUNATAKS	MAWSON ESCARPMENT SOUTH	MOUNT TWIGG	
GROVE MOUNTAINS	MOUNT CRESSWELL	SS40 - 42/15	

PRELIMINARY EDITION ISSUED

BEAVER LAKE	FISHER MASSIF - MOUNT HICKS	OYGARDEN & LAW PROMONTORY
CROHN MASSIF	MAWSON - MOUNT HENDERSON	STINEAR NUNATAKS

(OVERLAY)
AUS 2/314

FRONTISPIECE (1)



1:250 000 B56-8 BOUGAINVILLE-BUKA, PNG, ALSO PUBLISHED

PUBLISHED 1 MILE SERIES MAPS

ALMADEN	CHILLAGOE	HUMPTY DOO	MOUNT HAYWARD	MUNGANA	TENNANT CREEK
BAN BAN	DALY RIVER	KATHERINE	MOUNT STOW	RANFORD HILL	TIPPERARY
BATCHELOR	DILGIN HILL	LEWIN SPRINGS	MOUNT TODD	RAVENSWOOD	TUMBLING WATERS
BLACK CAP	GOODPARLA NORTH	MARRAKAI	MOUNT TOLMER	REYNOLDS RIVER	WATERHOUSE
BURNSIDE	GOODPARLA SOUTH	MOUNT BUNDEY	MULDIVA CREEK	RUM JUNGLE (SPECIAL)	WOOLWONGA
BURRUNDIE	HERBERTON	MOUNT GARNET	MUNDOGIE HILL	SOUTHPORT	

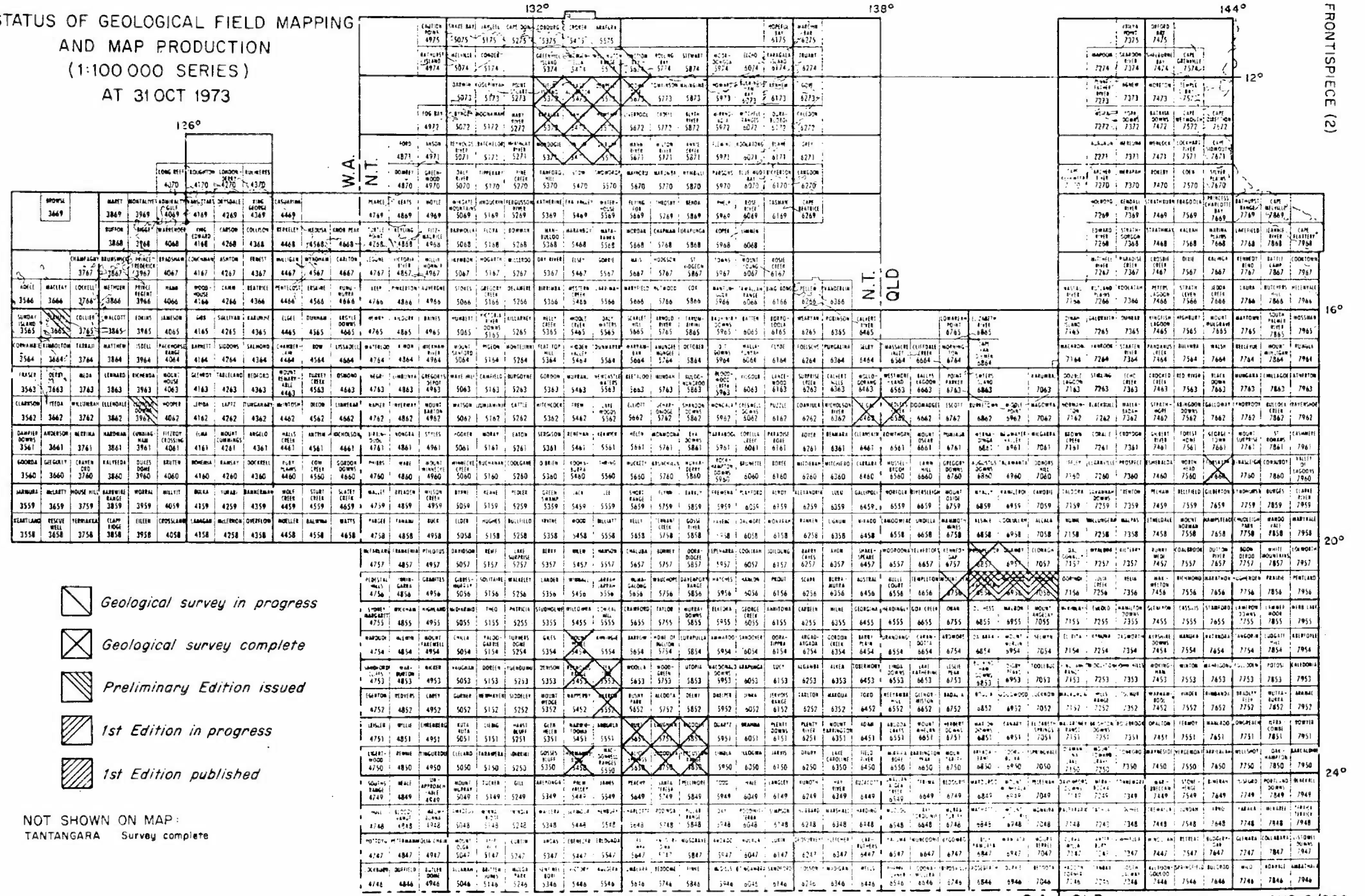
1:100 000 - MAPPING SEE FRONTISPIECE (2)

ANTARCTICA 1:250 000

FIELD WORK IN PROGRESS

To accompany Record 1973/174 AUS 2/314

STATUS OF GEOLOGICAL FIELD MAPPING AND MAP PRODUCTION (1:100 000 SERIES) AT 31 OCT 1973



To accompany Record 1973/174

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GEOLOGICAL BRANCH
ANNUAL SUMMARY OF ACTIVITIES
1973

RECORD 1973/174

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SUMMARY

SEDIMENTARY SECTION

Priority was again given to completing the 1:250 000 geological mapping of sedimentary areas. Four parties, three including geologists from State surveys, were engaged full time on regional mapping and stratigraphic drilling in the Carpentaria, Canning and Western Eromanga Basins, and in the Melville-Cobourg area of the Northern Territory. Six geologists spent the year preparing maps, and reports, and synthesizing the results of earlier regional mapping in the Eromanga, Officer, Surat and Ngalia basins. A record 19 preliminary geological maps were issued, including a 3-colour line map of the Southern Carpentaria Basin at 1:1 000 000 scale.

Hydrological activities continued and good progress was made with the Great Artesian Basin study. Three-quarters of the selected basin data from State water authorities has now been processed and it is planned to feed this into and test the mathematical hydrological model in 1974. Water bore logging continued; 45 bores, mainly shallow, were successfully logged in the Surat Basin, Qld and the information used in the synthesis of the geology of the basin and in the Great Artesian Basin Study. Following similar success in the Carpentaria Basin in 1972 shallow stratigraphic drilling proved the presence of high quality artesian water in a Mesozoic aquifer in Cobourg Peninsula, Northern Territory in 1973.

Detailed geological mapping of the Tantangara 1:100 000 Sheet near Canberra was completed and mapping of the adjacent Brindabella Sheet started. This resulted in considerable modification to the previously interpreted history of the area. A 3-year study of chemical weathering, superficial geology, land form development and Cainozoic tectonics in SW Queensland was started. Cores were taken through the various weathered profiles for mineralogical and chemical examination. Evaporite studies included the drilling of one of the Madley Diapirs in the Officer Basin, and the completion of a draft review of Australia-wide evaporite occurrences.

Sedimentological studies include reporting and laboratory work on modern estuaries (Broad Sound, Qld; Mallacoota Inlet, Vic), studies of core from site 262 in the Timor Trough by a geologist who took part in Leg 27 of the Deep Sea Drilling Project in the Indian Ocean, studies of well exposed Permian sequences in the northern part of the Bowen Basin by two Colombo-Plan fellows from the Geological Survey of India, and laboratory work on samples collected from the Upper Devonian and Lower Carboniferous sequences in the Canning Basin. Field work was undertaken in Lake Frome, SA as a start of a study to determine whether sediments and fluids in such an internal drainage system could concentrate metals through evaporation or the action of organisms. Auger samples from 60 locations throughout the lake show that organic matter is common and that pyrite is present in both sand and mud. Further work on samples of heavy mineral sands from offshore NSW and Qld has shown that broad stratigraphic units can be recognised and interpreted.

The marine geological reconnaissance of the eastern Australian continental shelf was extended into Bass Strait and around Tasmania from February to May. A study of echograms obtained by the Division of National Mapping during their bathymetric survey of the continental shelf was started. Fossil shorelines recognized in the records will be a valuable guide to the location of submerged strand lines which may have relevance for heavy mineral occurrences.

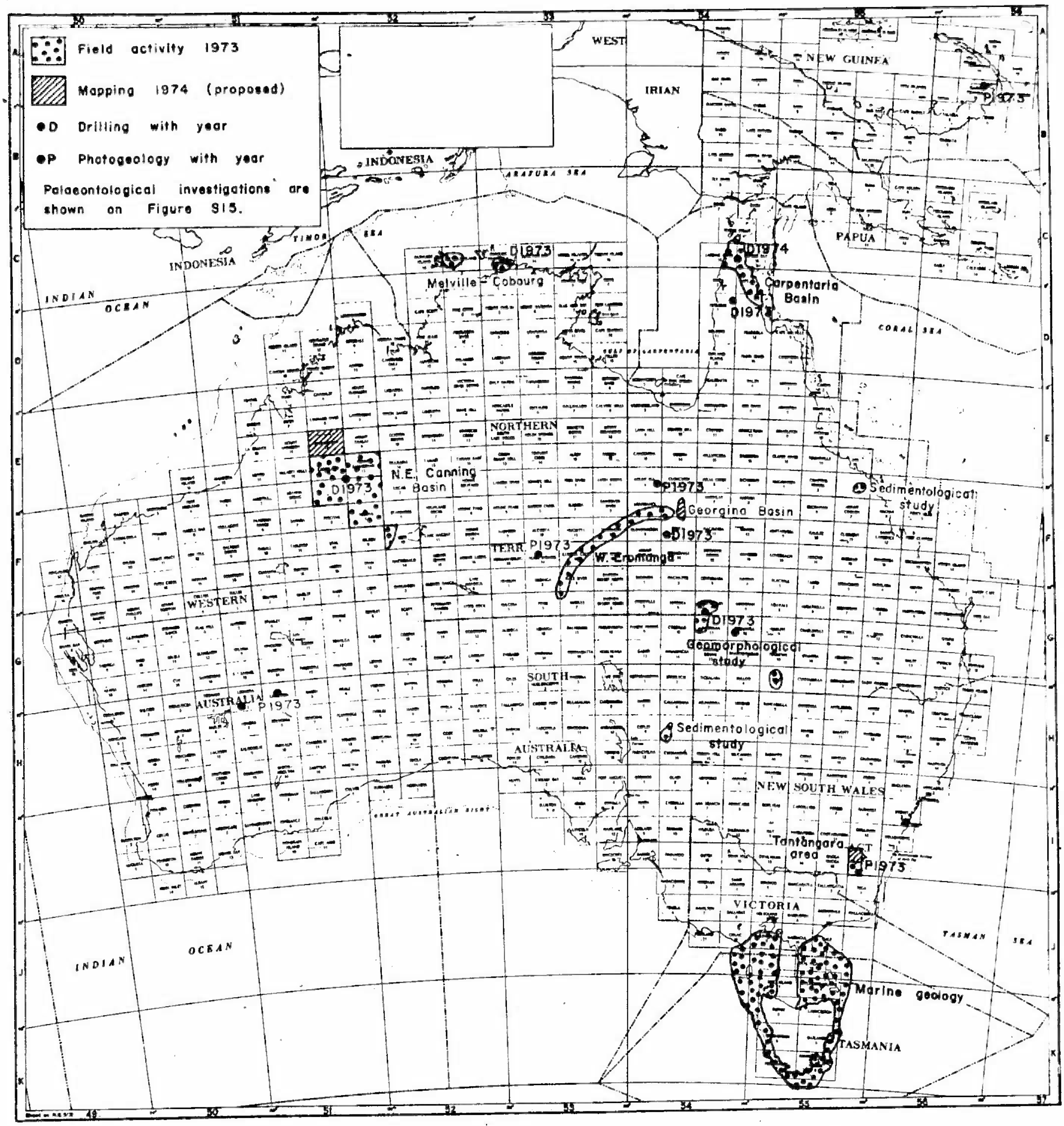

Figure SI : Sedimentary Section Field Activities.

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The photogeological and remote sensing group were again heavily involved in administrative matters relating to the Australian Committee for Earth Resources Technology Satellites (ACERTS). Imagery from ERTS-1 was evaluated and proposals for participating in ERTS-B and SKYLAB were formulated. Evaluation of SLAR imagery continued. Thermal infrared imagery was obtained over the Rabaul area to assist in locating thermal areas within the caldera.

The palaeontological group continued systematic descriptions of faunas and floras from Australia, Papua New Guinea, and Antarctica and several major studies were written up in the Bulletin series. Much of the work is directly connected with assisting field mapping projects, particularly in Papua New Guinea, and in the Carpentaria, Officer, Canning and Eromanga Basins.

METALLIFEROUS SECTION

Figure M1 shows the areas where geological mapping and other field activities were carried out by the Metalliferous Section in 1973, as well as areas where similar operations are planned for 1974.

Regional mapping was carried out in the Arunta, Granites-Tanami, Red River, and Wewak areas and in Antarctica, and semi-detailed mapping in the Alligator Rivers, Mount Evelyn, Mount Isa, Westmoreland, Georgetown, and Rum Jungle areas, and in the Arunta Block.

Laboratory staff took part in a number of field projects involving mapping, petrological and geochemical studies, and geochronology, as well as designing and executing their own geochemical sampling programs in the Georgetown and Westmoreland areas.

Semi-detailed mapping of the basement rocks in the Alice Springs 1:250 000 Sheet area has been completed. Isotopic dating of rocks in the Hermannsburg 1:100 000 Sheet area has set an older limit of about 1080 m.y. for the time of deposition of the Heavitree Quartzite, the basal Formation of the Amadeus Basin succession; a migmatization event in the Arunta Block took place at that time.

Reconnaissance mapping of the Granites-Tanami region as far south as the Webb Sheet area has been completed. Parts of the Mount Ramsay and Mount Bannerman Sheet areas were visited to correlate formations in the Granites-Tanami region with those in the adjacent Kimberley region.

Semi-detailed mapping of the Alligator River 1:250 000 Sheet area was completed, except for the southern half of the Kapalga 1:100 000 Sheet area. A more complete understanding of the components and structure of the Nanambu and Nimbuwah Complexes came out of the year's work. There appears to be a relationship of the main uranium deposits and prospects, not only with the margins of the complexes, but also with metamorphosed equivalents of the Koolpin Formation.

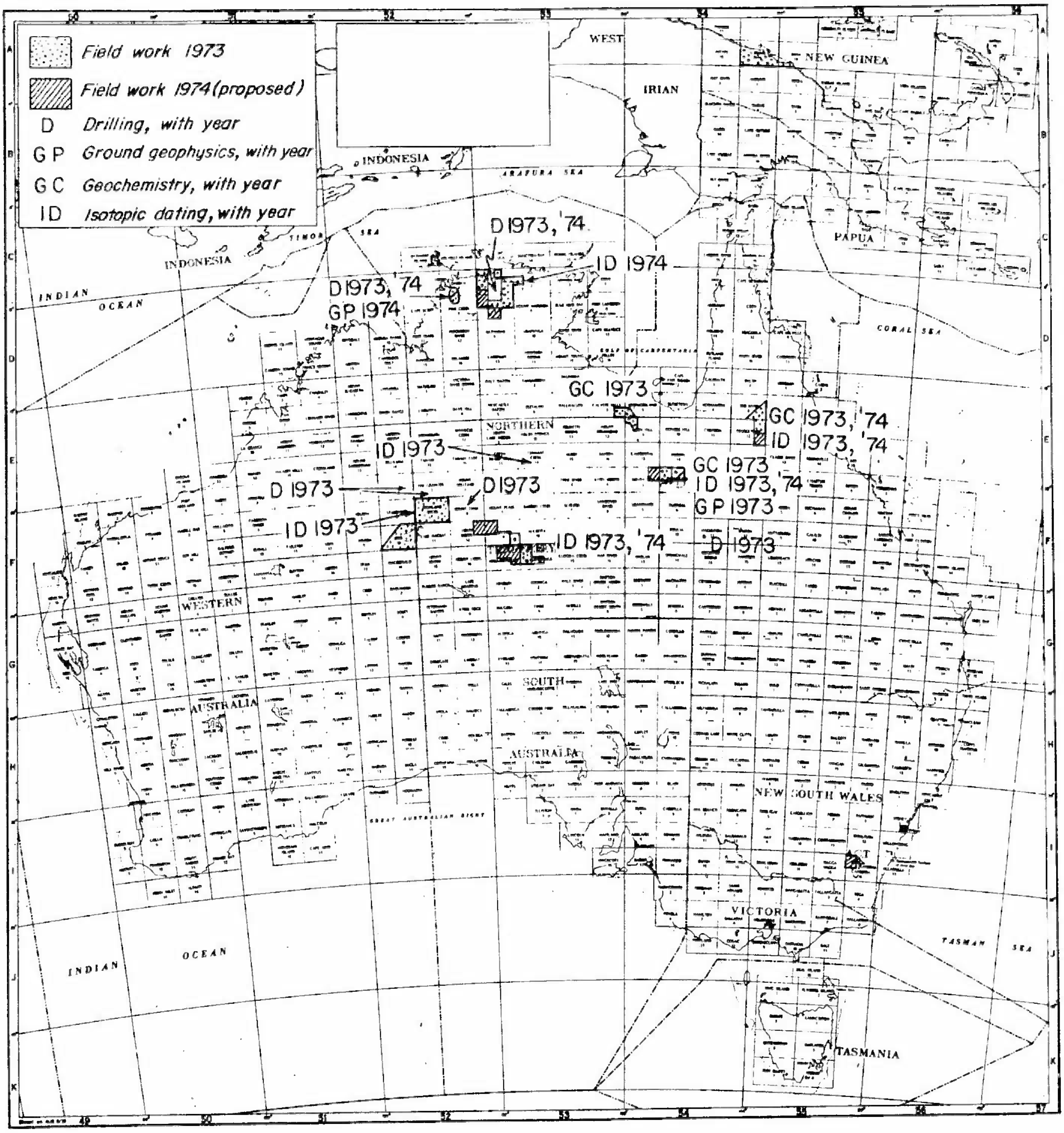

Fig. M1. Field activities, Metalliferous Section

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Semi-detailed mapping of the Prospector 1:100 000 Sheet area strengthened earlier evidence that the upper part of the Surprise Creek Beds and the Mount Isa Group are correlatives. Correlation of the eastern and western sedimentary successions across the basement complex remains a problem.

Mapping of the Seigal and Hedleys Creek 1:100 000 Sheet areas was completed, and reconnaissance traverses were carried out on the Bowthorn and Lawn Hill 1:100 000 Sheet areas. Correlation of formations below the South Nicholson Group in the Seigal-Hedleys Creek area and the Lawn Hill 1:250 000 Sheet area is difficult because of lack of continuity of outcrop, but it is nevertheless of considerable importance because the rocks in the Lawn Hill area form a belt that is virtually continuous with the Mount Isa region. Field relationships suggest that both the so-called Nicholson Granite and the Norris Granite (previously regarded as the younger of the two), intrude the Cliffdale Volcanics. It is now proposed that all granites should be brought together under the name "Nicholson Granite Complex", the complex has been tentatively divided into six phases, and mineralization in the area is thought to be associated with some of the younger phases.

Reconnaissance mapping of Precambrian rocks in the Red River 1:250 000 Sheet area was carried out by helicopter. Mapping of the Forsayth 1:100 000 Sheet area was completed except for a small area in the southeast. Field evidence shows that the Robin Hood Granite is younger than previously thought. The discovery of many rhyolite dykes occupying faults peripheral to the Newcastle Range Volcanics lends support to Branch's suggestion that the volcanics occupy a cauldron subsidence area. The relationships between the Etheridge Formation and the Robertson River and Einasleigh Metamorphics are complex; it is hoped that isotopic dating will help to clarify these relationships.

Mapping of the mountainous country north of the Sepik River, PNG, was completed. Basement rocks in the area consist of Eocene to Lower Miocene basic and intermediate volcanic rocks intruded by granodioritic to gabbroic plutons; all these rocks are intersected by crush-zones up to several kilometres wide which may have been formed as a result of interaction between crustal plates. Slices of ultramafic rocks have been caught up in the crush-zones in a few places. The basement rocks are overlain by poorly consolidated Neogene flysch and shallow-water clastic sediments.

Geological mapping in Antarctica showed the metamorphic grades in the southern Prince Charles Mountains range from greenschist to granulite facies, and that polymetamorphic effects are widespread. Glacial striae and roches moutonnes on flat mountain tops indicate that ancient ice-flow directions were roughly parallel to those of the Lambert Glacier system, and that ancient ice-levels were up to 800 m above present levels.

Laboratory staff took part in field work in the Arunta, Westmoreland, Mount Isa, and Georgetown areas as well as in Antarctica.

An extensive petrological and geochemical study of acid igneous rocks from northeast Queensland is nearing completion. Stanniferous granites in this area, like those in other parts of the world, are enriched in volatile elements such as boron, beryllium, lithium, and fluorine.

Field work in the Aileron 1:100 000 Sheet area suggests that there is a relation between granulite-facies metamorphism and the origin of granites.

Detailed petrological, geochemical, and mineralogical (micro-probe) studies of Antarctic rocks are planned to provide information which, it is hoped, will lead to a better understanding of granulite and amphibolite facies metamorphism, and the relation between these facies in MacRobertson Land.

Stream-sediment and other kinds of geochemical sampling were carried out in the Georgetown and Westmoreland areas using a helicopter. Large (10 kg) samples of stream sediments were collected from pre-determined sites, and these were then sieved at base camp. Background sampling of several formations in the Westmoreland area was carried out.

Analytical and petrographic work and processing of results for the Tennant Creek geochemical project continued. Analytical problems arising from the high iron content of the ironstones were overcome. Interesting and probably significant variations were shown in the bismuth, copper, cobalt, manganese, and molybdenum contents of the ironstones. A model system involving derivation of granitic rocks, diorite, and lamprophyre through contamination of a basic magma by Warramunga sediments is being considered. As a by-product of this process, iron, silica, and magnesium-rich solutions carrying trace amounts of other metals migrated into situations where the lodes and ironstone bodies are located.

Pollution of the Molonglo River system and Lake Burley Griffin caused by tailings dumps and abandoned mine workings at Captains Flat continued to be studied. Additional sampling stations were set up within 5-6 km of Captains Flat to establish more clearly the actual manner of pollution of the Molonglo River water by zinc and sulphuric acid.

Dating of rocks from the Mount Isa-Cloncurry area suggests that the Mount Isa Group is less than 1570 m.y. old, and not older than 1930 m.y., as postulated in a recent publication.

Satisfactory dates of about 1800 m.y. for certain granites and related acid volcanics in the Granites-Tanami area have been established. Another of the granites (Lewis Granite) appears to be distinctly younger (1600-1700 m.y.) than this, but further work remains to be done. A glauconitic sandstone from the Gardiner Formation has been dated at about 1600 m.y., an age that is in agreement with field relations and ages determined on underlying igneous rocks.

Check determinations on the Elizabeth Creek and Herbert River Granites have confirmed earlier results indicating that their ages overlap; in most places, however, the Elizabeth Creek Granite is older than the Herbert River Granite.

Work in the Baas Becking Geobiological Research Laboratory showed that the enrichment of the light isotope of sulphur in stratiform ore bodies could be indicative of biological activity during ore genesis. A simulated sedimentary system proved to be a useful medium in studies of geobiological problems such as the formation of sulphide minerals, diagenesis of metastable carbonates, the distribution and accumulation of metals, and the participation of microorganisms in such processes.

Experimental work has confirmed the importance of concentrated brines in the transport of lead and zinc at low temperatures. It was found that, with increasing brine concentration, the increase in the solubility of lead is very much greater than that of zinc.

A geochemical investigation of sedimentary rocks associated with the McArthur lead-zinc deposit showed that shales characterized by anomalous lead, zinc, iron, arsenic, and mercury contents extend laterally for at least 20 km from the ore deposit; shales showing such should therefore be useful in prospecting for orebodies of the McArthur type.

Field work directed partly at preparing a revised edition of the Rum Jungle Special map continued. Owing to lack of outcrop, the contact between the Coomalie Dolomite and the Golden Dyke Formation, which is important for ore localization, has not been well established in many places, and was therefore checked by drilling in a few of these places. In one area it was found to be about 2.4 km west of the position shown on the existing map. The contact between granite and sediments in many places around both the Rum Jungle and Waterhouse Complexes was found to be strongly sheared and steeply dipping. The steep dips of the sheared contact and of the sediments unconformably overlying the basement complexes can probably be explained by updoming of the complexes, possibly through post-Archaean granite intrusion. Such granite may have been at least partly responsible for concentration of ore minerals in the area. A study of Brown's lead-zinc-copper deposit and its host rocks has been started.

Publications and Records issued and in various stages of completion are listed in a separate section of this report. Totals for the period under review are:

Bulletins: Published 6, in press 3, in preparation 4.

Reports: Published 1, in press 8, in preparation 2.

Maps and Explanatory Notes: Published 9, in press 7, with editor 8.

Special Maps: Published 1, with editor 2.

Outside publications: Published 26, in press 16, submitted 17, in preparation 9; 11 of these were accepted for publication in the new A.I.M.M. volume on the Economic Geology of Australia and PNG.

Records: Issued 22, with P. & I. Section 1, in preparation 11.

GEOLOGICAL SERVICES SECTION

The continued rapid growth of Canberra maintained the demand for engineering geological services. The systematic evaluation of the Tuggeranong urban development area was completed, and follow-up work and project-type investigations were continued or initiated as required: e.g. assessment of the Isabella Plains groundwater conditions, foundation and excavation conditions for the Tuggeranong Town Centre, the effect of the construction of a dam on Tuggeranong Creek, and geological constraints on the development of the Lanyon area. General geological and soils mapping, at 1:25 000 scale, and evaluation of the Gungahlin urban development area were completed and more detailed work was done in the Halls Creek sector. Studies of several smaller areas in the ACT were also undertaken.

Excavation of the 30 000 foot-long Tuggeranong Sewer Tunnel is more than three-quarters complete and conditions continue to prove to be as predicted from previous geological and geophysical investigations; geological services were provided throughout the year. Construction of the Molonglo Valley Interceptor Sewer started in the middle of the year. Geological design investigations for Googong Dam, on the Queanbeyan River, were completed; construction work is expected to begin early next year.

Preparation of standard geological maps of Canberra urban areas and accompanying notes continued. Hydrological work in and around the ACT continued; it included some detailed studies in development areas and conversion to metric of hydrological records. Assistance was given with the investigation of a site for a second steam power station at Darwin, N.T.

The Map Editing and Compilation Group completed the editing of 21 maps. The 1:2 500 000 scale PNG mineral deposits map and notes were finalized and compilation of the 1:2 500 000 NT geological map was completed. Planning of the format and reference for a 1:2 500 000 scale geological map of Australia (in 4 sheets) was undertaken.

The work of the Indexing group was greatly increased by the requirement to check the typescript of the 4-volume AIMM "Economic geology of Australia and Papua New Guinea" with over 600 articles. Fascicule 5H-Australia, General-of the International Stratigraphic Lexicon was sent to the printer, in Paris. Mineral resources reports on bauxite, nickel and phosphate were revised for new editions, and commodity reports on tin and uranium are being prepared. The mineral index is being up-dated.

Substantial progress was made with the reorganization and proper storage of rock, fossil and mineral collections. Most of the museum's mineral specimens were recorded on computer-compatible index cards. Several most fruitful field collecting trips and exchanges were made and displays were arranged as required. The Transit Room handled 8775 samples on which specimen preparation or determinations were required.

A high level of production was maintained by the Geological Drawing Office; nevertheless, a backlog of work continues in most sections of the Drawing Office.

Twelve Records were issued from the Section during the year and 14 others were written and being processed at the end of the period. Six publications were submitted to editors or sent to press.

SEDIMENTARY SECTION

REGIONAL MAPPING PROJECTS

CARPENTARIA BASIN PROJECT

by

J. Smart

Staff: H.F. Doutch, J. Smart, S. Powell, D.L. Gibson (BMR), K. Grimes (GSQ).

The work of the Carpentaria Basin Party in the year ending 31 October, 1973 consisted of compilation of maps and reports from 1972 fieldwork in central Cape York Peninsula (see appropriate sections of this Record for details), field mapping further north, comprising the last of the onshore 1:250 000 sheet areas, field checking and revision of sheets mapped in previous years and an extensive rotary drilling and augering programme to examine problems of Cainozoic and Mesozoic stratigraphy in the northern part of Cape York Peninsula.

Field work in 1973 involved the mapping of JARDINE RIVER, TORRES STRAIT, ORFORD BAY and COEN 1:250 000 sheet areas and revision and problem checking in WEIPA, AURUKUN and CAPE WEYMOUTH sheet areas. Ground and helicopter traverses were supplemented by shallow auger holes (18 m max) to help fix boundaries in areas of poor exposure and to examine certain Cainozoic units. Helicopter spot checks were made in HOLROYD, EBAGOOLA, WALSH, RED RIVER, ATHERTON, GEORGETOWN, GILBERTON and CLARKE RIVER Sheet areas.

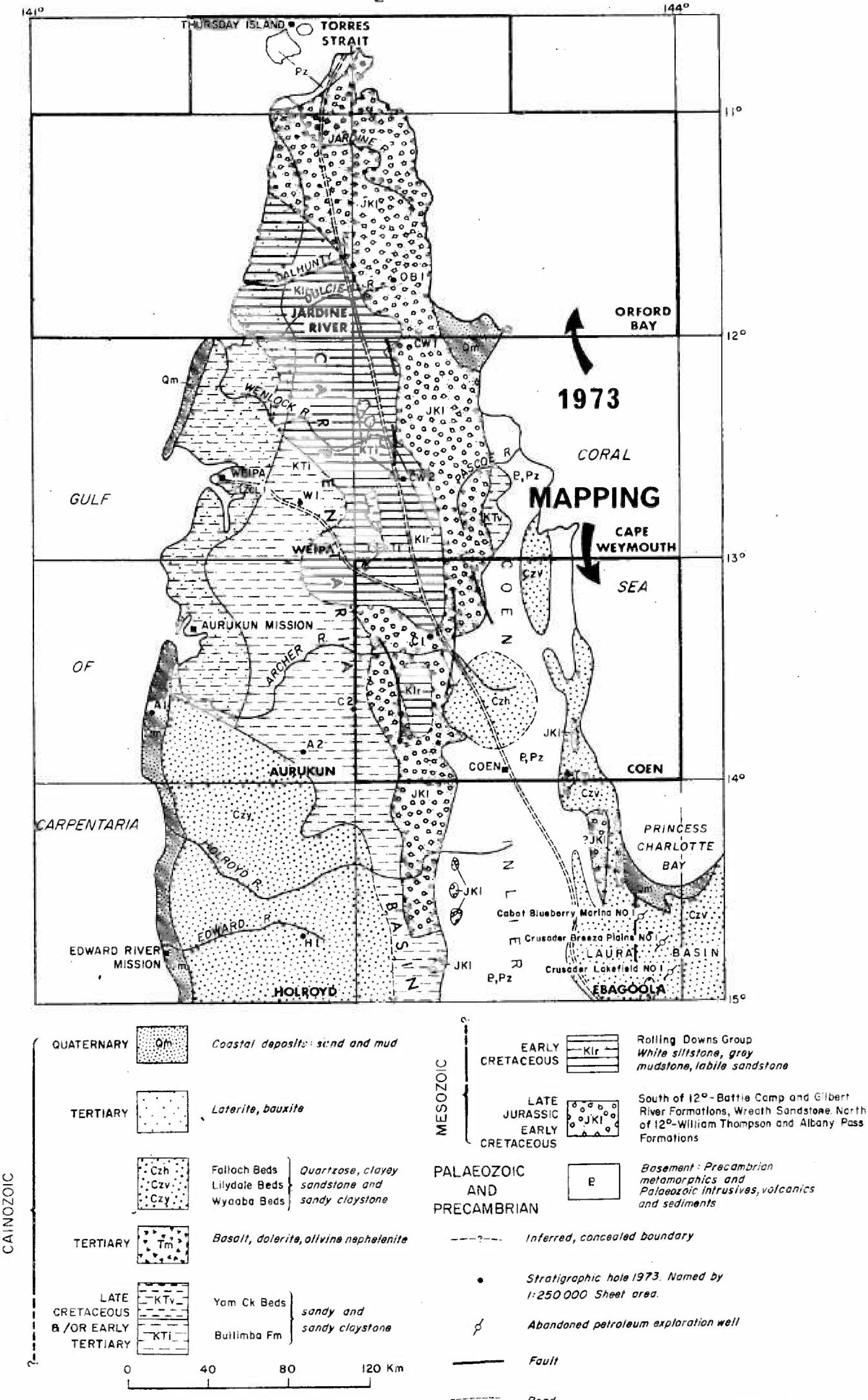
Eight shallow stratigraphic holes were drilled to depths between 130 and 310 m to help solve problems of Cainozoic and Mesozoic stratigraphy. Their positions are shown in Figure S2.

A series of beach ridges in southwest AURUKUN and northwest HOLROYD was extensively augered and a survey party from Department of Services and Property ran levelling traverses over the ridges and into Coen airport to provide profiles and absolute heights for the ridges.

Summary of Geological Results

In general, the geology of the northern Cape York Peninsula part of the Carpentaria Basin is similar to that further south, with a quartzose clayey sand sequence being overlain by mudstone and labile sandstone. It is possible to use some of the stratigraphic names already existing but others have been added. Mesozoic stratigraphic nomenclature is summarized in Table S1.

The late Jurassic - early Cretaceous quartzose sandy Gilbert River Formation of the southern Carpentaria Basin can be traced northwards in Cape York Peninsula as far as about latitude 12°S. In the Weipa area and southern CAPE WEYMOUTH, it is underlain by the Wreath Sandstone which appears to be equivalent to the Eulo Queen Group of the southern Carpentaria Basin. In the northern part of CAPE WEYMOUTH and ORFORD BAY none of these units can be recognized and the sandstones underlying the Rolling Downs Group are assigned to the William Thompson Formation - see Table S1. This name and some of the others used in Table S1 were first used informally by Australian Aquitaine Petroleum in 1966 and have yet to be formalized.



To accompany Record 1973/174

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FIG. S2 GEOLOGICAL MAP OF NORTHERN CAPE YORK PENINSULA

	SOUTHERN AND EASTERN CARPENTARIA BASIN		CAPE YORK PENINSULA CENTRAL	CAPE YORK PENINSULA NORTH OF 12°S	
EARLY CRETACEOUS	NORMANTON FORMATION ALLARU MUDSTONE TOOLEBUC LIMESTONE WALLUMBILLA FORMATION		ROLLING DOWNS GROUP	ROLLING DOWNS GROUP	
LATE JURASSIC TO EARLY CRETACEOUS	GILBERT RIVER FORMATION	Coffin Hill Member Yappar Member	GILBERT RIVER FORMATION	(WILLIAM THOMPSON FORMATION)	(Wasp River Member) ? - ? - ? - ? (Shelburne Bay Member)
JURASSIC	EULO QUEEN GROUP	LOTH FORMATION	(WREATH SANDSTONE)		
		HAMSTEAD SANDSTONE	(Four Cliffs Member)	(ALBANY PASS FORMATION)	

Note: Informal names bracketted.

TABLE S1.
MESOZOIC STRATIGRAPHIC NOMENCLATURE, CARPENTARIA BASIN.

In the southern Carpentaria Basin, the Rolling Downs Group, the muddy sequence overlying the Gilbert River and William Thompson Formations, is divided into several formations (Table S1) but these cannot be recognized by surface mapping in the northern part of the Peninsula. In the subsurface sandier beds at the top of the muddy sequence are apparently equivalent to the Normanton Formation, which is in part, if not wholly, of Albian age in the type area. Lower in the sequence, a small gamma-ray anomaly is present at the inferred level of the Toolebuc Limestone, although this unit has yet to be recognized lithologically. Generally, the Rolling Downs Group is more sandy, and the argillaceous units harder, than they are further south. The existence of rocks of Cenomanian age in the Carpentaria Basin was investigated by drilling in the deepest onshore part of the basin in southwest AURUKUN: the cores have yet to be examined for microfossils.

The main Cainozoic units mapped in northern Cape York Peninsula are similar to those further south, and consist of clayey quartzose sand and sandy clay, with minor pebble and granite conglomerate, locally indurated by iron or silica. These units, the Upper Cretaceous or Lower Tertiary Bulimba Formation and the Pliocene to Recent Wyaaba Beds, are separated by the effects of a major episode of weathering which appears to correspond to an episode commonly affecting Mesozoic rocks only elsewhere in the Carpentaria and Eromanga Basin.

In northern Cape York Peninsula other units with lithologies broadly similar to those of the Wyaaba Beds and Bulimba Formation also occur. The relation between them and the Bulimba Formation and Wyaaba Beds is complex, but some are apparently equivalent to the Bulimba Formation, others to the Wyaaba Beds. Some of the younger units have been deposited in restricted basins on a pre-Mesozoic basement of granite - for example, in the Archer River basin, north of Coen. Such basins are of particular interest for their sedimentary uranium, tin and gold placer potential.

A series of beach ridges on both sides of Cape York Peninsula indicate higher sea levels in the past; they are best developed on the western side, mainly south of the mouth of the Archer River. There is an old line of ridges, commonly poorly preserved, and a younger, more extensive series.

Auger drilling has shown that the older ridges are composed of clayey quartzose sand and are devoid of carbonate material, probably due to leaching. The younger ridges are composed of shelly quartzose, slightly clayey sand, with some layers rich in shells. These are partly cemented by carbonate in many places. The older ridges appear to rest directly on Wyaaba Beds, and the younger series overlie grey sandy and shelly marine mud, similar to much of the floor of the Gulf of Carpentaria today.

Shell samples collected from beach ridges in previous years in GALBRAITH, HOLROYD, AND AURUKUN were examined in 1972 and yielded C^{14} dates ranging from 470 to 5630 years B.P. The pattern of ridges suggests that a regression began about 1000 years ago, after a transgression and/or a stillstand of the sea which left untouched ridges as young as 3000 years B.P. There are shell-containing ridges which are probably older than 5630 years; the ages of the carbonate-devoid ridges may be considerably more.

Results of levelling together with auger drilling and C^{14} dating, will permit stratigraphic sections to be drawn across the beach ridges.

Bauxite

The regional mapping has provided a geological background to the bauxite deposits of Cape York Peninsula and a framework of geological history into which the origin of the bauxite can be tentatively fitted. The bauxite appears to have formed from the originally feldspathic sandstones of the Bulimba Formation. No evidence of transportation has been found and the deposits are regarded as having formed in situ. The bauxite probably formed in two stages. Firstly, during the Tertiary, the feldspathic Bulimba Formation was altered to an aluminous laterite or low grade bauxite, probably contemporaneous with lateritic weathering further south in the Carpentaria Basin. This event was followed by the development of the major river systems and the initiation of Wyaaba Bed deposition within the Gilbert-Mitchell Trough.

Later, probably during the Pleistocene, there was a further period of weathering and alteration affecting both Bulimba Formation and Wyaaba Beds and also Mesozoic units. This event upgraded the Tertiary aluminous laterites to give economic bauxite in the areas within 50 km of the west coast of the Peninsula, while lateritic soil profiles formed in the Wyaaba Beds and in the Rolling Downs Group in some areas. During this weathering episode, there is evidence of a drop in groundwater level in many areas, reflected in a downward movement of the boehmite (monohydrate of alumina)/gibbsite (trihydrate) boundary. This is probably related to sea level changes during glacial periods.

CENTRAL EROMANGA BASIN PROJECT

by

B.R. Senior

Staff: B.R. Senior.

A draft report which describes the geology of the Central Eromanga Basin was completed during 1973. The area discussed (approximately 325 000 km^2) is a little more than one-fifth of the Artesian Basin (approximately 1.5 million km^2).

The basement includes Precambrian to Silurian igneous, metamorphic and folded sedimentary rocks which are overlain by unmetamorphosed moderately folded to near horizontal sedimentary rocks of the Galilee, Drummond, Adavale and Cooper Basins. Outcrops of the Galilee and Drummond Basins are restricted to a small area in the northeast of the area discussed. In contrast the Adavale and Cooper Basins are entirely concealed and knowledge of them is from geophysical surveys and drilling.

Eromanga Basin rocks of Lower Jurassic to Upper Cretaceous age dominate the outcrop geology. Jurassic rocks are largely nonmarine quartzose sandstone, siltstone and minor coal. Conformably overlying the Jurassic rocks are Lower Cretaceous rocks consisting of shallow marine labile sandstone, siltstone and mudstone. A thin carbonate sequence (Toolebuc Limestone) in the northwest half of the area forms an excellent marker bed because the presence of minor organic phosphate causes a higher than normal radioactive peak on gamma-ray logs. The marine sequence is overlain by paralic to fluvial and lacustrine sediments containing lignite.

Rocks exposed in the Late Cretaceous and Cainozoic were affected by two phases of chemical weathering. The first, in the Late Cretaceous, kaolinized and partly silicified and ferruginized the uppermost 130 m of the Rolling Downs Group. After slight erosion of these altered rocks, Tertiary quartzose sediments were deposited as river alluvium over much of the area. In early Tertiary time a second weathering phase formed beds of silcrete in these quartzose sediments and pedogenically reweathered the Late Cretaceous chemically weathered rocks forming a weathered mantle. These altered rocks contain indurated beds which are in places folded allowing estimates to be made of post-weathering tectonic movements. Many folds show quite marked movement which possibly modified the distribution of any hydrocarbons present.

A zone of relative structural complexity separates the northwest and southeast areas which contain almost horizontal rocks overlying stable shelves in basement. Most Cainozoic downwarping and sedimentation has occurred in this diagonal zone and structures follow trends inherited from older basin systems. Some folds are over 100 km in length and are interpreted as overlying broad horsts which were slowly uplifted during initial sedimentation. Simultaneously, differential compaction occurred between the thick sedimentary columns in synclines forming a contrast with the thinner sediments in anticlines.

Apart from petroleum, groundwater is the main economic resource of the area. Approximately 3,700 water bores exist of which about 1,300 tap artesian water. In general the quality and quantity of water obtainable from the Eromanga Basin sequence increases with depth. The most prolific aquifers utilized are within the Hooray Sandstone. However, the depth to this formation becomes too great for economic recovery of water in the central and southwest areas. In these areas recourse is made to subartesian water, which is usually only suitable for stock, from aquifers within the Rolling Downs Group, and Tertiary and Quaternary sediments. The main drawback to utilization of groundwater is that most water contains bicarbonate which renders it unsuitable for irrigation, or excess fluorine which may damage the bone structure of young animals.

Most of Queensland's precious opals come from the Central Eromanga Basin area. Many of the old workings are abandoned and only the more accessible are mined in a desultory fashion by gougers and tourists. However the industry is recovering and organized attempts are being made to reopen some workings. Little attention has been given to finding new deposits (see Drilling and Geomorphology Project) although the Late Cretaceous chemically differentiated rocks to which opals are confined are very extensive.

WESTERN EROMANGA BASIN

by

A. Mond

Staff: A. Mond.

The study of the western part of the Eromanga Basin continued during 1973 with an assessment of the results from the 1971 fieldwork and drilling, and with a field season of two months duration from 12th June to 14th August 1973.

A report on the stratigraphy of the area (Record 1973/47) based on the previous fieldwork was prepared and issued in the early part of the year. It was suggested that 1) the Tarlton Formation, previously regarded as probably Triassic, consists of Permian Crown Point Formation plus Jurassic to Lower Cretaceous De Souza Sandstone; 2) the Rumbalara Shale appears to be restricted to the type area, the other Cretaceous rocks previously mapped as Rumbalara Shale are units of the Rolling Downs Group; 3) the undifferentiated sedimentary rocks cropping out in the northwestern Simpson Desert Sheet area (Expl. Notes SG/53-4) resemble Tertiary (Miocene) Etadunna Formation of South Australia.

Geological mapping carried out during the 1973 field season covered both Queensland and Northern Territory parts of the western Eromanga Basin. The geological mapping and reinterpretation of shallow stratigraphic drilling in the Hay River Sheet area (Record 1973/102) provided data to support conclusions made in the previous year.

Fossil plants were collected from the Tarlton Formation on the top of Tarlton Range (Tobermory Sheet area). Well preserved clear impressions in a micaceous sandstone show some fine detail and the plants were identified by R.E. Gould (pers. comm., 1973) as equisetalean stem (?Schizoneura sp.), Ptilophyllum sp. (P. pecten), Taeniopteris (Macrotaeniopteris) sp., Brachyphyllum sp. and Pagiophyllum sp. The flora contains only a few elements, but on the basis of the most abundant form, Ptilophyllum sp., it is Jurassic - Early Cretaceous.

From the 1973 fieldwork it is apparent that the Jurassic to Lower Cretaceous Longsight Sandstone of the northern part of the area is equivalent to the De Souza Sandstone of the western part. Further south, the De Souza is equivalent to a sandstone known in South Australia as the Algebuckina Sandstone, and to the overlying Cadna-owie Formation which is composed of calcareous sandstone and shale. The units overlying the Longsight Sandstone in the northern area, the Wallumbilla Formation and the Toolebuc Limestone, pinch out westwards and palynological evidence suggests that the Longsight is overlain by Allaru Mudstone towards the northwestern margin of the basin.

Geological study of Cretaceous rocks mapped previously as the Rumbalara Shale confirmed that they belong to the Rolling Downs Group (Table S2). At the present it is difficult to establish the distribution and relations of individual units in this western part of the basin (Figure S3). All rocks are very weathered and shallow stratigraphic drilling would be necessary to provide fresh material for palynological and lithological studies. Wire-line logging of water bores in this area

Era	Age	WESTERN EROMANGA BASIN: NORTHERN PART Vine, 1971 (Group)	NORTHERN PART Vine, 1971	WESTERN PART Wells et al., 1970	NORTHWESTERN PART (Group)	NORTHWESTERN PART	SOUTHWESTERN PART Wopfner, 1969 (Group)	SOUTHWESTERN PART Wopfner, 1969
Mesozoic	Lower to Upper Cretaceous	Rolling Downs Group	Winton Formation	Rumbalara Shale	Rolling Downs Group	Winton Formation	Neales River Group	Winton Formation
Mesozoic	Lower Cretaceous	Rolling Downs Group	Mackunda Formation	Rumbalara Shale	Rolling Downs Group	Mackunda Formation	Neales River Group	Mt Alexander Sandstone Member
Mesozoic	Lower Cretaceous	Rolling Downs Group	Allaru Mudstone	Rumbalara Shale	Rolling Downs Group	Allaru Mudstone	Neales River Group	Oodnadatta Formation
Mesozoic	Lower Cretaceous	Rolling Downs Group	Toolebuc Limestone	Rumbalara Shale	Rolling Downs Group	Toolebuc Limestone	Neales River Group	Wooldridge Lst Mbr
Mesozoic	Lower Cretaceous	Rolling Downs Group	Wallumbilla Formation	Rumbalara Shale	Rolling Downs Group	Wallumbilla Formation	Neales River Group	Coorikiana Member
Mesozoic	Lower Cretaceous						Neales River Group	Bulldog Shale
Mesozoic	Jurassic to Lower Cretaceous		Longsight Sandstone	De Souza Sandstone		De Souza Sandstone / Longsight Sandstone	Neales River Group	Cadna-owie Formation
Mesozoic	Jurassic to Lower Cretaceous		U — U					Algebuckina Sandstone
			Tarlton Formation	U — U		U — U		U — U
Plz	Permian		Undiffer. Permian	Crown Point Formation		Crown Point Formation		Mount Toondina Beds

Table S2. Comparison of stratigraphic nomenclature of the Permian to Cretaceous rocks in the western part of the Eromanga Basin, Queensland, Northern Territory and South Australia.

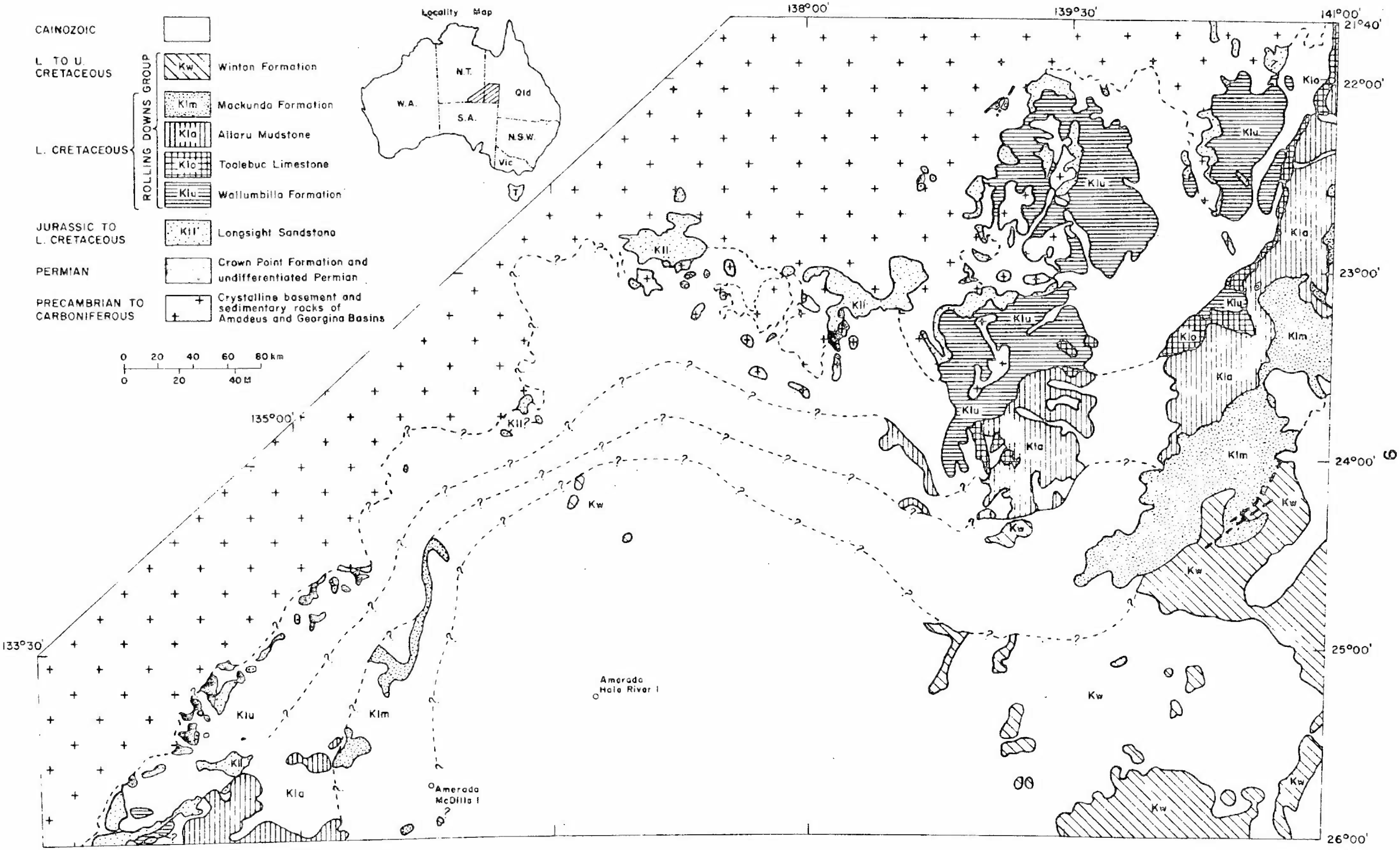


Fig. S3 Distribution of the Lower to Upper Cretaceous Rolling Downs Group in the northwestern part of the Eromanga Basin, N.T. & Qld.

To accompany Record 1973/174

AUS 2/307

has not proved very helpful, mostly because of very poor quality of recording. The results of drilling and geophysical surveys indicate that all units of the Rolling Downs Group thin towards the northern and western margins of Eromanga Basin.

Along the western and southern margins of dry lakes in the north-western Simpson Desert Sheet area, there are good exposures of a unit tentatively correlated with the Etadunna Formation. The relation of this sequence to the Tertiary Etingambra Formation is obscured by sand, but it is believed to be younger. In 1973 a visit to this area added to the number of previously discovered lungfish toothplates and shark teeth. A piece of silicified bone, the origin of which is at the present time unknown, was also discovered. A preliminary study has suggested (Prof. J.W. Warren, pers. comm., 1973) that it may be a part of whale's vertebra.

SURAT BASIN PROJECT

by

N.F. Exon

Staff: N.F. Exon.

All explanatory notes dealing with the 1:250 000 Sheet areas in the Surat Basin are published or in press. A paper entitled "Injune Creek Group - amendments and an addition to stratigraphic nomenclature in the Surat Basin", written jointly with GSQ geologists, was published in the Queensland Government Mining Journal.

The first draft of a paper for the 1974 APEA Conference entitled "The geological evolution of the southern Taroom Trough and the overlying Surat Basin" has been written. This concentrates on the development of the Taroom Trough, and the overlying Lower Jurassic sequence, which contains most of the petroleum reservoirs of the area.

In January, Exon gained valuable experience working with the wellsite geologist on AAO Bindango No. 1 well, west of Roma.

Surat Basin Bulletin

Since gas was first discovered at Roma in 1900, approximately 400 petroleum exploration wells have extended the petroleum reserves in the Surat Basin, the great majority drilled since 1960. Following BMR-GSQ regional mapping of the Surat Basin, outcrop and subsurface information is being combined in a Bulletin giving a coherent picture of the regional geology; the first draft of about half the text for the Bulletin has now been completed and the rest should be completed in 1974.

Well correlation diagrams have been prepared, and company seismic data were compiled for various horizons at 1:1 000 000 scale, the scale of the regional geological map. From correlation of 260 petroleum exploration wells and 170 wireline-logged water bores (logged during BMR's continuing program), as well as the seismic compilations, several maps have been prepared. These include 14 isopach, six structure contour, and two palaeogeological maps. A basement structure contour map, which illustrates the present-day structure, and four isopach maps covering the major subdivisions of the sedimentary sequence, are presented in Figure S4. On the basis of these maps it is now possible to present a synthesis of the Permian- Cretaceous deposition in the area.

The early Permian (see "Permian Isopach") marine sediments were laid down throughout the area northeast of a basement high. They thicken eastward, showing that the present-day easterly highs had not developed. Regressive strandline sands in this sequence have yielded petroleum in a number of wells, and such sands are the main targets in present exploration around the Roma Shelf. As much as 700 m of Upper Permian coal measures transgressed over the marine Permian onto the southwesterly basement high.

In the late Permian and early Triassic, granites were intruded in the east and the Texas High started to rise. By the late Triassic the Auburn Arch and Yarraman Block had also risen, and the faulted eastern margin of the Taroom Trough had completely formed. The Triassic isopach map (Figure S4) shows that Triassic sedimentation was thickest along the axis of the trough. Isopach maps of finer Triassic intervals show that Triassic sediments were not deposited east of the fault-line in the south, but were in the north, where the faulting commenced only in the mid-Triassic. The Lower Triassic sediments are red-beds derived from erosion of red soils, but in the Middle Triassic the fluvial sediments deposited contained no red detritus.

By the late Triassic the Taroom Trough had stabilized and a long period of erosion took place. Lower Jurassic sands of the Surat Basin were deposited on the unconformity surface, and even the basal sands extended well beyond the Taroom Trough. Each Jurassic Surat Basin unit covered a wider area than its predecessor, and by the late Jurassic the southwesterly high had been completely covered. The Jurassic-Neocomian isopach (see Figure S4) shows that this terrestrial sequence is thickest above the Taroom Trough, in which steady compaction led to subsidence which formed the Mimosa Syncline. The compaction ceased by the Upper Jurassic, when uplift occurred in the north and east and the former palaeoslope to the north was reversed. A second axis of deposition, overlying a basement depression, is now marked by the Dirranbandi Syncline.

Jurassic deposition was cyclic in nature with cycles hundreds of metres thick; broadly, the sequence of environments in each cycle was braided streams, followed by meandering streams, followed by swamps. In the first Lower Jurassic cycle the lower Precipice Sandstone was laid down by braided streams; this porous and permeable sandstone body is thickest (up to 100 m thick) and coarsest in the Mimosa Syncline, and the major petroleum fields lie within it on either side of the syncline. The only major marine interlude in the Jurassic occurred toward the end of the first cycle, when beach sands of the Boxvale Sandstone Member and oolitic ironstone horizons were laid down within the upper Evergreen Formation. The second cycle started in the Lower Jurassic with the Hutton Sandstone and terminated in the Middle Jurassic with the thick and economically important Walloon Coal Measures. After three more such cycles the Lower Cretaceous sea invaded the area.

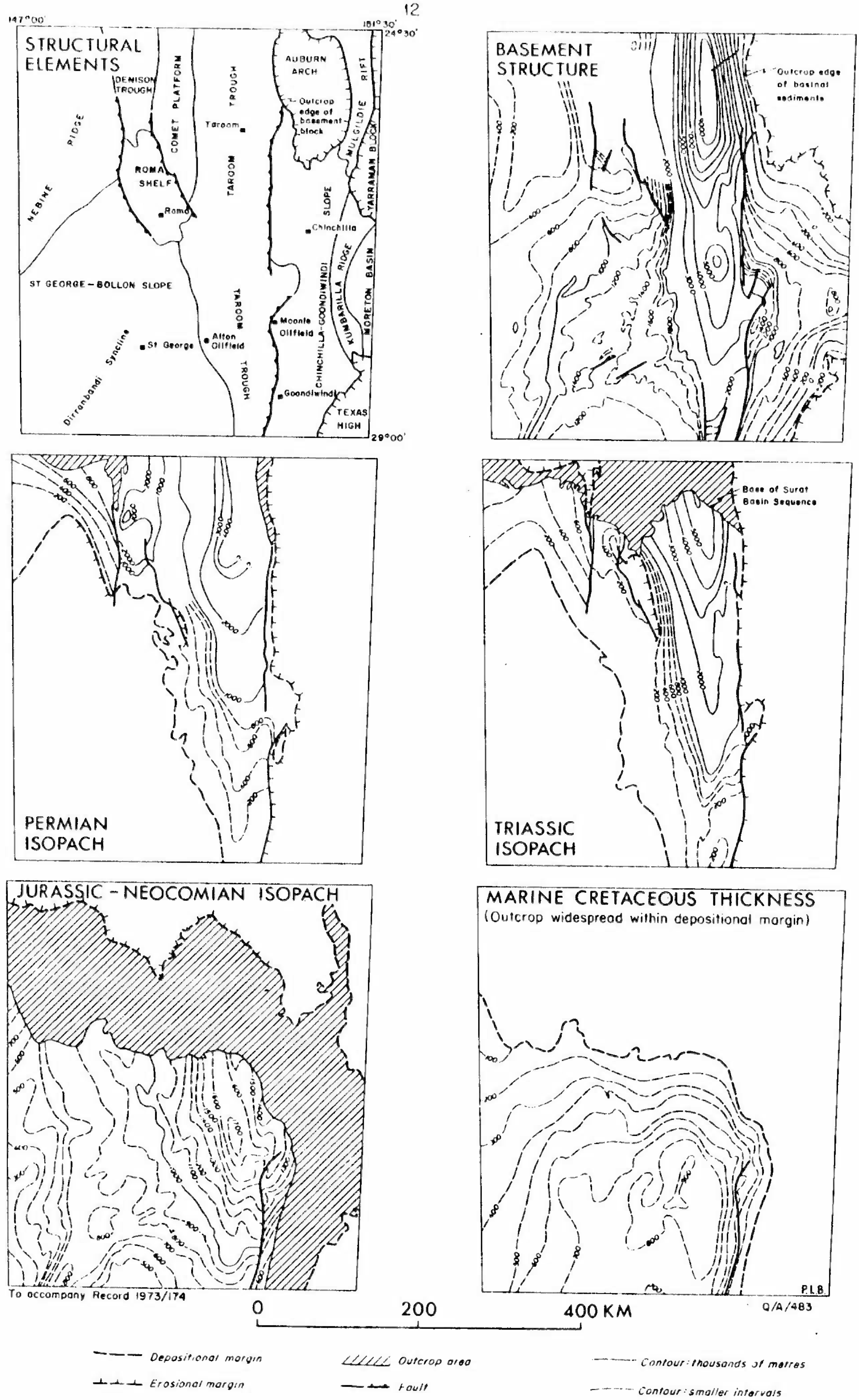


Fig. S4 Surat Basin and underlying Bowen Basin

The sea entered from the west or south in Neocomian times. The isopach map (see Figure S4) shows that the Nebine Ridge and the western part of the St George-Bollon Slope formed a high area, and that the Dirranbandi Syncline and Taroom Trough were no longer important. The initial transgression laid down beach sands and shallow marine silts (Bungil Formation). The rest of the Cretaceous sequence (Rolling Downs Group) consists of muds, silts and sands laid down during subsequent transgressions and regressions. The sea finally withdrew from the basin in the Upper Albian.

There followed a long period of planation and deep-weathering, before mid-Tertiary basaltic volcanism and uplift in the north and east led to the present regime of erosion and some deposition by southwesterly flowing streams.

From the various isopach maps, migrational trends for hydrocarbons produced at various times can be hypothesized. An untried prospect suggested by the present study is the Hutton Sandstone pinchout against the basement high in the Bollon area in the southwest. In Middle Jurassic times migration would have been westward into the pinchout which is sealed by the Walloon Coal Measures. Later movements produced the present slope up to the north, but structural traps or porosity/permeability barriers may have prevented escape in this direction.

OFFICER BASIN PROJECT

by

M.J. Jackson

Staff: M.J. Jackson, P.J. Kennewell (BMR); W.J.E. van de Graaff, J.C. Boegli (GSWA)

The main effort of the group was directed towards the production of the twenty 1:250 000 Preliminary Maps covering the Officer Basin area. The writing of Explanatory Notes and processing of maps from Preliminary Edition to First Edition was started and laboratory work with associated reporting was also done. The only field work, associated with the project, done during the year was a small amount of detailed mapping of Precambrian crystalline rocks along the southwest margin of the basin. This work was done by J. Bunting and R. Chin (Geological Survey of Western Australia) so that photo-interpretation and map compilation of four of the Sheet areas mapped in 1971 composed mainly of Officer Basin sedimentary rocks, but also containing some Precambrian basement, could be completed.

At the end of October twelve of the Preliminary Map Sheets had been printed (four were printed in late 1972). Of the remaining eight, Neale and Lennis are almost ready to go to the printers; Cundeelee, Minigwal, Plumridge and Rason are awaiting minor additions following the 1973 detailed mapping; and photo-interpretation and compilation is in progress on Waigen and Throssell. Explanatory Notes for Cobb, Herbert and Warri were written and authors' corrections were made to the maps.

A draft Record on the results of the 1972 stratigraphic drilling project was written, but completion has been delayed until results of additional palynological, petrological and geochemical work being done on core samples are available.

A.W. Compston (ANU) completed Rb:Sr isotope dating of basalt samples from the Table Hill Volcanics and is preparing the results for publication. He has obtained a moderately well-defined internal mineral isochron from the specimens indicating a Lower Cambrian extrusion and recommends abandoning the 1100 m.y. radiometric age previously assigned to the volcanics.

Glauconitic sandstone samples collected in 1972 from gently folded rocks of suspected Proterozoic age along the western margin of the basin have been dated by AMDEL. Six samples of glauconite collected from the basal 10 m of the sequence give an average K-Ar age of 1695 m.y. A sample of dolerite collected from a sill about 1000 m higher up the sequence dates at 1050 m.y. (Compston, ANU pers. comm.). Dr W.V. Preiss (Geological Survey of South Australia) is continuing a detailed morphological analysis of stromatolites collected from this sequence in 1972. The results of these individual studies are to be combined and published.

Lectures on Officer Basin work were given to the BMR and to the 45th ANZAAS Congress. In cooperation with authors from the Geological Surveys of South Australia and Western Australia a paper on the geology of the Officer Basin was written for the AIMM volume on the Economic Geology of Australia and Papua New Guinea.

NGALIA BASIN PROJECT

by

A.T. Wells

The objectives of this project are to prepare a summary of the geology of the Ngalia Basin in co-operation with the Geophysical Branch, to prepare 1:500 000 geological and geophysical maps, and to report on the results of shallow stratigraphic drilling. This work is scheduled for completion in 1974.

In 1973 a short review paper of the geology of the Ngalia Basin was written as a contribution to the AIMM Volume on the economic geology of Australia and Papua New Guinea. Drill core samples submitted by exploration companies searching for uranium, were examined.

NORTHEAST CANNING BASIN PROJECT

by

A.N. Yeates

Staff: A.N. Yeates, R.R. Towner, P.A. Jell (April-September)
Mrs L. Wyborn (April-August) (BMR); R.W.A. Crowe (GSWA).

The objective of the survey was to continue the mapping of the Canning Basin, W.A. started in 1972 by revising the Phanerozoic geology of the Mount Bannerman and Cornish 1:250 000 Sheet areas and by mapping and compiling 1st edition geological maps of the Crossland, Dummer, Helena and western part of the Webb 1:250 000 Sheet areas.

A BMR Mayhew 1000 rig was used to provide subsurface data and cores from below the weathering profile suitable for palynological dating. Twelve holes totalling approximately 2000 metres were drilled. Hand auger samples were taken from numerous claypans and salt lakes.

Regional Geology

The Canning Basin contains dominantly Ordovician to Cretaceous marine and continental epiclastic sedimentary rocks deposited within an intra-cratonic basin.

The major tectonic elements in the northeastern part of the Canning Basin are the Bannerman Shelf, the Gregory Sub-basin (the southeastern extension of the Fitzroy Trough) the Barbwire Terrace and the Crossland and Helena Platforms which form part of the Mid-Basin Platform (Figure S5). Movements along the faults which separate these tectonic elements produced subsidence during deposition. Faulting persisted well into the Triassic.

Near the northeastern margin of the Canning Basin (Billiluna and Mount Bannerman 1:250 000 Sheet areas) Ordovician sandstones lie with angular unconformity on a basement of tightly folded Proterozoic quartzite and granite. In the Mount Bannerman Sheet area, conglomerates of the Permian Grant Formation unconformably overlie these Ordovician sandstones; in the Billiluna Sheet area, they are most probably overlain disconformably by Upper Devonian sandstone. Other Devonian and Carboniferous units intersected in Wapet Lake Betty No. 1 have been overlapped by Permian sedimentary rocks in the area mapped, and do not crop out.

The Permian sequence consists of at least five cycles of alternating marine and nonmarine rocks.

A slight regional disconformity separates the Palaeozoic Formations from the overlying Triassic rocks which are largely nonmarine. The Triassic units are continuous with those in the Fitzroy Trough to the northwest, though the Culvida Sandstone appears to be restricted to within 150 km of its type area. It is the oldest known Triassic unit in the Canning Basin.

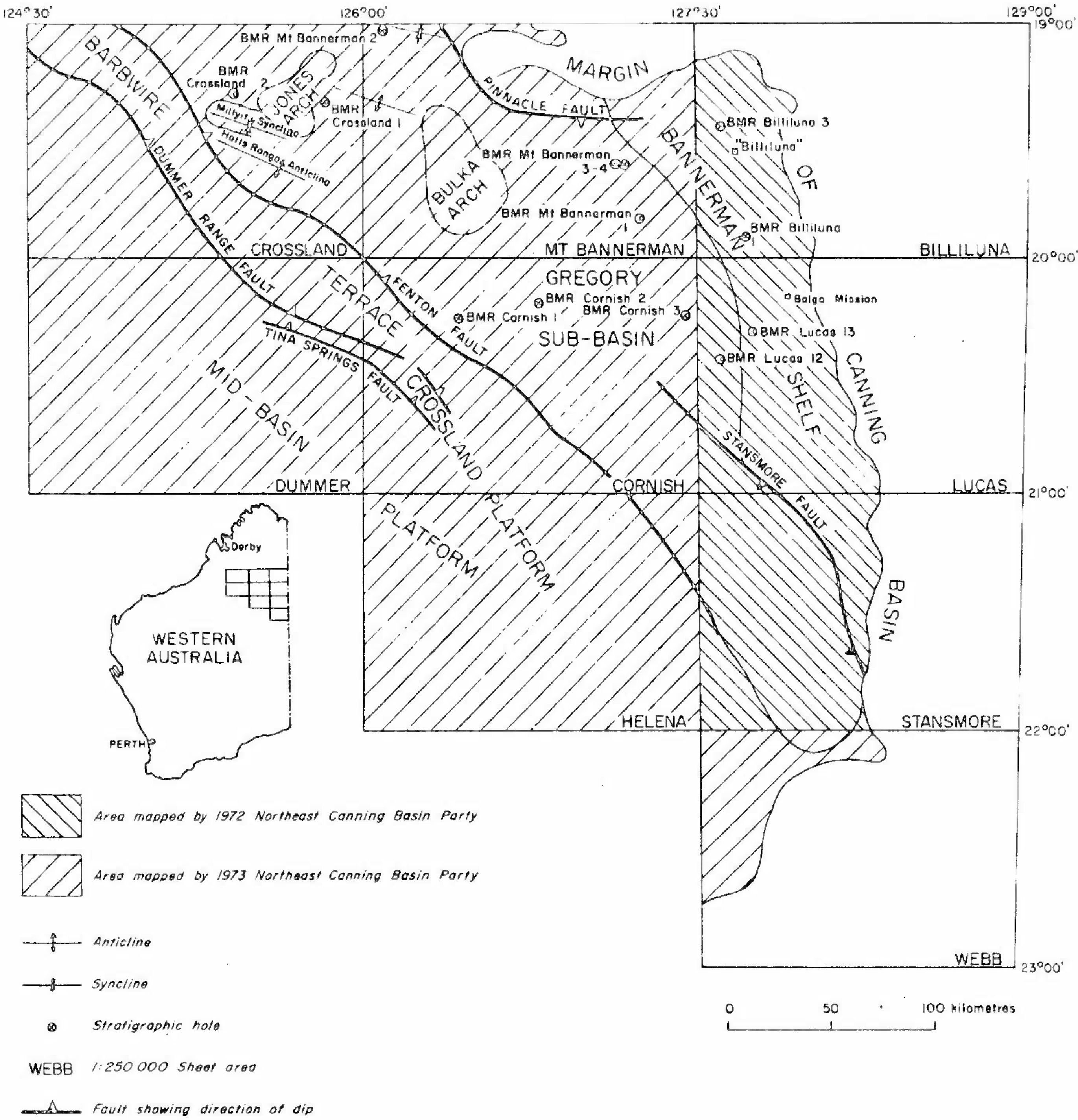


Fig. S5 Tectonic map of the northeastern part of the Canning Basin, showing area mapped and position of BMR stratigraphic holes.

Table S3: PHANEROZOIC STRATIGRAPHY OF THE NORTHEASTERN PART OF THE CANNING BASIN

Age	Formation and Map Symbol	Thickness in Metres	Lithology	Fauna or Flora	Environment of Deposition	Economic Geology
Quaternary	Qa	10±	Silt, sand and gravel		River, creeks, claypans	some aquifers
	Qs	5±	Sand (occurs in depressions)		Ancient drainage depressions, flood out areas	
	Qz	20±	Sand (aeolian)		Aeolian desert	Possible aquifer if underlain by impermeable beds
	Qe	1	Evaporites - gypsum, caliche		Desert, salt lake	
Undivided Cainozoic	Czk	3±	Calcrete	Rare gastropods, algal structures	Evaporitic lakes, floodouts, river deposits and ground water seepage deposits	Excellent shallow aquifer if below the water table
	Lawford Beds	15±	Calcrete, marl, conglomerate	Wood fragments, algal structures, leaves	River deposits, associated with evaporating groundwater	Contains alkaline water
	Czl	10±	Laterite		Fossil soil profile developed on labile rocks	
	Czs	2±	Silcrete		Weathered profile developed on highly quartzose rocks	
Triassic	Erskine Sandstone Tre	50±	Fine sandstone	Plant remains, trace fossils	Small channel deposits on alluvial plain	Potential aquifer in some areas. Potential petroleum reservoir
	Blina Shale Trb	13 130±	Micaceous siltstone, shale	Plant remains, trace fossils, burrows, vertebrate bones, pelecypods crustaceans.	Low relief alluvial plain, lagoons and mud flats	Potential petroleum cap rock
	Culvida Sandstone Trc	200	Sandstone, siltstone, conglomerate, redbeds	Plant remains	Meandering river deposits	
PERMIAN OR MESOZOIC	Barbwire Sandstone Pw	20	Conglomerate, coarse to medium sandstone, siltstone		Fluviatile	
	Millyit Sandstone Pm	30 m	Conglomerate, coarse to medium sandstone	Plant fossils	Fluviatile	
	"P_3" **	50 m±	Ferruginous shales and siltstones, micaceous	Brachiopods, pelecypods, gastropods, burrows	Shallow marine	
	"P_2" **	40 m ±	Labile quartzose sandstone	Wood fragments	Fluviatile	
	Godfrey Beds	250 m ±	Fine quartzose sandstone	Worm burrows, trace fossils, plant remains	Intertidal-coastal plain	
PERMIAN	Liveringa Formation: Hardman Member Ph	200 ±	Labile sandstone, siltstone, shale	Brachiopods, pelecypods, gastropods, trace fossils, burrows	Near shore shallow marine to tidal flat	
	Liveringa Formation: Condren Sandstone Member Pr	150±	Quartzose sandstone, kaolinitic and carbonaceous siltstone	Plant remains, trace fossils, burrows	Meandering river, delta and estuarine	Thin coal seams
	Liveringa Formation: Lightjack Member Pj	250±	Labile sandstone, quartzose sandstone, conglomerate, siltstone and shale	Brachiopods, pelecypods, gastropods, scaphopods trace fossils, burrows, plant remains	Near shore, shallow marine and tidal flat	
	Noonkanbah Formation Pn	200±	Shale, siltstone, coquinite, fontainbleu siltstone, ferruginous beds with concretions	Brachiopods, pelecypods, gastropods, trace fossils, fish and shark teeth and bones.	Beach, tidal flat and shallow marine	
	Poole Sandstone Pp	250±	Fine, thinly bedded, quartzose sandstone		Estuarine, coastal plain and beach	Excellent aquifer
	Grant Formation	at least 250±	Quartzose sandstone conglomerate, siltstone, shale	Wood fragments, trace fossils, burrows	Fluvial and shallow marine	Excellent aquifer
Carboniferous	C	?	Subsurface unit only		?	
Upper Devonian	Knobby Sandstone* Duk	at least 200	Quartzose sandstone, conglomerate	Fish plates, plant remains	Sheet flood river deposits	Potential aquifer
Lower Ordovician	Carranya Formation* Oc	100±	Fine quartzose sandstone, labile sandstone, conglomerate	Trace fossils, trilobites, gastropods, brachiopods, pelecypods	Shallow marine, possibly shoreline in places	Potential petroleum reservoir rock.

** new units

* new names

Results

The revised stratigraphy is shown in Table S3 and rock relationships in Figure S6. Previously unknown Permian and Mesozoic units were mapped and the distribution of others modified. Two new units of Upper Permian or Mesozoic age were discovered in the Crossland Sheet area. The Erskine Sandstone was found to extend into the Cornish and Mount Bannerman Sheet areas and the Meda Formation, Poole Sandstone, and Grant Formation found to be present in the Cornish Sheet area. The Godfrey Beds (previously thought to be Lower Cretaceous) are now thought to be possibly Permian.

The mapping has shown that the youngest sedimentary formations are mostly restricted to the axial region of the Fitzroy Trough, and its southeastern extension, the Gregory sub-basin. Fault zones separate the Fitzroy Trough and Gregory Sub-basins from the Bannerman Shelf in the north and the Mid-Basin Platform in the south (Figure S5). In most places these faults separate blocks that have been downthrown towards the axis of the Gregory Sub-basin. Faulting which was continuous over several periods during deposition, allowed a greater thickness of sediment to be deposited in the Gregory Sub-basin than on the adjacent platform and shelf areas.

New stratigraphic names will be proposed for the Ordovician sandstone (Carranya Formation) and the previously informally named Upper Devonian Knobby Sandstone will be formalised. Plant fossils collected from the Millyit and Barbwire Sandstones may allow more accurate dating of these units. The two new Permian units will be named when their distribution is better known.

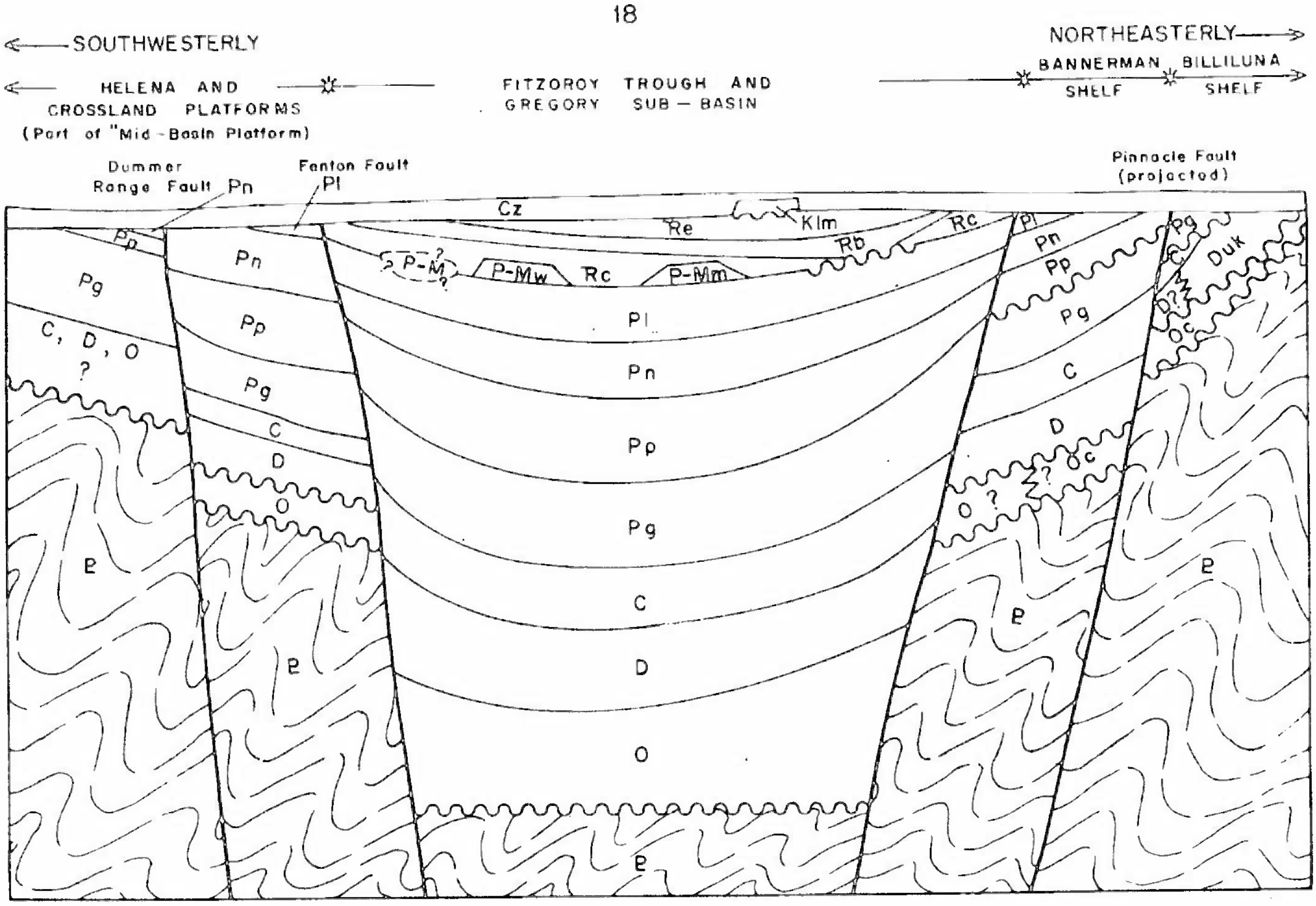
Sedimentary facies recognized indicate deposition under shallow marine, intertidal and terrestrial conditions. Facies changes are apparent within many units but some persist with little change for distances of at least 400 km.

Many plant and animal macrofossil collections were made from new localities and study of these, in conjunction with that of microfloras from drill core should enable accurate dating of several units.

Fresh cores of the following units were recovered during the shallow stratigraphic drilling: Hardman Member, Condren Sandstone Member, Lightjack Member, Noonkanbah Formation, Culvida Sandstone, Blina Shale, and Cainozoic deposits associated with Lake Gregory. BMR Cornish 2 intersected "red beds" in the base of the Culvida Sandstone.

The discovery of algae (including stromatolite-building types) being encrusted by calcium carbonate precipitated from alkaline spring waters in McDonaldson Spring has suggested a likely origin for the Lawford Beds and other Cainozoic calcrete deposits, which occur over large parts of the area. Algal structures can explain many pustular and curvi-laminar textures in ancient calcretes. In some modern calcretes these structures are apparently nonbiogenic and a study of the spring deposits may suggest ways of distinguishing nonbiogenic and biogenic calcretes.

The stromatolites grow actively on the well-oxygenated, turbulent face of small waterfalls in the creek draining from the spring seepages. On such waterfalls, pustular aggregates of filamentous blue-green algae form curvi-laminar layers of carbonate that are broadly parallel to the



CANIOZOIC	Cz	*Sand, alluvium, evaporites, calcrete, laterite*	CARBONIFEROUS	C	Sub-surface Carboniferous units
CRETACEOUS	Klm	Meda Formation	DEVONIAN	Duk	Knobby Sandstone ✲
TRIASSIC	Re	Erskine Sandstone		D	Sub-surface Devonian units
	Rb	Blina Shale	ORDOVICIAN	Oc	Carranya Formation ✲
	Rc	Culvida Sandstone		O	Sub-surface Ordovician units
PERMIAN OR MESOZOIC	P-Mw	Barbwire Sandstone	PROTEROZOIC	P	Proterozoic undivided
	P-Mm	Millyit Sandstone		✲	*Name not yet approved*
	P-M	Godfrey Beds			
PERMIAN	Pl	Liveringa Formation		∿∿∿	*Unconformity*
	Pn	Noonkanbah Formation		——	*Major lineament-fault*
	Pp	Poole Sandstone			*Folding diagrammatic*
	Pg	Grant Formation			

Fig. S6 Rock relationship diagram, northeastern part of Canning Basin, W. A.

To accompany Record 1973/174

M(S) 289

face of the waterfall. Downstream progradation of the waterfall thus results in the formation of small "reef-like" bodies up to 2 metres in width.

Algal slime on the bottom of the creek binds detrital sediment to form an extremely porous type of calcareous sandstone. In places, the detrital grains are not in contact; they were initially supported by a meshwork of algae. Carbonate was precipitated around the algae which later decomposed producing the very porous structure.

Evidence of rapid precipitation of carbonate is shown by the abundance of relatively fresh Eucalyptus and Acacia leaves embedded in carbonate. Often, these can be extracted from the carbonate substrate to reveal leaf imprints before the leaf has completely decomposed.

Samples of the stromatolite-building algae (both live and dead) will be studied in cooperation with Dr Walter and the Baas-Becking Laboratory to determine whether they actively precipitate carbonate and to see if they accumulate metals.

MELVILLE ISLAND, COBOURG PENINSULA PROJECT

by

R.J. Hughes

Staff: R.J. Hughes.

The reconnaissance geological mapping of the Mesozoic and Cainozoic sediments of the Melville Island and Cobourg Peninsula 1:250 000 Sheet areas was completed between 14 May and 13 September. Investigations of heavy mineral beach sands on Melville Island were continued and a detailed examination of bauxite on Cobourg Peninsula was made. Stratigraphic drilling was carried out on Cobourg Peninsula to provide subsurface information on the Cainozoic and Mesozoic sequences, to investigate groundwater potential and to find the depth to, and nature of, basement. The drilling shows that during the late Cretaceous a thin wedge of marine sediment was deposited over much of the Cobourg Peninsula Sheet area and that it rests on Lower Proterozoic metamorphic and igneous rocks probably of the Nimbuwah Complex.

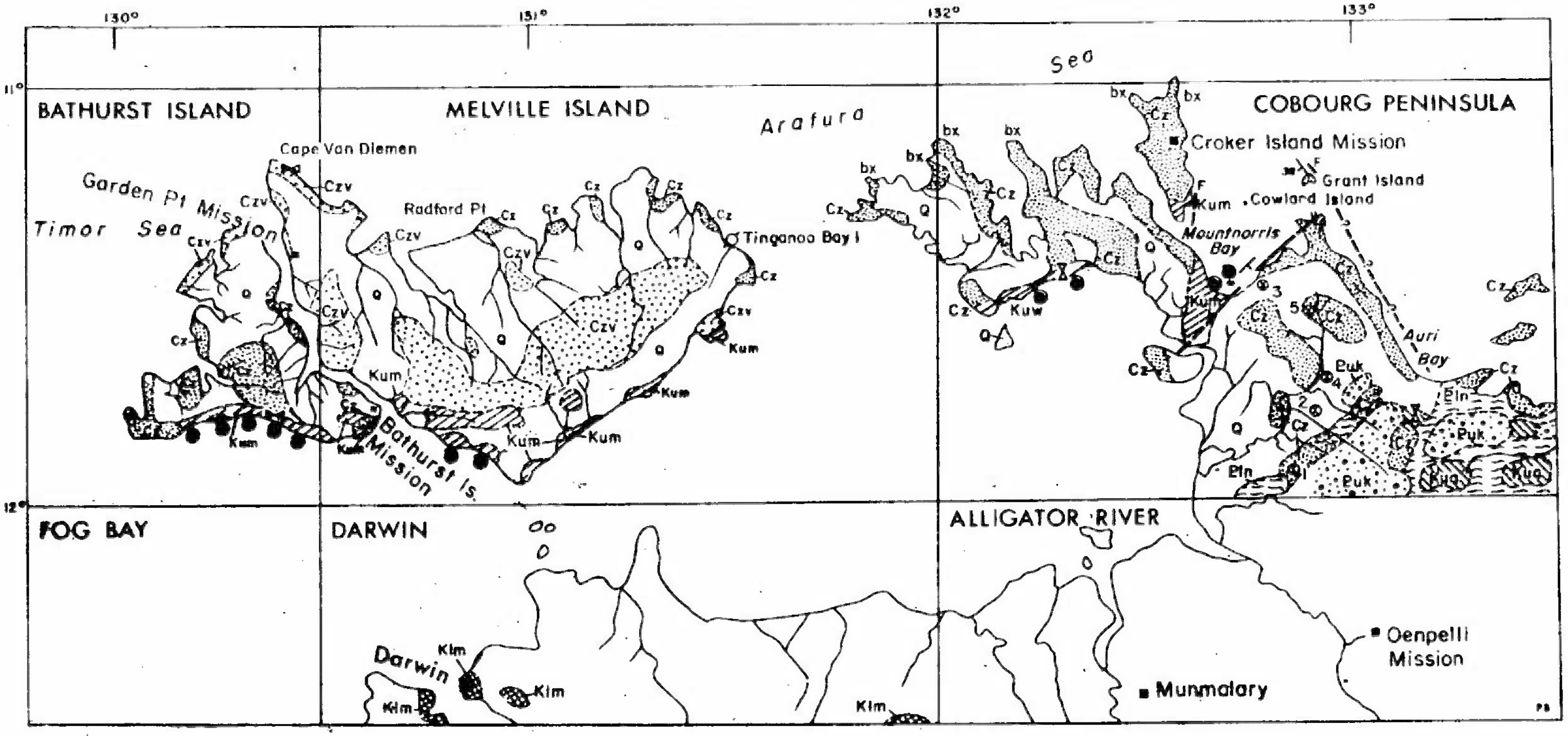
The results of the drilling are summarized in Table S4 and the positions of the holes are shown in Figure S7.

Analysis of beach sands collected from Bathurst and Melville Islands in 1972 indicated that concentrations of heavy minerals are present on their northern coasts. Four areas were further sampled in 1973. Samples were collected by hand auger from several environments at each locality including beaches, sand dunes, tidal flats and vegetated former strandlines. Although analyses are not yet available field observations suggest that high concentrations of heavy mineral sands occur within the beach and dune sands at Cape Van Diemen and in the region of Radford Point, Melville Island. The heavy mineral concentrations have almost certainly been derived from nearby Tertiary Van Diemen Sandstone, cliff sections of which contain thin laminae of opaque minerals.

TABLE S4: STRATIGRAPHIC DRILLING RESULTS COBOURG PENINSULA, NORTHERN TERRITORY, 1973

Hole	Location	T.D.	Coring/ Recovery	Wireline logs	Objectives	Results	Status
Cobourg Peninsula 1	GR 626476	67.5m	2 cores Cored 1.8m recovery 0.6m 33% recovery	No logs	1. Determine thickness and nature of laterite profile. 2. Determine depth to and nature of basement.	0-3m Pisolitic & concretionary ironstone. 3-4.5m Mottled sandstone & claystone. 4.5-21m Leached sandstone & claystone 21-58m Poorly sorted, quartzose sandstone & siltstone (Marligur Member) 58-67.5m Serpentinite.	Plugged and abandoned
Cobourg Peninsula 2	GR 626490 Murgenella Plain	134.0m	1 core Cored 1.5m recovery 1.5m 100% recovery	No logs	1. Determine nature and thickness of Cainozoic sediments on Murgenella Plain. 2. To find whether Cretaceous sediments are present at this locality and if so to provide fresh samples for palynological examination. 3. Determine depth and nature of basement.	0-13m Soil, iron-stained quartz sand and clay (Cainozoic) 13-73m Dark grey mudstone (Wangarlu Mudstone Member) 73-134m Poorly sorted, quartzose sandstone (Marligur Member) Artesian water flowed from a coarse-grained sandstone aquifer, 120-134m interval, at estimated rate 45m^3/hr.	Cased to 2.4m cemented off, plugged and abandoned.
Cobourg Peninsula 3	GR 610525 Murgenella Barge Landing	290.5m	9 cores Cored 15.2m recovery 11.2m 74% recovery	SP & R to 151.2m	1. Determine nature of Cretaceous sediments in vicinity of Mountnorris Fault. 2. Provide information of facies changes and stratigraphic control within	0-10m Soil & fine sand (Cainozoic) 10-70m Interbedded, fossiliferous fine sandstone, siltstone and minor mudstone (Moonkinu Member)	Cased to 10.4m plugged and abandoned

					Upper Cretaceous. 3. Examine nature of inferred unconformity between the upper and Lower Cretaceous Sediments.	70-281.5m Fossiliferous, dark grey mudstone (Wangarlu Mudstone Member) 281.5-289m Poorly sorted, quartzose sandstone (Marligur Member) 289-290.5m Quartz, feld-spar biotite gneiss (Nimbuwah Complex)	
Cobourg Peninsula 4	GR 628499 Murgenella Plain	138.5m	1 core Cored 1.8m recovery 1.8m 100% recovery	SP & R to 138.5m	1. Test for groundwater closer to Murgenella than Cobourg Peninsula 2. 2. Determine nature and thickness of Cretaceous sediments. 3. Provide fresh samples for palynological examinat-ion. 4. Find depth and nature of basement.	0-5m Soil & pisolitic gravel (Cainozoic) 5-98 Fossiliferous, dark grey mudstone (Wangarlu Mudstone Member) 98-138.5m Poorly sorted, quartzose sandstone (Marligur Member) Artesian water flowed from coarse-grained sandstone aquifer, interval 120m-138.5m, at estimated rate $70m^3/hr$.	Cased to 14.3m flow sealed off by valve acting under instruct-ions of NTA Water Resources & hole abandoned.
Cobourg Peninsula 5	GR 630519 Murgenella Forestry Settlement	276.0m	1 core Cored 1.5m recovery 1.5m 100% recovery	No logs	1. Test for groundwater at Murgenella. 2. Determine nature of Cretaceous and provide fresh samples for palyn-ological examination. 3. Provide information on facies changes occurring in Upper Cretaceous. 4. Find the depth and nature of basement.	0-30m Interbedded, fine sandstone, siltstone & mudstone (Moonkinu Member) 30-212m Fossiliferous, dark grey mudstone with minor siltstone (Wangarlu Mudstone Member) 212-274.5m Poorly sorted, quartzose sandstone (Marligur Member) Sandstone similar to No 4 & 2 but mud system prevented testing for aquifers 274.5-276m Quartz, feldspar biotite Gneiss (Nimbuwah Complex)	Cased to 11.5m plugged and abandoned



QUATERNARY		Q	*Alluvial and colluvial sediments, beach deposits of sandy coquinite*	
CAINOZOIC		Czv	*Van Diemen Sandstone. Quartzose cross-bedded sandstone, ferruginized in part*	
		Cz	*Chemically weathered sediments, laterite*	
UPPER CRETACEOUS	Bathurst Island Formation	Kum	*Moonkinu Member*	*Fossiliferous sublabile sandstone, siltstone and mudstone, calcareous and carbonaceous in part*
		Kuw	*Wangarlu Mudstone Member.*	*Mudstone, siltstone, pyritic in part*
		Kuq	*Marligur Member*	*Quartzose sandstone and siltstone*
LOWER CRETACEOUS		Klm	*Mullaman Beds*	
UPPER PROTEROZOIC		Puk	*Kombolgie Formation; quartzose sandstone, quartz pebble conglomerate*	
LOWER PROTEROZOIC		Eln	*Nimbuwah Complex. Gneiss, granite, migmatite, dolerite*	

bx	*Bauxite*
F —	*Fault*
⊥	*Dip and strike of strata*
●	*Fossil locality*
⋈	*Type section*
⊗	*BMR drill hole*

0 20 40 60 80km

FIG. S7 GEOLOGICAL SKETCH MAP OF BATHURST ISLAND, MELVILLE ISLAND, AND COBOURG PENINSULA 1:250,000 SHEET AREAS

To accompany Record 1973/174

NT/A/374a

Bauxite crops out along the northern coast of Croker Island and western Cobourg Peninsula (Figure S7) and is closely associated with the laterite profile formed by the in situ weathering of Cretaceous sediments. Where bauxite is present the laterite profile generally has an iron-enriched, hard capping up to one metre thick which is separated from a zone of pisolitic bauxite by an irregular boundary. The bauxite layer increases in thickness (and probably grade) northwards up to a maximum of three metres. The off-shore extent of the bauxite is unknown. Mottled and leached zones underlie the bauxite but in places are separated from it by a zone of concretionary and tubular ironstone. Thirty eight samples were collected for analysis including some from each zone of the laterite profile.

Good quality artesian water was shown to be present in coarse-grained sandstone at the base of the Cretaceous sequence. Supplies will probably be developed in the near future for a forestry settlement. Further traverses across Melville Island enabled the Van Diemen Sandstone and the Moonkinu Member of the Bathurst Island Formation, and the unconformity between them, to be mapped more accurately. Type sections for the Van Diemen Sandstone were measured on Cape Van Diemen, and a well preserved and diverse flora of fossil leaves was collected from the unit.

Preliminary editions of the Bathurst Island, Melville Island, Cobourg Peninsula and Fog Bay 1:250 000 geological maps were issued during the year, as was a Record on the 1972 field program.

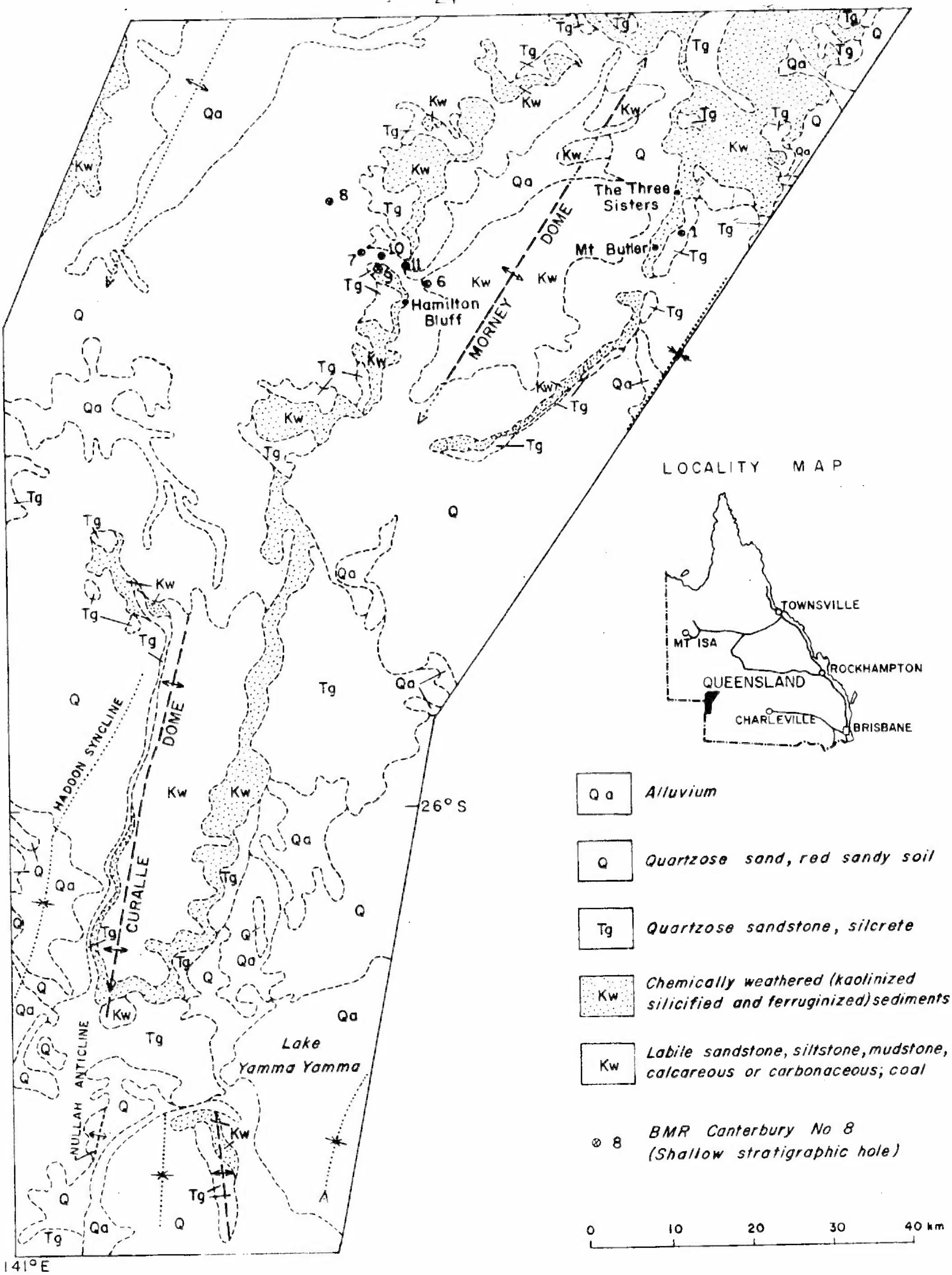


Fig.S8 Drilling & geomorphology project southwest Queensland.

To accompany Record 1973/174

G 54/A/8

DETAILED MAPPING PROJECTS

DRILLING AND GEOMORPHOLOGY PROJECT: SOUTHWEST QUEENSLAND

by

B.R. Senior

Staff: B.R. Senior.

From early June to mid-September shallow stratigraphic drilling and geological field work were carried out in southwest Queensland, as the commencement of a three year program devoted to a study of chemical weathering, superficial geology, landforms development, and Cainozoic tectonics.

The study area is situated in the northwest part of Barrolka and the western part of the Canterbury 1:250 000 Sheet areas (Fig. S8). This area encompasses an en echelon series of folds including the Nullah Anticline, and the Curalle and Morney Domes. Chemically weathered rocks are particularly well exposed in cuestas and contain indurated beds the attitude of which provides a measurable indication of post-weathering fold movements. Up to 110 m of weathered rocks are exposed in some cuestas. Down dip these weathered rocks are concealed below younger Cainozoic and Quaternary sediments.

Six stratigraphic holes were drilled along a transect across the western flank of the Morney Dome. At this location chemically weathered Winton Formation and the unconformably overlying silicified Glendower Formation dip gently westwards. At the western end of the drilled line the weathered rocks are concealed below Cainozoic fluvial and aeolian sediments. The objectives of the drilling were:

1. To establish the thickness of preserved weathered rocks in an environment of slight tectonic disturbance;
2. To recover cores and cuttings of chemically weathered rocks uncontaminated by spurious weathering effects present in outcrop;
3. To collect fresh rock from the Winton Formation for palynological study and for mineralogical comparison with their weathered counterpart.
4. To determine the nature of silicification within the Glendower Formation for comparison with outcropping silcrete beds.

Table S5 summarizes the drilling results. A total of 493 m of drilling were completed of which 67 m were cored. Wireline logs which include self potential, single point resistivity and gamma-ray logs were obtained from each hole. Sufficient core and cuttings were recovered to achieve the objectives listed above.

Preliminary assessment of measured sections and drill holes indicate that the chemically weathered Winton Formation has a trizonal profile. This profile can only be seen where the preserved sequence is in the excess of 70 m thick. The basal third of the profile has abundant ferruginous concretions, lenses and beds. The central third is varicoloured, ochreous and grades by increasing silica induration to a siliceous capping. Boundaries between the zones are indistict and all have random iron-oxide mottling, staining, and preservation of parent sedimentary textures.

TABLE S5. STRATIGRAPHIC DRILLING AND

HOLE/LOCATION/RIG (Canterbury 1:250 000 Sheet	ELEVATION	TOTAL DEPTH	WIRELINE OGS	SECTION PENETRATED (Formation tops)
CANTERBURY NO. 6 Grid ref. 460843 Mayhew 1000	115 m	141 m	SP to 140 R to 140 Gamma-ray to 139	0 Quaternary 15 Winton Fm. (unweathered) 141 TD
CANTERBURY NO. 7 Grid ref. 450846 Mayhew 1000	103 m	90 m	SP to 89 R to 89 Gamma-ray to 85	0 Quaternary 2 Glendower Fm. 42 Winton Fm (chemically weathered) 65 Winton Fm. (unweathered) 90 TD
CANTERBURY NO. 8 Grid ref. 445854 Mayhew 1000	137 m	94 m	SP to 93 R to 93 Gamma-ray to 92	0 Quaternary 20 Glendower Fm. 39 Winton Fm. (chemically weathered) 61 Winton Fm. (unweathered) 94 TD
CANTERBURY NO. 9 Grid ref. 453845 Mayhew 1000	109 m	93 m	SP to 94 R to 94 Gamma-ray to 93	0 Glendower Fm. 8 Winton Fm. (chemically weathered) 60 Winton Fm. (unweathered) 93 TD
CANTERBURY NO. 10 Grid ref. 455846 Mayhew 1000	112 m	43 m	Gamma-ray to 40	0 Winton Fm. (chemically weathered) 33 Winton Fm. (unweathered) 43 TD
CANTERBURY NO. 11 Grid ref. 457845 Mayhew 1000	121 m	32 m	Gamma-ray to 31	0 Quaternay 3 Winton Fm. (chemically weathered) 26 Winton Fm. (unweathered) 32 TD

SP Spontaneous potential
R Resistivity

CORING AND RECOVERY %	OBJECTIVES	RESULTS
7 cores Cored 20 m Recovered 18 m 90%	To obtain lithological information within the unweathered Winton Fm. for mineralogical/chemical comparison with chemically weathered equivalents.	Lignitic coal seam at 15 to 17 m Recovered sufficient core and cuttings for analyses and palynology.
12 cores Cored 30 m Recovered 29 m 97%	To obtain core and cuttings for clay mineralogy, chemical analyses and palynology. In addition, information on attitude, distribution and lithology of chemically weathered Winton Fm. and silicified Glendower Fm. was sought.	Glendower Fm. was thicker than expected and overlies a truncated sequence of chemically weathered rocks of the Winton Fm. Numerous aquifers within Glendower Fm.
5 cores Cored 9 m Recovered 8 m 89%	as above	Numerous lenses and beds of silcrete within Glendower and Winton Fm. chemically weathered rocks progressively truncated down dip. Some aquifers in cavernous silcrete and interbeds within Glendower Fm.
5 cores Cored 15 m Recovered 12 m 80%	as above	Very strongly indurated surface silcrete bed. Chemically weathered Winton Fm. is 52 m thick and was the thickest encountered in this series of holes but falls well short of the 100 m+ thicknesses measured in outcrop around the peripheral cuestas the Morney Dome.
Nil	Drilled for closer correlation between holes 6 & 7.	Penetrated basal portion of chemically weathered Winton Fm. profile through transitional zone into unweathered rock.
Nil	as above	as above

Chemically weathered Winton Formation rocks are very extensive in southwest Queensland and precious opal deposits are restricted to this zone of weathering. The profile is usually incomplete and is truncated by early Cainozoic erosion. It appears that the basal zone of the profile is most receptive to the formation of opal; migrating monosilicic acid has been arrested in voids in 'ironstone' concretions and along basal portions of channels and small compaction faults. It seems probable that opal enrichment took place after erosion caused the basal portion of the profile to be closer to the ground surface, providing conditions suitable for the access of siliceous groundwater in the phreatic zone. Establishment of a demonstrable profile within the chemically weathered Winton Formation may enable refinement of the prospecting techniques for this gem mineral.

Drill holes revealed that silicification within the Glendower Formation is more diffuse than in nearby outcrop. The typical strongly indurated grey-coloured silcrete was not penetrated in the subsurface. It is possible that proximity to the surface and further drying out of the amphorous silica gel may result in hardening of silcrete

TANTANGARA AREA PROJECT

by
M. Owen

<u>Staff</u>: M. Owen, D.E. Gardner, D. Wyborn (part-time), J. Saltet, Miss M. Shackleton (part-time).

The Tantangara Party mapped a total area of 2150 km^2, 1550 km^2 in the Tantangara 1:100 000 Sheet area and the remainder in the Brindabella 1:100 000 Sheet area. Drafting of the Preliminary Edition of the Tantangara Sheet is well advanced.

The more important advances in knowledge include the recognition of the Tantangara Beds as an early Llandovery flysch sequence, the first of this age reported from the southern Lachlan Geosyncline; the recognition of a major mid-Llandovery orogenic phase, not previously reported from southern NSW; and the recognition that sedimentation was continuous in the area from the late Llandovery through the Wenlock and Ludlow to the early Pridolian.

The boundaries of the various intrusions within the Murrumbidgee Batholith were accurately delineated, and clear field evidence of the order of intrusion of the various bodies was obtained. The Gingera Granite was found to be a composite body, and to be significantly different from the granite near Adaminaby previously included within it, and which has now been named the McLaughlin Flat Granodiorite.

The oldest rocks in the area, the Boltons Beds, are possibly middle Ordovician. Five units have been distinguished within the Bolton Beds, based on relative proportions of arenitic, argillitic and tuffaceous material. The beds are essentially a quartz-rich flysch sequence that passes gradually upwards into the Temperance Chert. The latter, in addition to chert, has many interbeds and lenses of agglomerate, tuff and lava and passes up into the Nine Mile Volcanics, within which three units have been recognized. The thin basal unit of interbedded sediment and tuff passes up into a thick sequence of tuff and minor interbedded sediment which is overlain by a thick sequence of basaltic lava and minor sediment. Graptolites from both the basal and upper units indicate a Gisbornian age for the Nine Mile Volcanics.

The relationship between the Nine Mile Volcanics and the younger Nungar Beds and Adaminaby Beds is uncertain, but could be conformable. Both the Nungar Beds and Adaminaby Beds are formed of quartz-rich arenite and siltstone, slate and minor chert, and have been dated by graptolites as Eastonian. The two units could be lateral equivalents.

The Ordovician was brought to a close by a period of folding, the Cobblers Creek Orogenic Phase of the Benambran Orogeny, and sedimentation resumed in the early Llandovery with the deposition of a thick flysch sequence, the Tantangara Beds. Further folding took place in the middle Llandovery (the Panuara Orogenic Phase of the Benambran Orogeny) and this appears to have been the major orogenic episode in the area.

Sedimentation resumed in the late Llandovery with deposition of the Peppercorn Beds, a sequence of clastic shelf sediments, and appears to have been continuous from this time until the early Pridolian in the Cooleman Caves area, with the deposition of a complex sequence of limestone, siltstone and chert. While marine sedimentation was taking place in the Cooleman area a thick sequence of acid terrestrial volcanics, the Goobarragandra Volcanics, was extruded to the west, and is possibly represented in the Cooleman area by tuffaceous material in the Pocket Beds. All marine deposition ceased probably early in the Pridolian.

The Murrumbidgee Batholith, Gingera Granite, McLaughlin Flat Granodiorite and Lucas Creek Granite appear to be the oldest igneous bodies in the area and are probably of late Silurian age. The Murrumbidgee Batholith consists of nine named intrusions, eight of which are present in the Tantangara Sheet, and numerous smaller unnamed bodies. Field mapping has indicated that the foliated and contaminated granodiorites, such as the Clear Range Granodiorite are intruded by the Shannon's Flat Adamellite, which is in turn intruded by leucogranites. This is in contrast to the conclusions of Joyce (1973) who considered the Shannon's Flat Adamellite to be the oldest body in the Batholith.

The Gingera Granite is a composite body composed of foliated biotite adamellite and leucoadamellite intruded by stocks of fine to medium-grained leucogranite. The McLaughlin Flat Granodiorite is a foliated biotite granodiorite which grades into hornblende-biotite granodiorite and hornblende-biotite tonalite. The Lucas Creek Granite is a foliated biotite adamellite similar to the bulk of the Gingera Granite. The Kelly's Plain Volcanics consists of porphyritic lavas and ignimbrites ranging from dacites to rhyolites. They contain phenocrysts of quartz and andesine in a felsic groundmass, and appear to be extrusive equivalents of the Gingera Granite.

The Burrinjuck Granite is probably the same age as the Gingera Granite, and intrudes its own extrusive equivalent, the Goobarragandra Volcanics. The Burrinjuck Granite consists of biotite and rarely hornblende-biotite granodiorite and adamellite. The Goobarragandra Volcanics are porphyritic dacitic and rhyodacitic ignimbrites.

The Burrinjuck Granite and Goobarragandra Volcanics are intruded by gabbros and dolerites of the Micalong Creek Basic Igneous Complex. Its age is unknown. The rocks range from olivine gabbro, uralite gabbro and pigeonite-bearing gabbro to quartz and orthoclase-bearing diorites.

During the Lower Devonian many stocks were intruded; ranging from pyroxenite, gabbro, granogabbro and granodiorite to granophyre, granite and leucogranite. The largest of these intrusions are the Happy Jacks and Jackson Granites. The Happy Jacks Granite is a composite body composed of leucogranite, sodic leucogranite, hornblende- and augite-bearing granodiorite and adamellite, granogabbro and hypersthene gabbro. The Jackson Granite is a pink orthoclase granite. On Cooleman Plain hypersthene and augite granodiorite stocks occur within 200 m of their extrusive equivalent, the Rolling Grounds Latite. The latite consists of phenocrysts of augite, chloritised hypersthene and plagioclase in a felsic groundmass. Further north the latite is overlain by potassic rhyolites of the Mountain Creek Volcanics. These are possibly the extrusive equivalent of the Jackson Granite. It is probable that the Lower Devonian intermediate rocks (granogabbro, granodiorite and adamellite) were produced by hydridisation of a tholeiitic basic magma with a potassic granitic magma.

Harker variation diagrams and various triangular diagrams were drawn for the igneous rock units. The Gingera Granite and McLaughlin Flat Granodiorite are chemically very similar to the Murrumbidgee Batholith and belong to the calcalkaline lineage. The Happy Jacks Granite and Hell Hole Creek Granite are also calcalkaline, with a slightly wider range of composition than the Gingera Granite. The fractionation trends of these intrusions are well defined.

The rocks of the Cooleman Complex - the Jackson Granite, Gurrangorambla Granophyre, Mountain Creek Volcanics and Coolamine Diorite - and the Kellys Plains Volcanics are calcalkaline potassium-rich rocks. The volcanic suites show a poor fit to fractionation trend lines since they have suffered post-depositional alteration. The Coolamine Diorite also shows a poor fit to fractionation trend lines and it is thought that it may be a hybrid body, formed by mixing of the Jackson Granite which has a very limited composition range, with an unknown basic magma.

The Nine Mile Volcanics are very altered rocks because of burial metamorphism, and samples do not fit fractionation trend lines. It is also difficult to tell the magmatic lineage from variation diagrams. Further work is in progress on the geochemistry of these rocks.

Another 45 whole rock silicate analyses made during 1973 brings the total for the Tantangara area to 120. A total of 580 stream sediment samples have been collected, and analysed by AMDEL for a wide range of elements.

WEST CANNING BASIN PROJECT

by

E.C. Druce

Staff: E.C. Druce, R.S. Nicoll, B.M. Radke.

In 1972 a joint BMR-Geological Survey of Western Australia field party conducted a detailed examination of the late Devonian-early Carboniferous sequence on the Lennard Shelf, Canning Basin. The sequence (the Laurel and Fairfield units) consists of poorly exposed limestone shale and sandstone. The geological history of this part of the sequence was poorly known and various differing interpretations have been published. Geologically the sequence is important because it interfingers with, and conformably overlies rocks assigned to the Devonian reef complex and significant traces of hydrocarbons are present in places.

The party undertook detailed petrological, palaeontological and geochemical sampling to help elucidate some of these problems.

The party returned from the field in October 1972 and began analysing data on the fauna, petrology, geochemistry and general geology of the Laurel-Fairfield sequence.

R.S. Nicoll has examined the Fairfield conodonts and is beginning to examine the Laurel conodonts after preliminary identifications were made by E.C. Druce.

B.M. Radke drew up detailed information on measured sections. Lithological, petrological, and faunal data was used to delineate different units in the sequence. B.M. Radke and E.C. Druce have recognized the units in the subsurface; isopach, clastic ratio, entropy, and basement maps have been prepared. These show a general sinking of the Fitzroy Trough relative to the Lennard Shelf with tilting of basement blocks away from the axis. Individual blocks have moved independently with resultant changes in facies patters. The basin appears to have also undergone gentle regional tilting to the north or northeast. Finally a cyclic transgressive - regressive pattern of sedimentation can be observed.

E.C. Druce and B.M. Radke examined the geochemical results. Limestones from outcrop, and limestones and calcareous clastics from the subsurface were analysed. Generally the samples are low in Fe and Mg; they are enriched in Pb, Zn and Ba. The Fairfield calcarenite is considerably enriched in Pb (mean 37 ppm) and the clastic-dolomite unit at the Laurel-Fairfield boundary has high Zn values (mean 34 ppm). Druce spent February in Perth and Radke August/September in Perth examining material and discussing Canning Geology with Western Australian Geological Survey, WAPET, and University of Western Australia.

HYDROLOGICAL STUDIES

HYDROGEOLOGICAL STUDY OF THE GREAT ARTESIAN BASIN

by

M. Audibert (BRGM)

Staff: R.S. Abell, M.A. Habermehl, G.E. Seidel (BMR); M. Audibert, G. Krebs (BRGM)

The Great Artesian Basin, probably the second largest in the world, extends over parts of three States (NSW, Qld, SA) and the Northern Territory, where since it was first exploited around the 1880's, the water authorities concerned meticulously gathered an enormous amount of hydrogeological data. Although some remarkable hydrogeological syntheses have been made within the limits of a particular State (such as the one of F.W. Whitehouse and C. Ogilvie in 1950 for the Queensland part of the basin) no attempt has ever been made to study the hydrogeology of the basin as a whole.

The GAB hydrogeological project, which was started in 1972, proposes to achieve such a synthetic study using modern methods such as mathematical and analog models, and to prepare a tool which allows the user to make:

(a) an assessment of the basin groundwater resources
(b) recommendations on how these resources should be managed
(c) predictions of the long term consequences of a given exploitation scheme.

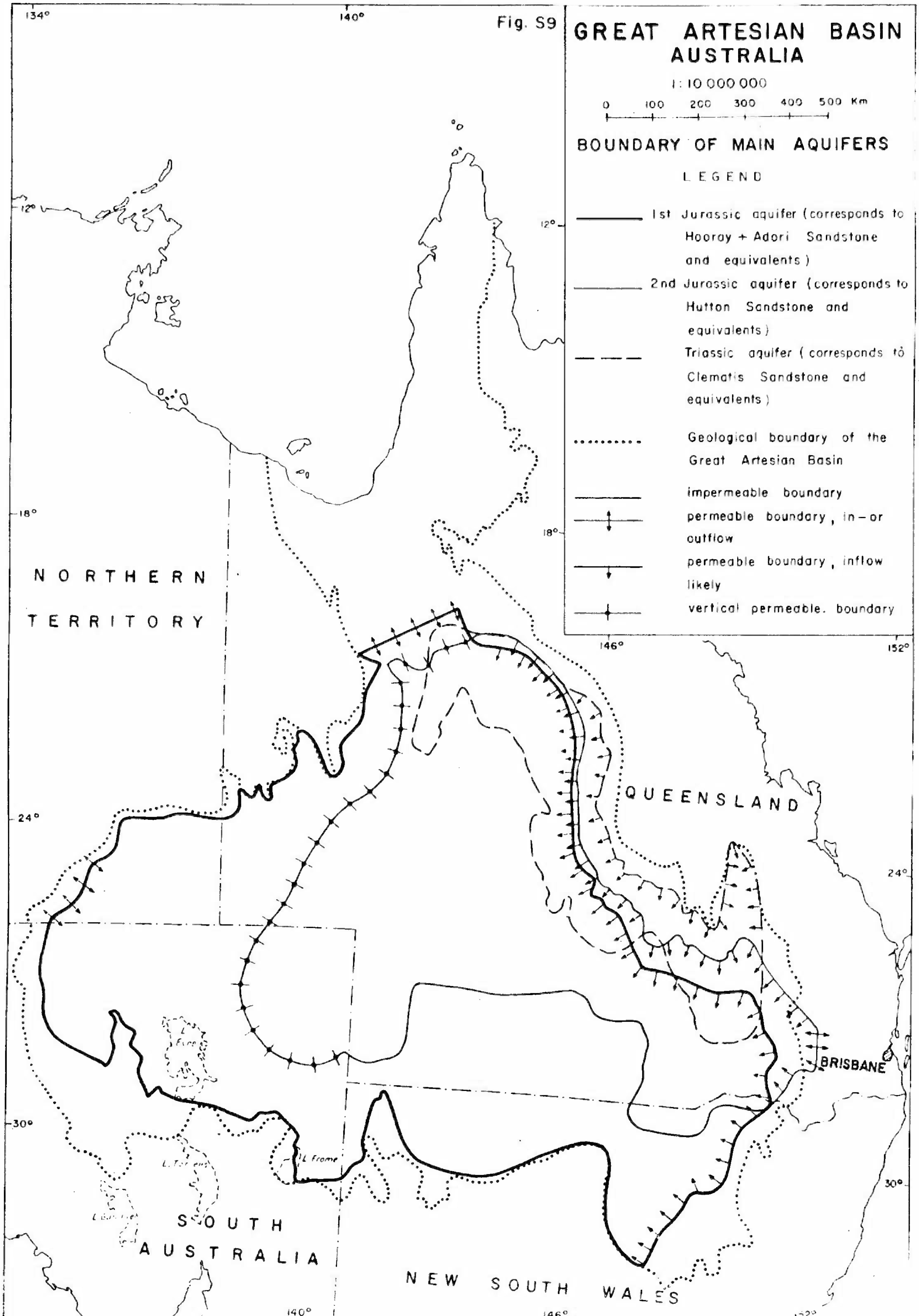
The tool selected is a mathematical model, for which the computer program was written in 1972. The theoretical basis of the model, is such that it allows the GAB to be modelled either as a multilayer aquifer system if it can be demonstrated that recorded measurements actually reflect pressure differences between aquifers, or as a single semi-confined aquifer if this condition is not fulfilled.

During the year 1973, the GAB team has been occupied with:

1. the collection of data and organization of the data bank;
2. the preparation of the prerequisites to the input documents;
3. the preparation of input data.

1. Data collection and organisation of the data bank

The main source of hydrological information on aquifers are the water bores. Because of the great number of bores and the numerous observations and measurements performed on them a standardized data storage system was designed in 1972 (BMR Record 1973/25). The process of coding and transferring all available hydrological data concerning artesian bores commenced in 1972, continued during 1973 and is expected to be completed by the beginning of 1974. In 1973 32 000 computer cards were punched, classified, stored, and their content checked by specially written checking programs (BMR Record in prep.). Furthermore a method has been devised, and the corresponding set of computer programs written, which allows the



To accompany Record 197? /174

transfer of all data to magnetic tapes for permanent storage, and their simple retrieval (BMR Record in prep.). The reason for this procedure is that repeated manipulation of punched cards could result in accidental loss or destruction.

2. Preparation of prerequisites to input documents

As a working hypothesis, it has been assumed that three semiconfined aquifers connected to the water-table should be distinguished. These are the permeable layers of the following formations or their equivalent, from top to bottom:

(i) Hooray and Adori Sandstones;
(ii) Birkhead Formation, Hutton and Precipice Sandstone;
(iii) Clematis Sandstone.

All hydrological information has to be sorted and related to the aquifer(s) concerned. In other words the aquifer(s) tapped by water-bores must be defined. This was an essential and difficult part of the work carried out in 1973. The method used consisted of:

(i) preparing structure contour maps of the formations;
(ii) processing the relevant data to obtain elevations of tapped intervals in each bore;
(iii) comparing the results.

This part of the program has been completed, but for many reasons (such as the variable accuracy of bore locations and elevations, the lack of information and the degree of exactitude of geological correlations) cannot be considered as entirely satisfactory.

3. Preparation of input documentation

The input requirements for the theoretical model to be applied to the GAB comprise:

3.1 the geometry of the system, that is - a simplified representation of the basin in terms of aquifers and aquicludes;

3.2 the areal changes in the hydraulic parameters;

3.3 the boundary conditions, that is - whether the lateral boundaries are permeable and if so either the flow or the head variations with time, and the potentiometric map of the water-table;

3.4 historical records of the artificial discharge of every artesian bore since its completion.

3.1 The geometry of the system (Fig. S9) was established from petroleum well completion reports and geological maps. Aquifer and aquiclude isopach and isobath maps were produced from this information after computer processing.

The planar geometry of each unit containing aquifers was then recorded on maps at a scale of 1:2 500 000. In addition, hydrogeological sections across the basin were prepared which show the vertical distribution of permeable and impermeable layers.

3.2 The hydraulic parameters include horizontal transmissivity values of aquifers, vertical permeability values of aquicludes and storage coefficient values of aquifers. No field measurements of vertical permeabilities and storage coefficient were performed. Some laboratory measurements of vertical permeability are available but very few concern shales which represent 90% of the aquicludes. The values of these parameters had consequently to be estimated. Using the information in reports of petroleum wells shown on the abovementioned cross-sections the storage coefficient values were estimated, assuming that the value recorded on sonic logs is proportional to porosity.

As to the horizontal transmissivities, direct measurement records are available of which a great number are in an already interpreted form (Queensland bores). Processing of the rest by two programs (COJAC and CALKA) has been completed. However further steps will have to be taken in early 1974 before the input documents are ready.

3.3 The only study related to boundary conditions completed in 1973 was that leading to the preparation of the water-table potentiometric map. The basic data have been obtained by processing (program PINLI) bore drilling information. The processing method was based on the assumption that the first water encountered within the known aquifer was at the water-table. The results seem quite reasonably accurate.

3.4 The historical records of artificial discharge have not yet been treated although the necessary programs (CPRWL and DECNA) were written in 1973.

To summarise the 1973 activity, three quarters of the data have now been collected and processed to suit the input requirements of the hydrological mathematical model. The plans for 1974 are to finalize this stage and to work and adjust the model until it can be said to be "tailored" or "calibrated" so that it satisfactorily reproduces the hydrodynamic behaviour of the GAB aquifers.

WIRELINE-LOGGING OF WATER BORES IN SOUTHERN QUEENSLAND

by

N.F. Exon

Forty-five water bores in the western parts of Dalby and Goondiwindi 1:250 000 Sheet areas in the Surat Basin were wireline logged, in late 1972 and early 1973, by Down Under Well Services under contract to the BMR. Both artesian and subartesian bores were logged, average depths being 500 m on Dalby Sheet and 350 m on Goondiwindi Sheet. The logs normally run were gamma ray-neutron, differential temperature and casing collar location; in the few cases when it was feasible electric logs and flowmeter logs were also run.

The bores penetrated major aquifers in the Jurassic Gubberamunda Sandstone and the Lower Cretaceous Mooga Sandstone, and minor aquifers in other Jurassic and Cretaceous units. In this continuing program about 200 Surat Basin water bores have now been logged; another 50 should be logged in the 1973/74 program, concluding the work in the Queensland part of the Surat Basin.

The basic log scale is 1 inch = 100 feet, and the logs have so far been used mainly for stratigraphic purposes, although the program has also been designed for aquifer studies. The quality of the logs is very good, and the present coverage of the Surat Basin has allowed detailed stratigraphic correlations to be run throughout the basin, making use also of petroleum exploration bores.

SEDIMENTOLOGICAL STUDIES

BOWEN BASIN PROJECT, QLD

by

P.K. Dutta (Geological Survey of India)

Staff: S.C. Shah and P.K. Dutta of the Geological Survey of India (Colombo Plan Fellows)

Outcrops around Exmoor Homestead in the northern part of the Bowen Basin, Queensland, constitute one of the most complete sections through the marine Back Creek Group in the basin. The sequence comprises the Tiverton Formation at the base, overlain by the Gebbie Formation which in turn is overlain by the Blenheim Formation (Fig. S10).

Field studies of about one month were undertaken to record the sequence in some detail. Apart from the general aim of environmental interpretation through lithological features and fauna, a more specific aim was to investigate the origin of the very poorly sorted sedimentary rocks of the Blenheim Formation.

The Tiverton Formation (368 m thick) is characterised by an alternation of fine-grained sandstone, calcareous in places, and siltstone with rare limestone beds. Some of the fine-grained unfossiliferous, non-calcareous sandstones are cross-bedded and probably were deposited in a near-shore environment. The major part of the sequence is calcareous and fossiliferous suggesting deposition in deeper water.

The Gebbie Formation (320 m thick), on the basis of lithology, has been divided into three sub-units. The basal part commonly known as "Wall Sandstone Member" is characterised by a medium to coarse-grained well-sorted, quartz sandstone with low angle cross-stratification, ripple mark and shaft-like "skolithos" burrows. At places the sandstone is calcareous and contains calcareous nodules." The fossil assemblages and sedimentary structures indicate that this sandy facies was deposited in off-shore bars.

Overlying the sandstone member is an unfossiliferous siltstone sequence interbedded with fine-grained sandstone. It is suggested that it was deposited in a restricted lagoonal environment which did not support any marine life.

The siltstone sequence grades to a medium to coarse-grained lithic sandstone with conglomerate lenses. Fining upward sequences resting on an erosional surface, cross-bedding, ripple marks, current lineation, plant impressions, rootlets, plant stems, the faunal assemblage and the vertical burrows indicate an estuarine to tidal flat environment.

The Blenheim Formation (658 m thick) overlies the Gebbie with a gradational contact and is marked by an influx of coarse clastics including pebbles, cobbles, and boulders and a corresponding change in faunal assemblage. Sandy siltstone to silty sandstone is the predominant

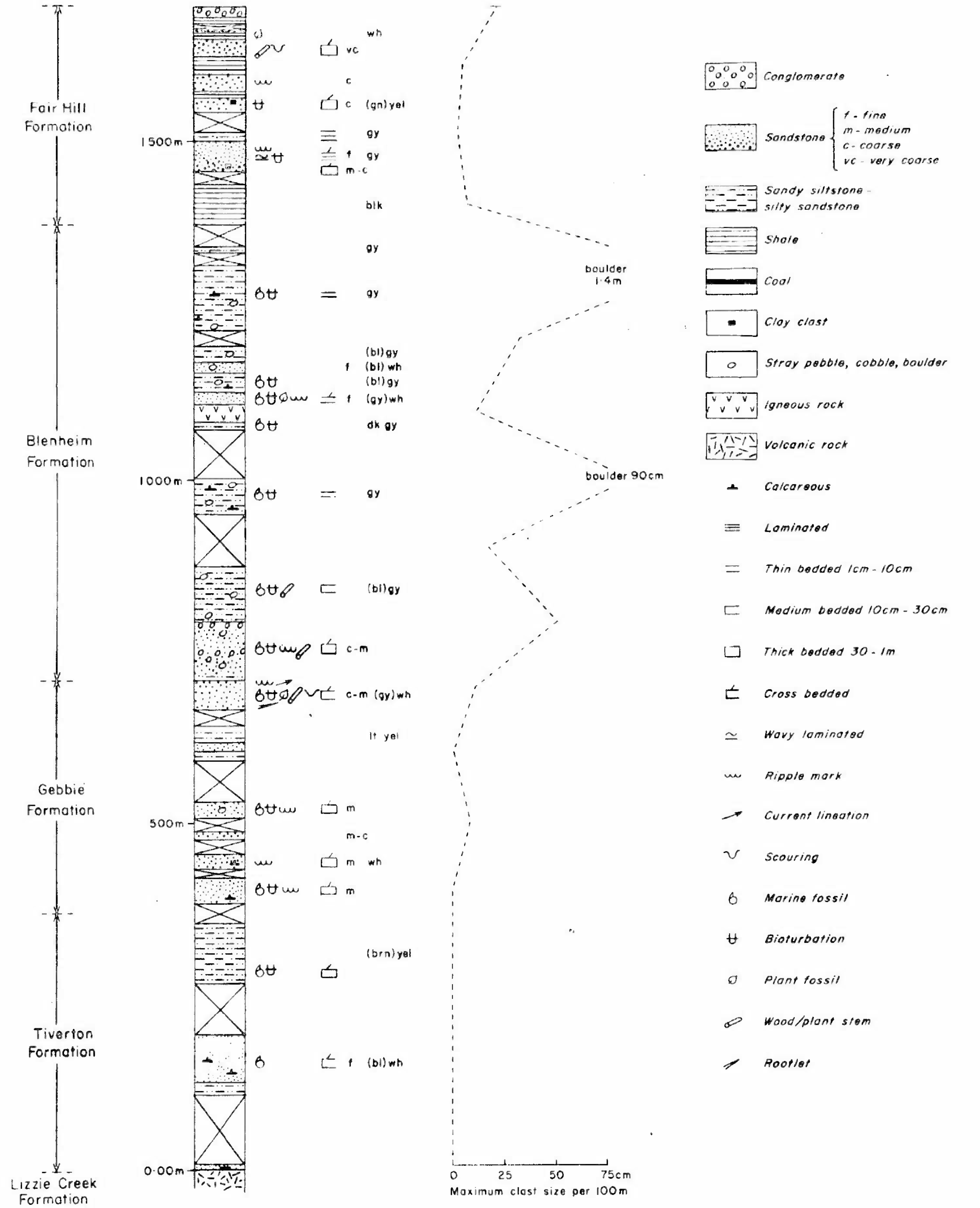


Figure S10 Section measured in Permian sequence at Exmoor, Bowen Basin, Queensland

To accompany Record 1973/174

M(S)288

rock type but moderately sorted fine-grained sandstones are present. Bioturbation structures, marine fossils and boulders, cobbles and pebbles are present throughout the sequence. Deposition took place in moderately deep water where the coarse clastics were brought by ice rafting.

The basal part of the unit overlying the Blenheim Formation, the Fair Hill Formation was deposited in a continental environment. The transition from marine to continental is marked by a deltaic sequence represented by dark grey shale, of the pro-delta facies overlain by thinly laminated, bioturbated fine-grained sandstone, siltstone and shale deposited within the interdistributary plain.

LAUREL-FAIRFIELD PROJECT, FITZROY BASIN W.A.

by

B.M. Radke

Staff: B.M. Radke

The Upper Devonian and Lower Carboniferous sequence in the Canning Basin is subdivided into the Fairfield Beds and the overlying Laurel Formation. These units crop out in limited exposures on the basin side of the Middle Devonian reef complex which rims the northeast margin of the Fitzroy Trough (Fig. S11). In the subsurface, the sequence extends over the entire Lennard Shelf and is possibly continuous with a similar sequence on the southwestern trough margin.

The aim of this part of the Laurel-Fairfield Project is to recognize lithological criteria by which the Laurel and Fairfield can be differentiated, to investigate the lithostratigraphy, and to determine the controls of sedimentation. (For other parts of the project see West Canning Basin, p.31).

A major part of the project this year was the multivariate analysis of limestones in the sequence in order to find lithological criteria for the differentiation of Laurel and Fairfield limestones. Field observations and petrographic studies of samples from 21 measured sections were used to determine 19 lithological attributes which included each limestone type, sand, silt and dolomite content, 3 inorganic and 9 skeletal grain types. The analysis incorporated several computer programs, MULTBET, GROUPER, GOWER and GOWECOR. In the first analysis, a sample of 111 limestones was subdivided into 13 groups; 4 Fairfield, 5 Laurel and 4 mixed. To test this classification, a second analysis with a sample of 125 was specified to produce 13 groups, and the result was that 5 Fairfield, 4 Laurel and 4 mixed groups were produced.

A regional stratigraphic study was undertaken of the sequence in the Shelf area based on core and composite log data from 15 subsidised and 3 BMR wells. Four units were recognized, only two of which crop out. Basement, isopach, entropy, clastic ratio and sand-shale ratio maps were compiled for each unit and the units showed considerable lateral variations in properties although they are distinctive enough to justify the subdivision. The units are presently informal and their constituent rock types are summarised in Table S6.

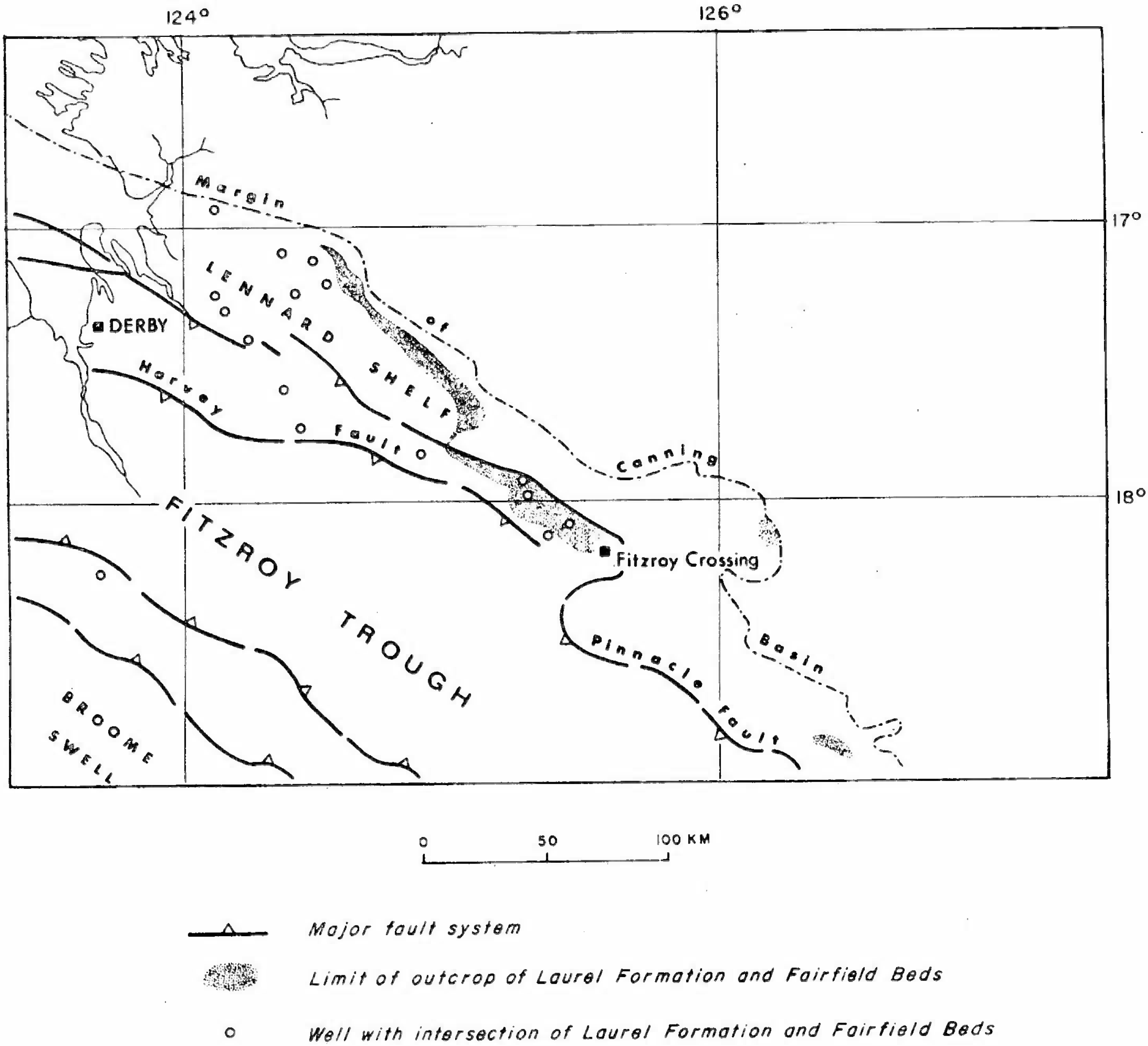


Fig. S II - Tectonic setting of the Lennard Shelf

To accompany Record 1973/174 W/A 253

Generally all units are relatively thin and irregular on the Lennard Shelf but the thickness increases rapidly over the Pinnacle and Harvey Faults into the Fitzroy Trough.

In units 1, 2 and 3, sandstone, siltstone and shale predominate along the basin margin. Limestone and dolomite are more significant in thicker sections. In unit 4, a large carbonate province with local highs exists in the northern end of the Shelf onshore and is surrounded by a more terrigenous, siltstone dominant facies.

Table S6: Informal Subdivisions of Laurel-Fairfield Sequence

Age	Unit	Lithology
	1	Siltstone, sandstone, shale, limestone
lower Carboniferous	2	Limestone, shale, dolomite, siltstone, sandstone (Equivalent to Laurel Formation)
	3	Sandstone, shale, siltstone, dolomite, limestone
upper Devonian	4	Limestone, siltstone, shale, minor dolomite, sandstone (Equivalent to Fairfield Beds)

LAKE FROME PROJECT

by

A.R. Jensen & J.J. Draper

Staff: A.R. Jensen, J.J. Draper, T.K. Zapasnik

In September 1973 a start was made on the study of an internal drainage basin in an arid environment to determine if the movement of sediments and fluids in such a system could concentrate metals through evaporation or the action of sulphate-reducing bacteria. The area selected for study was Lake Frome, a playa lake about 40 km east of the Flinders Ranges in South Australia. The lake is approximately 100 km long, 45 km wide and it covers an area of about 2700 square km. Alluvium composed of sand and gravel derived from the ranges forms a plain between the ranges and the lake, and low angle sediment fans extend into the lake. Sediment is also carried into the lake by the Siccus River in the south, and by Salt Creek and channels draining Lake Callabonna in the north. There is no significant drainage into the lake from the eastern side.

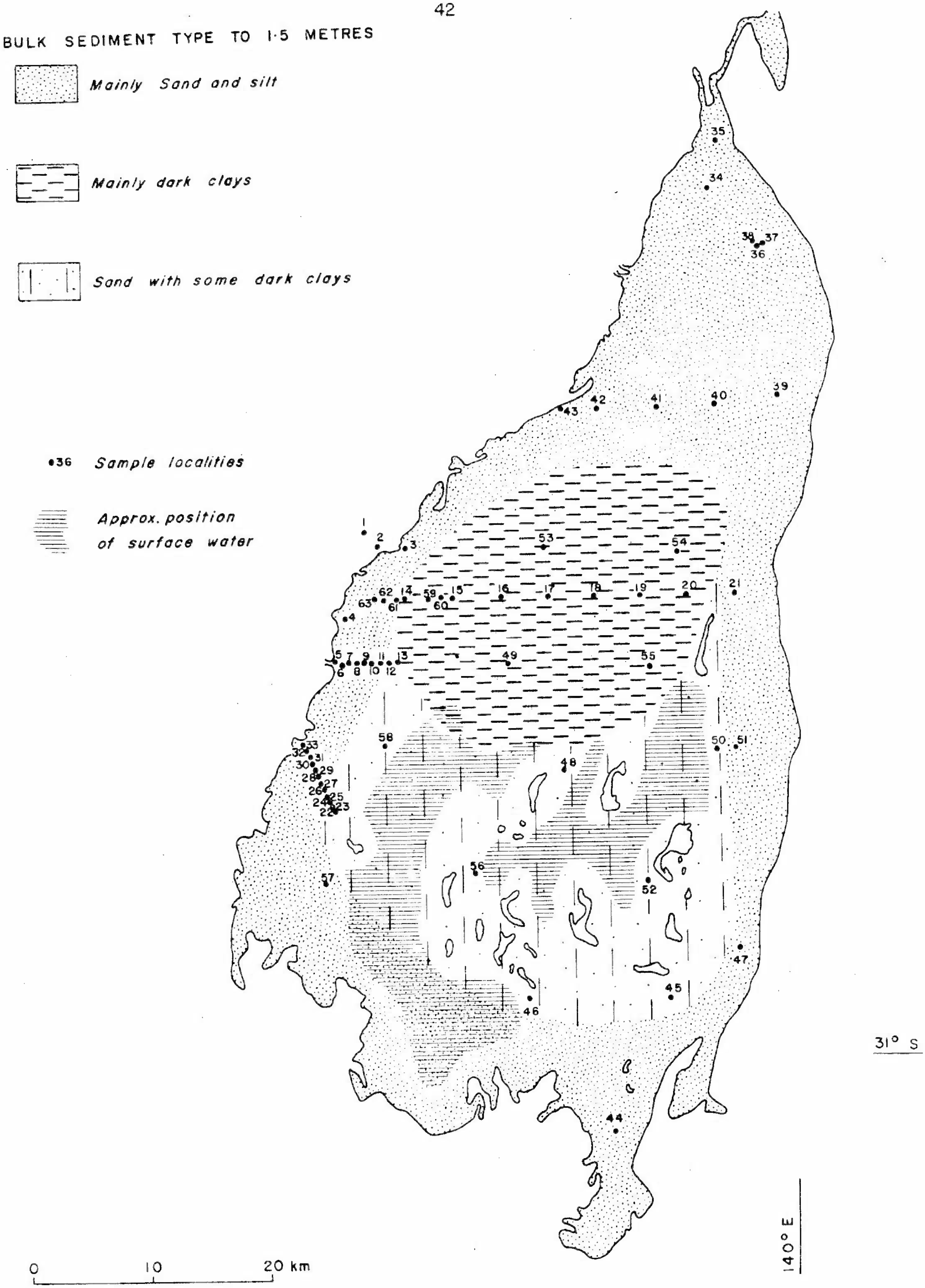


Fig. S12 Lake Frome, South Australia.

To accompany Record 1973/174

H 54/A10/2

The surface of the lake is flat, the difference in elevation between margin and centre being only in the order of 3 m. The southern central area does however contain a number of islands up to 6 km long and 30 m high.

The average yearly rainfall totals only 130 mm but at least 50 mm fell just prior to the survey and water up to one metre deep covered about 20 percent of the surface. Water was also encountered in each of the 60 auger holes drilled into the lake and it was particularly close to the surface in the central area. Mound springs on the eastern side of the lake indicate an influx of artesian water.

The surface sediment varies considerably from place to place. Sand and silt predominate on the margins of the lake, and in the central area there is a hard crystalline crust at least 20 cm thick of halite and gypsum. Farther north the surface is covered by a thin (3 mm) soft layer of brown clay which overlies up to 5 cm of black very carbonaceous, fetid clay with a rubbery texture. The average sediment type encountered in the first 1.5 m below the surface is shown in Figure S12. In the central area the surface clays are underlain by a sequence of green and dark bluish grey fetid clays. This clayey sequence extends beneath the crystalline crust and beneath the sandy sediments of the western and southern margins.

Organic material is present in a number of forms on the lake surface and in the sediment beneath. Black algal mats coated with silt are abundant in the central area directly above the layer of black rubbery clay. Algal mats are common on the surface of the mound springs and filamentous algae grow inside the carbonate mounds. Oogonia and ostracods are present in both the sandy sediments and in the dark coloured clays. Plant debris, including large logs, is scattered over the surface of the lake.

Samples were collected and auger holes drilled to depths up to 4.5 m at about 60 locations on the lake. The few samples of mud analysed to date contain no abnormal concentrations of metals. Pyrite has been discovered in both sands and muds.

Concurrent studies of the lake area are being undertaken by Dr J.M. Bowler of the Australian National University and Mr R.A. Callen of the Geological Survey of South Australia. Dr Bowler's study will concentrate on obtaining morphologic, stratigraphic and isotopic evidence for past hydrologic changes in the Lake Frome system which in turn reflect past climatic changes. Mr Callen is studying the Cainozoic sedimentology and stratigraphy of the Lake Frome embayment particularly with regard to stratiform uranium mineralization. Dr B. Bubela of the Baas Becking Geobiological Laboratory is examining organic material collected from the surface of the lake and from mound springs and has succeeded in growing algae in the laboratory.

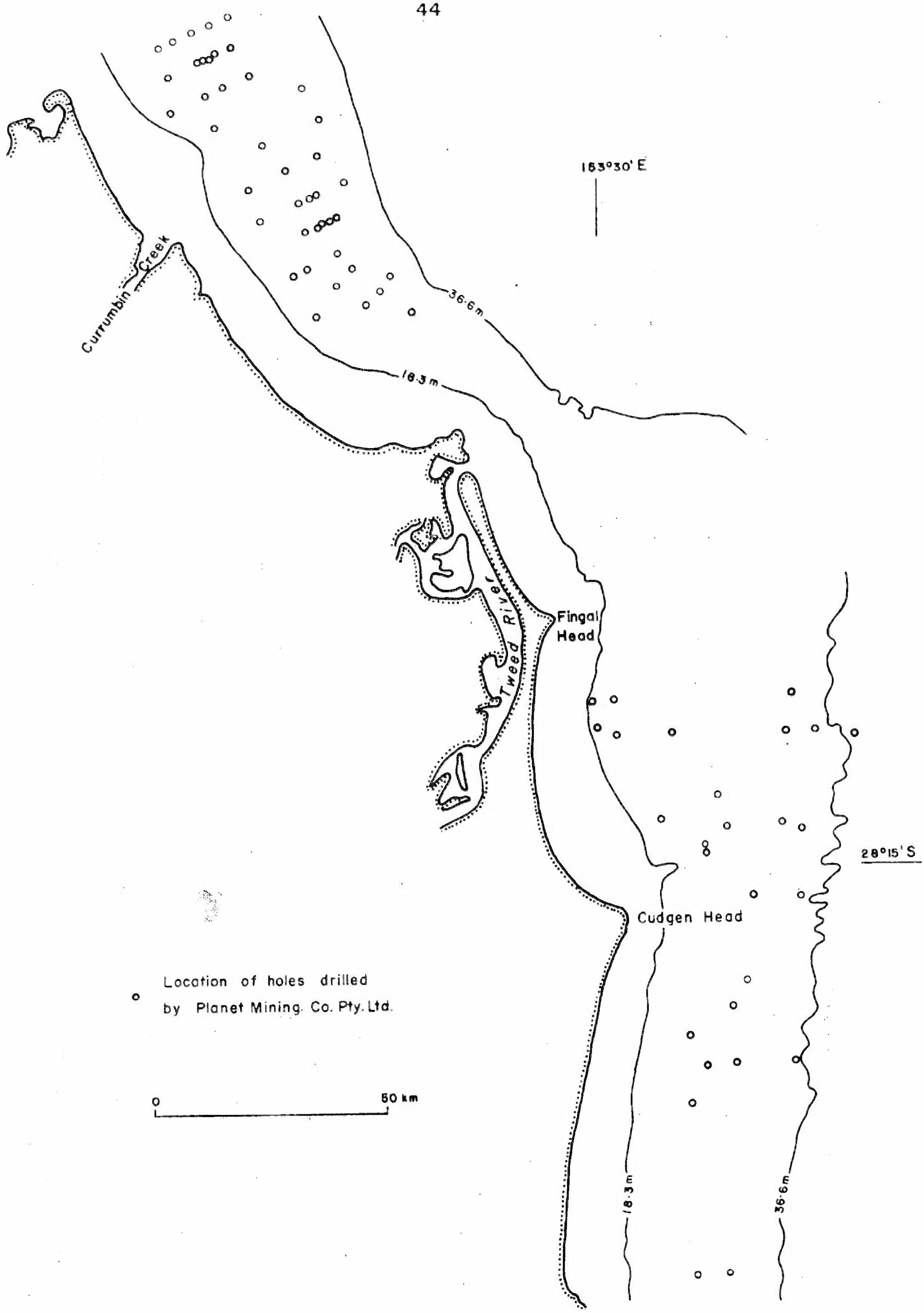


Fig. S 13 Heavy mineral sand study

To accompany Record 1973/174

H 56/A3/2

HEAVY MINERAL SAND STUDY

by

A.R. Jensen

Staff: A.R. Jensen, T.K. Zapasnik

After a brief survey during 1972 of current geological investigations into heavy mineral sands in Australia it appeared that the need for future studies lay more with possible offshore accumulations rather than with those occurring on land. If it can be shown that sands laid down in environments suitable for the accumulation of heavy minerals exist in offshore areas, further offshore prospecting will be justified. The greatest concentration of heavy minerals on land occurs on beaches but economic deposits also exist within dunes. The possibility that beach sands exist offshore depends on the likelihood that bodies of sand can be protected from reworking during a marine transgression. This could happen where dune sands are deposited over a beach during a regression to form a protective cover during the subsequent transgression. It is therefore important to establish if there is a method relatively available to detect buried beaches, if they exist offshore.

During 1973, drilling samples collected in waters adjacent to New South Wales and Queensland (Fig. S13) were examined to see if the sampling method used by Planet Mining Co. Pty Ltd was sufficiently accurate to allow identification of stratigraphic units and correlation from hole to hole. Approximately 300 samples from about 70 holes were analysed, each sample representing material from a 1.5 m interval. The composition, colour and grainsize of each sample were noted and the results were plotted on a series of cross-sections. The total heavy mineral content was also derived by analysis and recorded.

The study is incomplete, but preliminary results indicate that the sampling method is sufficiently accurate to allow recognition of broad stratigraphic units and that correlation from hole to hole is possible. Three broad units can be differentiated: (a) a surface layer of yellowish-brown sand about 1.5 m thick, probably representing sand reworked during the latest transgression; (b) pale olive grey sand, ranging from 1.5 m to 6 m thick, devoid of carbonate and possibly representing sand leached by subaerial exposure during a regression; and (c) dark olive grey sand with a carbonate content between 5 and 50 percent representing material which remained submerged or beneath the water table during the last regression.

BULIMBA FORMATION PROJECT

by

A.R. Jensen

Staff: Miss W.A. Burgis

Miss Burgis commenced a study of part of the Late Cretaceous or Tertiary Bulimba Formation of the Carpentaria Basin, Queensland, in 1972. The aim of the study was to determine the palaeogeography and controls of sedimentation operative during deposition of the formation, and the nature of post-depositional changes. Miss Burgis continued the study part-time during 1973 and resigned in July to undertake further university studies in the United States. Much of her report on the Bulimba Formation is written and it is expected that she will complete the remainder during 1974.

In the area studied the Bulimba Formation consists of unfossiliferous granule conglomerate, mudstone and sandstone. Fining-upward sequences and rapid lateral changes of sediment type indicate that the formation is a fluvial deposit. The streams depositing sediment on the eastern margin of the basin were confined to steep-sided valleys cut into sandstone, granite and metamorphic rocks, farther west they flowed across broad plains developed on mudstone. Detailed studies of the vertical sequences of rock types using Markov chain analysis revealed no significant difference between the fining-upward pattern in the valley-fill deposits and that characteristic of plain deposits.

Evidence gathered from the area of study, from the southern part of the Carpentaria Basin, and from the Eromanga Basin suggests that Early Cretaceous and older rocks were kaolinized during a late Cretaceous period of deep weathering. The Bulimba Formation was therefore derived from deeply weathered rocks and deposited on a deeply weathered surface. The formation was subsequently lateritized, and the older rocks re-weathered throughout the eastern part of the Carpentaria Basin during the Early to Middle Tertiary.

In the tectonically stable Weipa area the Bulimba Formation remained subaerially exposed during the Late Tertiary and it may have been subjected to bauxitization throughout the Tertiary. South of Weipa the lateritic profile was eroded and the fluvial Wyaaba Beds were deposited over the Bulimba Formation following Pliocene downwarping of the Gilbert-Mitchell Trough.

ESTUARY STUDIES

BROAD SOUND PROJECT

by

P.J. Cook

Staff: P.J. Cook, W. Mayo

No fieldwork was undertaken during 1973 and the main effort of the group was directed towards compilation of all available data and the writing up of results.

All data from the catchment and the estuary were put onto magnetic tape to facilitate data manipulation. The data were analysed using various statistical programs. A number of chapters of the Broad Sound Bulletin were completed including those dealing with sampling techniques and errors, grain size, hydrology, seismic work and depositional environments.

Tentative conclusions which have been reached include:

(i) Q-mode factor analysis is a useful numerical technique for the classification of samples (as opposed to arbitrary field classification). This is particularly so in estuarine sediments where a small number of factors explain a large proportion of the total variance.

(ii) Mean and standard deviation grain size values are useful for distinguishing estuarine depositional environments. Skewness and kurtosis were found to have little value for environmental recognition.

(iii) Depositional progradation over the past 5500 years has produced an extensive coastal plain up to 20 km wide. The west side of Broad Sound appears to have been stable throughout this time but there may have been some uplift on the east side.

MALLACOOTA INLET ESTUARY PROJECT

by

P.J. Cook

Work on Mallacoota Inlet material by G.E. Reinson (ANU) was completed during the year. Exhaustive statistical treatment of the geochemical and sedimentological data revealed a variety of inter-element and textural associations in the estuarine sediments. Important geochemical associations in the surface waters of the catchment area were also recognized. Examination of surface and sub-surface data made it possible to split the estuarine environment into various sub-environments, some of which may be of significance in the geologic record. This work has been written up in thesis form for submission for the degree of PhD, and is currently being modified for publication by BMR.

MARINE GEOLOGY

MARINE GEOLOGY OF BASS STRAIT AND THE TASMANIAN SHELF

by

P.J. Davies

Staff: H.A. Jones, P.J. Davies, J.R. Marshall

The geological reconnaissance of the east Australian continental margin between Latitude 39° and 44°S was completed in early May. Three hundred bottom samples and 4000 km of seismic profiles were obtained from the continental shelf around Tasmania and in Bass Strait. Since the cruise preparation of the samples for mechanical analyses has continued. A broad interpretation of the sediment distribution and seismic structure of the east Tasmanian Shelf has already been prepared for publication. These preliminary results are briefly reported below:-

The facies distribution of the continental shelf sediments surrounding Tasmania is shown in Figure S14. Four principal lithologies can be identified.

a. Quartz Facies This occurs to the south of Great Oyster Bay, off the east coast of Tasmania, off the south coast, and sporadically off the west coast. The sediments are principally medium-grained quartz sands, but to the south of Great Oyster Bay, quartz gravels predominate. Off the west coast, quartz sands occur only close to Port Davey and Macquarie Harbour.

b. Mixed Quartz Sand/Carbonate detritus facies This occurs off the east coast to the north of Great Oyster Bay, and in south-east Bass Strait. Off the west coast, this facies occurs only to the north of Macquarie Harbour. It forms a narrow zone close to the coast, but its distribution broadens significantly to the northwest, especially in the vicinity of King Island.

c. Mud Facies This only occurs in Bass Strait and on the east side of Tasmania. In Bass Strait, the sediments consist of blue-grey to olive-green plastic muds. Cores indicate that thicknesses exceed 1.5 m. Off the east coast of Tasmania, olive-green muds containing abundant bryozoan and molluscan debris occur. Cores indicate that this is at least 2.0 m thick.

d. Carbonate Facies Clastic carbonates occur predominantly to the south of Flinders Island, on the edge of the shelf off eastern Tasmania, over most of the shelf off south and west Tasmania, and a large part of western Bass Strait. Molluscan and bryozoan debris form the major portion of the facies.

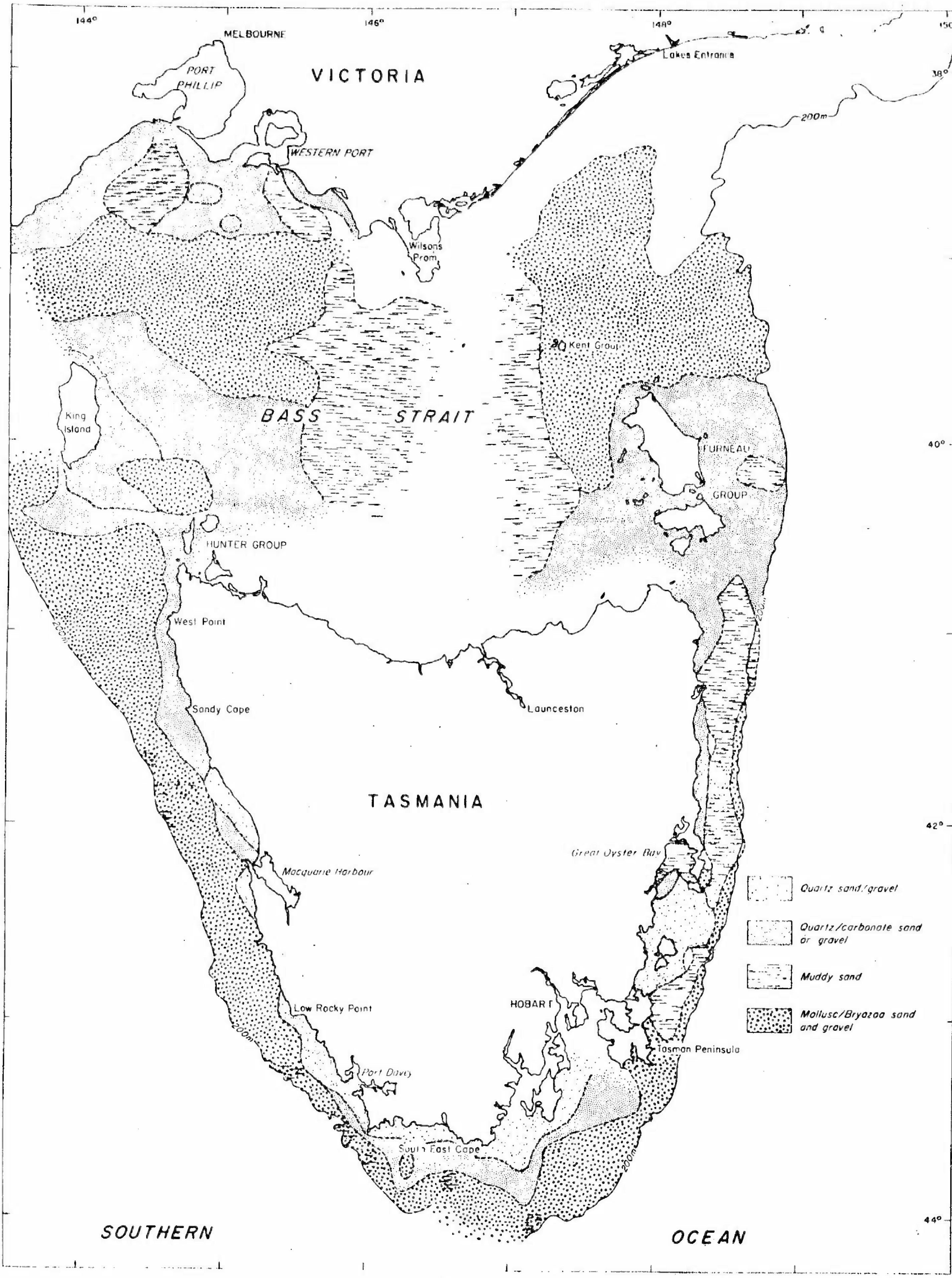


Fig. S14 Facies map–Bass Strait & continental shelf around Tasmania

Morphology

The width of the continental shelf around Tasmania ranges from 15 to 55 km. Off the east coast the inner shelf slopes relatively steeply, and is highly irregular due to outcropping of basement. The outer shelf is often sharply dissected. In the south the inner shelf is commonly terraced, and the outer shelf forms a wide plain at a depth of approximately 160 m. Off the west coast, the shelf surface has a rugged topography due to the cropping out of consolidated sediments. The shelf break around Tasmania varies from 125-175 m. The upper continental slope has a gradient of between 5° and 15°. Submarine canyons occur off the east, south and west coasts. A canyon off Sandy Cape extends across the shelf. This is considerably wider than other canyon traversed, and it has a U-shaped profile rather than the same typical V-shaped profile. It is likely that it has originated under different circumstances from the typical types.

Structure

Approximately 4000 km of seismic reflexion profiles were run over the continental shelf around Tasmania and in Bass Strait. In eastern Bass Strait, the sediment sequence overlying basement is essentially flat-lying, apart from drape structure over basement rises. An infilled channel was located in Ringarooma Bay.

To the east of Tasmania, the sediments dip to the east, parallel to the basement surface, and are truncated by the present shelf plain. Close to the shelf break, a subsurface unconformity at approximately 200 msec depth is visible in many profiles. A sediment wedge occurs above this unconformity. Gravitational slumping of sediments down the continental slope is a characteristic feature of this wedge. To the south of Tasmania, basement crops out on the inner part of the shelf, and then slopes gently to the south. In the sedimentary sequence above basement, a number of disconformities are present. In western Bass Strait, the sediments are flat-lying. In most areas, penetration was insufficient to locate basement. Gentle warping of the sediments is a common characteristic.

Tin and Phosphate

Offshore prospecting for detrital tin in Tasmanian waters by Ocean Mining A.G. in 1966-67 has indicated low grade deposits in Ringarooma Bay, in the northeast corner of the island. Twelve surface sample stations were occupied and 75 miles of combined seismic and magnetometer profiles were obtained in Ringarooma Bay during the present survey. No significant tin values were noted in the surface sediments and the nature of the sediments prevented piston coring. The seismic profiles indicate the presence of a major filled channel in the western part of the bay, which may be an extension of the channel now separating Waterhouse Island from the mainland of Tasmania.

Large areas of the middle and outer continental shelf off western and southwestern Tasmania are covered by a thin and patchy veneer of unconsolidated sediment amongst which calcareous gravels and nodular material, often more or less phosphatized, are common. Preliminary analyses suggest that the phosphate content is highly variable and generally low. A complete analysis of one nodule showed 10 percent P_2O_5, extremely high iron (40% Fe_2O_3), 18 percent CaO and 11 percent SiO_2. Trace metals are about average for marine phosphorites and rare earths much less than average.

CONTINENTAL SHELF MORPHOLOGY

by

H.A. Jones

A study of echograms obtained by the Division of National Mapping during their bathymetric survey of the continental shelf was undertaken with the objective of delineating submerged shorelines and other features which may be related to offshore accumulations of heavy-mineral sands. Interpretation of the profiles available between Sandy Cape at the northern end of Fraser Island, and Tweed Heads, on the Queensland/New South Wales border, was completed and published in Record form; work was in progress on the northern New South Wales shelf data at the end of the year.

The sounding lines are accurately positioned and closely spaced, with a line spacing usually of 1500 m, and they provide an important new source of data on the detailed physiography of the shelf.

The most widespread fossil shoreline occurs at a depth of about 105 m; it maintains a constant depth over long distances indicating that no detectable warping of the continental margin has occurred during the late Quaternary. It is unrelated to the shelf break, which is the point where an increase in gradient at the outer edge of the essentially flat continental shelf marks the commencement of the continental slope. In this area, as is the case in parts of the Northwest Shelf, there is a poorly defined, gently sloping zone between the true continental shelf and the true continental slope which does not naturally form part of either. Other less persistent linear features, which are believed also to represent fossil shorelines occur at several shallower depths along the middle and inner shelf. Shallow depressions on the shelf elongated parallel to the coast-line represent drowned coastal lake systems. No channels crossing the shelf which could be related to a subaerial drainage system developed at a time of low sea level were seen in the areas surveyed.

Although close inshore-bathymetric data are few, it appears that the relatively steep slope of the present-day beach continues seawards for about 2 km before levelling out to form the inner shelf terrace at 25 to 30 m depth. It follows that if similar forms were developed during ancient low sea level still stands, the most prospective areas for fossil beach heavy-mineral sand deposits would be near the crest of slopes on the landward sides of terraces.

It is not known how and to what extent any heavy mineral deposits which may have been associated with beaches now submerged would have been modified during and after the transgression of the sea. It is logical to assume that rising sea level and advance of the shore line would result in partial destruction of the beach dune system and in some redistribution and dilution of heavy mineral seams. It is also probable that the bulk of the littoral zone sand would migrate landwards with the advancing shore line, except where the beach dunes are backed by lagoons or swamps. If this is so, then the present-day beach zone is likely to contain a major part of the total east coast heavy mineral resources, even if large deposits were at one time concentrated in low-level shore lines on the continental shelf.

There is, however, still a possibility that substantial deposits exist off-shore, and although drilling has not yet revealed any high grade deposits, these may be present also. While some reworking of the upper part of the beach profile appears inevitable during a transgressive phase, heavy mineral seams lower in the profile could well be protected by the overburden, particularly if the rise in sea level was rapid. The chances of preservation would also be increased where some induration of the heavy mineral sand body, or the overburden, had occurred; this is not uncommon among the lower level deposits onshore.

DEEP SEA DRILLING PROJECT

by

P.J. Cook

P.J. Cook took part in Leg 27 of the Deep Sea Drilling Project, as a sedimentologist, in Nov - Dec 1972. Five holes were drilled in the Eastern Indian Ocean during this time; these showed, amongst other things, that the initial opening of the Indian Ocean occurred approximately 140 million years ago. Subsequent to the cruise Cook was concerned with the major and trace element geochemistry of the sediments, the phosphate content of the sediments and the porewater geochemistry at site 262 in the Timor Trough. Conclusions reached as a result of this work include:-

(i) Abnormally high alkalinity values in Timor Trough sediments are the result of the incorporation of abundant plant material in the sediments and the activity of bacteria.

(ii) Sulphate-reducing bacteria have a marked effect on the chemistry of the porewaters.

(iii) Phosphate maxima in deep sea sediments are probably associated with diastems.

(iv) Mesozoic and Cainozoic sediments in the Eastern Indian Ocean basin are chemically rather different.

(v) Barium is associated with both the biogenic and siliceous fraction and with clays.

The post-cruise conference at the Scripps Institution of Oceanography in California was attended in September.

EVAPORITE STUDIES

by

A.T. Wells

Staff: A.T. Wells, P.J. Kennewell.

Objectives

To review Australian occurrences of evaporite deposits and assess their economic potential. To investigate surface and near surface occurrences of bedded basinal evaporites to determine their mineralogy, and to investigate the depth to the more soluble evaporites beneath the ubiquitous surface gypsum breccias which were regarded as possible cap rocks.

Results

Field investigations consisted of the completion of drilling of one of the Madley Diapirs in the Officer Basin, W.A., a brief ground inspection of five of the six well exposed diapirs and an aerial inspection of other diapirs in the basin late in 1972.

BMR Madley No. 1 was prematurely abandoned at a total depth of 208 m because of poor core recoveries and lack of time. The hole was drilled in the westernmost diapir in the Madley chain where evaporites of presumed late Precambrian age occur in the core of a dome in which Permian and Cretaceous rocks are exposed; it is commonly referred to as Madley Diapir No. 6.

The drilling program was designed to continuously core the evaporites to a total depth of 300 m and obtain samples beneath the caprock zone. Twenty two cores were obtained in the lower part of the hole totalling 52.12 m, with 100% recovery over most intervals, and an average of about 90% recovery overall. Using the results and experience from drilling a similar sequence at the Woolnough Hills Salt dome it was planned that casing should be run in the cap rock to seal off water bearing zones and air-drill the underlying more soluble evaporitic sequence. However, the designed casing string was not of sufficient length and the cementing procedures were unsuccessful.

The cores of the cap rock zones revealed a variety of brecciated and recrystallization textures chiefly in gypsiferous and anhydritic dolutite and dolarenite. Anhydrite first occurs in a core at 154 m but the core above at 45 m contains gypsum. The most abundant minerals in the breccias are anhydrite, dolomite, quartz, mica, chlorite and feldspar.

Geochemical studies showed that most of the cores contain over 1% potassium but further quantitative analyses are to be made because the feldspar content could account for these values. Sodium values gradually increase from near surface (0.2%) to total depth (0.5%) and increasing halite content with depth is readily apparent by visual inspection of the core samples. As no halite samples below the caprock zone were recovered no further comments can be given regarding the economic potential of the evaporite sequence.

The reporting of the results of the evaporite drilling is currently in progress.

The review of Australian evaporite occurrences was completed and will be issued as a record. As a result of this review the following recommendations were made for further studies of evaporite occurrences in Australia -

1. Additional geological investigations of surface evaporite occurrences and palaeogeographic studies of evaporite sequences in the more prospective basins.

2. Stratigraphic drilling of the surface or near surface occurrences and shallow pattern drilling of the diapir cores.

3. Geochemical studies of evaporite drill cores particularly bromine content which gives an indication of the stage the evaporite cycle has reached and whether the bittern salt stage has been approached.

4. Geophysical investigations; detailed gravity and seismic traverses of known diapirs, and in other areas to solve specific problems such as the attitude, depth, source and dimensions of the mostly buried and largely concealed evaporite bodies.

5. Further drilling to detail targets outlined by geophysical surveys and ground mapping.

The most prospective areas for further investigation are the Adavale Basin where potash zones are already known and the Officer Basin which has well exposed evaporite cores in salt domes.

A paper on the occurrences of evaporites in central Australia was prepared as a contribution to the AIMM Volume on the Economic Geology of Australia and Papua New Guinea.

PHOTOGEOLOGY AND REMOTE SENSING

by

C.J. Simpson.

Staff: W.J. Perry, C. Maffi, C.J. Simpson.

During the period the group has been mainly occupied with evaluation of the imagery from, and administrative matters relating to, the Earth Resources Technology Satellite - ERTS 1.

Photointerpretation

Photointerpretation assistance was given to projects in Geological Branch, such as the surveys of the East and West Canning Basin Parties, projected sewer tunnel locations in Canberra, and to the Petroleum Exploration Branch in a study of the Douglas Point area, South Australia.

Remote Sensing

ERTS 1 Project

Since the launch of ERTS 1 on 23 July 1972 a steady stream of imagery of BMR test sites has been received. Evaluation of imagery has continued throughout the period and two reports on findings have been submitted to NASA.

Imagery of the following test areas has been evaluated:

Mount Isa	-	11 different scenes
Alice Springs	-	15 different scenes
Canberra	-	8 different scenes

In all areas major linear features are readily identifiable. Some correlate with known faults and fractures, some are undoubtedly previously unrecognized geological structures and others are of unknown origin at this stage. Differences between rock types can only rarely be distinguished on the imagery. W.J. Perry presented a lecture on ERTS-1 at the BMR Symposium, Canberra 22-23 May, 1973.

ERTS B Project

The Group gave assistance in formulating Australia proposals to NASA for participation in ERTS B experiments.

Mt Isa-Cloncurry SLAR Project

The evaluation of Side Looking Airborne Radar (SLAR) obtained in 1972 continued, and a report is scheduled to be completed early in 1974. C. Maffi presented a lecture on the project to the BMR Symposium, 22-23 May 1973. Copies of all imagery are available for public purchase through the Division of National Mapping.

Western Australia Remote Sensing Project

In 1970 a detailed airborne, magnetic and photographic survey was conducted over test areas at Laverton and Leonora WA to assess the value of geological data obtainable from the combination of these airborne techniques. A preliminary evaluation of the data was reported in BMR Record 1972/131.

C.J. Simpson and E.P. Shelley (Airborne and Metalliferous Section, Geophysical Branch) made a ground inspection of the test areas with Dr D. Gee (Geol. Surv. WA) from 28.9.73 to 7.10.73 prior to finalizing the project.

Bowen Basin Thermal Infrared Project

During August 1971 an aerial thermal imaging survey was carried out to test the technique for detecting buried coal deposits in parts of the Hail Creek Syncline of the Bowen Basin, Qld.

Results indicate that in the environment studied the coal seams could not be directly detected by the method. The report on the project is scheduled for completion early in 1974. A lecture on the project was given during the BMR Symposium 22-23 May 1973.

Rabaul Thermal Infrared Project

W.J. Perry visited Rabaul from 30.4.73 to 9.5.73 to supervise the contract for acquiring the imagery, the purpose of which was to locate thermal areas within the caldera. A record on the survey was in progress at the end of the period. The thermal imagery shows clearly the known thermally active zones, but no new thermal areas were discovered.

SKYLAB Project

The group carried out administrative duties related to the Australian involvement in the Earth Resources Experimental Package (EREP) project of the NASA manned orbiting laboratory SKYLAB. Four test sites - Mt Isa, Alice Springs, Kalgoorlie, and Canberra - will be photographed by Skylab astronauts if conditions permit.

The purpose of the photographic experiment is to assess the value of small scale space photography for earth resources studies. The Skylab photography will be compared with the electronic imagery produced by ERTS 1 over the same test areas.

The Skylab spacecraft (SL1) was launched 14 May 1973 into circular orbit with an altitude of approximately 400 km.

The first manned mission (SL2) occupied the spacecraft from 25 May to 22 June 1973.

During the second manned mission (SL3 - from 28 July to 25 September 1973) EREP photography of the Alice Springs and Canberra test sites was obtained on a continuous track from near Yuendumu Mission, N.T, to near Bega NSW. The photographs taken with a multispectral six camera system, and a high resolution terrain camera are expected to be received in Australia in November.

Training

Four new BMR geologists were instructed in basic photogeological interpretation techniques.

External Lectures

W.J. Perry, C. Maffi, and C. Simpson assisted in the organization and execution of a course on "Photo-Interpretation for Exploration and Survey Geologists" at the Australian Mineral Foundation, Adelaide, April 2 to 13, 1973. Thirty geologists representing exploration companies and teaching institutes attended.

W.J. Perry delivered lectures on photogeology and remote sensing at the 1973 TCUW Groundwater School at the Australian Mineral Foundation Adelaide in May.

During the period Group members delivered lectures on photogeology and remote sensing to various university and tertiary college classes.

A brief review of group work was given to the "International training course in Mineral Exploration and Administration" presented by the Department of Foreign Affairs.

Group Displays

Displays on photogeology and remote sensing were prepared for the Scientific Committee for Antarctic Research meeting, Geology students ANU, the "International training course in Minerals Exploration and Administration" and the opening of the new premises of the Australian Mineral Foundation Adelaide.

Overseas Visits

C. Simpson was overseas during the period 1.11.72 to 5.12.72 as part of a visit to the USA, Canada and UK. The primary purposes of the visit were to gain experience in the interpretation of data from ERTS-1 and to compare the satellite data acquisition and remote sensing systems of the USA, Canada and UK.

Because of initial data supply problems, only a few US and Canadian investigators had experimented with ERTS imagery at the time of the visit. Despit this, some could demonstrate that the satellite data can provide new information to some disciplines.

Only the USA and Canada have the capability of directly receiving data from the satellite. All the other nations receive their data via USA tracking/receiving facilities and are thus dependent on satisfactory operation of a tape recorder on board the satellite.

The potential benefits to Australia of ERTS-1 data should be evaluated within 12 months and this information will be used by the authorities in deciding whether the installation of special satellite tracking/receiving facilities in this country is warranted when an operational ERTS-type satellite is launched. Mr Simpson obtained figures on the costs of such facilities. He attended a Skylab Earth Resources Experiment Package (EREP) Principal Investigators' Conference on behalf of Dr Fisher. As a result of discussions with NASA representatives and consultation with the ACERTS Working Group, photography from Skylab of four test areas was requested, namely: Priority 1, Mt Isa, Priority 2 Alice Springs, Kalgoorlie, Canberra (equal).

C. Maffi left Australia on 30.7.73 and was overseas until the end of the period to undertake United Nations work in Brazil and to attend a course in France on remote sensing.

Australian Committee for ERTS (ACERTS)

Throughout the period the Geological Branch of the Bureau continued to provide the secretariat for the interdepartmental committee ACERTS, which is concerned principally with Australian participation in the United States Earth Resources Technology Satellite and Skylab programs. N.H. Fisher is Chairman of the Committee which also has representatives from the Division of National Mapping. Other organizations represented in the IDC are CSIRO and the Departments of Science, Supply, Environment and Conservation, Primary Industry, Northern Territory, and Army. C.J. Slater was appointed Secretary of the IDC on 16 April, 1973, but W.J. Perry still attends to technical matters. Two ACERTS meetings were held during the period.

C.J. Simpson visited Canada, USA and UK in October and November 1972 to study ERTS data reception and distribution methods, and progress in the interpretation of ERTS data.

As reported in the Annual Summary for 1971-72, ACERTS arranged for dissemination of information relating to opportunities for participation in the ERTS B experiment, and as a result 42 proposals in the following fields were approved by the various technical assessment panels as suitable for submission to NASA: Agriculture and related fields 9; Geography 5; Geology 21; Hydrology 3 and Forestry 4. Subsequently NASA announced that the launch of ERTS B had been postposed until early in 1976, and that proposals for participation in the ERTS B experiment would as far as possible be satisfied by changing them over to ERTS-1. At the end of March the tape recorder on ERTS-1 was turned off because of deterioration of the tape, thus preventing further acquisition of imagery of Australia, at least on a routine basis, although later it became clear that part of the tape was still usable and thus it was still possible to obtain imagery of limited areas on special request e.g. of flooded regions. NASA announced that proposals for participation in the ERTS B experiment would be re-solicited closer to the projected launch date.

Under the terms of the agreement with NASA relating to ERTS 1, investigators submitted through ACERTS two reports during the period on the progress of their investigations. Following are extracts from the results, which are essentially of a preliminary nature:

ERTS imagery has been used for mapping the distribution of forested versus cleared land, reefs and islands, areas of snow cover, water bodies, extent of bush fires, broad geological features particularly long linear features, major soil landscapes, and irrigation areas versus dry farm areas. Some investigators expressed the view that the imagery did not provide information over and above that obtainable by conventional means.

Evaluation of the imagery was still in progress at the end of the period; a symposium for investigators is scheduled for December 3-4, 1973, and final reports are required by NASA by the end of February 1974.

The formal agreement with the USA covering Australia's participation in the manned orbiting satellite project SKYLAB was signed on May 11.

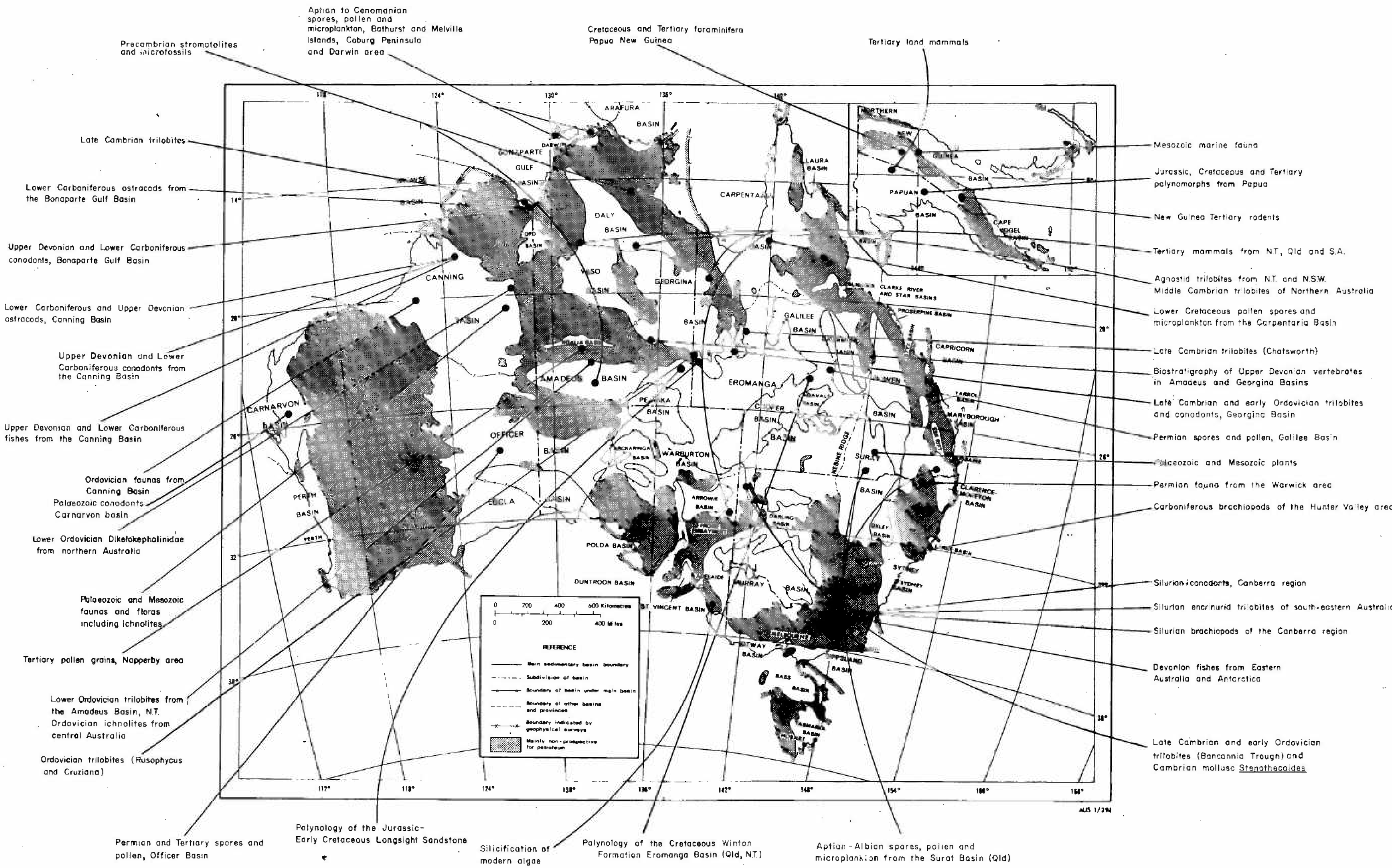


FIG S15 CURRENT PALAEONTOLOGICAL PROJECTS

To accompany Record 1973/174

M(P)446

PALAEONTOLOGICAL STUDIES

Staff: J.M. Dickins, M. Plane, J.H. Shergold, D.L. Strusz, J. Gilbert-Tomlinson, G.C. Young, D.J. Belford, P.J. Jones, E.C. Druce, D. Burger, R.S. Nicoll, E.M. Kemp, M.R. Walter.

E.M. Kemp joined the Group in April. She has had wide experience in palynology and will continue to work on fossil pollen and spores in BMR.

M.O. Woodburne concluded her work in Australia on fossil marsupials and returned to the USA in April.

S.C. Shah has been working in the Group since April under a Colombo Plan Fellowship. He is mainly concerned with comparing the Indian Permian invertebrate faunas with those from Australia and studying the palaeogeographical and age relationships.

Specialist work under contract has been continued by A.A. Opik (Cambrian trilobites and stratigraphy) and Mary E. White (fossil plants).

J.M. Dickins

Examination of the 1972 Permian invertebrate collections from the Northeast Canning Basin in collaboration with P. Jell was completed and the report prepared. A joint paper with R.A. McTavish of West Australian Petroleum Pty Ltd on a reassessment of the age of the Triassic Kockatea Shale of W.A. was submitted for publication to the Journal of the Geological Society of Australia.

J.M. Dickins attended the Sydney Basin Symposium in Newcastle and the Tasman Geosyncline Symposium held in Brisbane in honour of Professor Dorothy Hill. As chairman of the Organizing Committee he took part in organizing and participated in the Third International Gondwana Symposium in Canberra, 20-25 August 1973. The Symposium was sponsored by the International Union of Geological Sciences and the Australian Academy of Science.

Much time was spent on the organization of the Palaeontological Group and the care of the fossil collections.

M. Plane

Work was completed and published on the middle Tertiary Thylacoleonidae (marsupial lions) from Bullock Creek, N.T. and Lake Ngapakaldi, S. A. Work on other aspects of Tertiary mammal faunas from Bullock Creek, Riversleigh, Qld., and Lake Ngapakaldi continued. The genus Neohoolos is now recognized from all three localities.

Material from Morgorufugwa, in the western highlands of Papua New Guinea extended the known geographical and chronological range of the wallaby-like Protemnodon.

Field work in the Frome Embayment of South Australia and southwest Queensland was most successful in that small and large fossil marsupials were found in quantity at Lake Pinpa in S.A. The search for Cretaceous or Early Tertiary marsupials in southwest Queensland did not produce any fossils. From what was seen of the collections in the field it seems many new species and probably one new family of marsupials were found. These are represented not only by teeth but by entire articulated specimens in many cases.

A paper with M.O. Woodburne of the University of California, R.H. Tedford of the American Museum of Natural History and others entitled 'Biostratigraphy, Chronology, and the continental mammal record of Australia and New Guinea' was presented at the Geological Society of America meetings in November. A popular paper on fossil mammals of New Guinea was published.

J.H. Shergold

J.H. Shergold was engaged in the following major activities:

Descriptions and illustrations of latest Cambrian and earliest Ordovician trilobites from the southern part of the Burke River Structural Belt, western Queensland, were completed and presented for publication (BMR Bulletin 153).

Description and illustration of late Cambrian trilobites from the Lily Creek/Chatsworth area, also within the Burke River Structural Belt, a project initiated during the year and continuing. To date material from 38 collected horizons on two sections, Lily Creek and Horse Creek, close to Chatsworth HS, has been prepared, photographed and preliminarily analysed.

Late Cambrian Eocrinoids from the Lily Creek Section have been technically prepared and await description.

In collaboration with Dr R.A. Cooper, New Zealand Geological Survey, a small collection of late Cambrian trilobites from the Bowers Group, northern Victorialand, Antarctica, was processed. A paper describing this fauna is in preparation.

The stratigraphical and areal distribution of the agnostid trilobite genus Pseudagnostus, of potential zonal value, was investigated on a global scale, and the conclusions prepared for publication.

Some description and determination of collections made by GEOPEKO Ltd was undertaken.

Minor activities included: the preparation, in collaboration with E.C. Druce, for intended field work with the Georgina Basin Party, and for 25th International Geological Congress excursion 4C.

As a member of an infra committee of the organising committee of the 25th IGC, preparations were made for the palaeontological symposia of the congress.

A NATO sponsored symposium on advanced trilobite morphology was attended in Oslo, Norway, between 1-8 July.

The Third International Gondwana Symposium, held in Canberra in August, was attended.

Visits were made to the University College of Wollongong, University of Sydney, and the NSW Department of Mines.

D.L. Strusz

D.L. Strusz continued work on a revision of the encrinurid trilobites of southeastern Australia. Several localities in Canberra have yielded relatively large numbers of specimens, needing careful preparation. Several species can now be recognized in the Canberra faunas, including one which is probably new. Encrinurus etheridgei (with which Mitchelaspis duntroonensis is synonymous) and E. mitchelli are the most common species.

Study of Silurian sequences and faunas has extended beyond the Canberra area. A Record has been written, with Dr R.S. Nicoll, on Ordovician to Devonian faunas collected by the geologists of Jododex (Australia) from the "Woodlawn" prospect east of Lake George. In preparation for writing a chapter on the Silurian of the southern part of the Cowra-Yass Synclinorial Zone, for the forthcoming N.S.W. Geological Survey publication on the Silurian System in N.S.W., collecting trips have been made to the Cooma district. These have confirmed the Silurian age of a number of limestone-shale-acid volcanics sequences which appear to be southward continuations of the Canberra and Captains Flat Graben sequences. An excursion to examine the Lachlan Geosyncline between Canberra and the Cretaceous around Mudgee - Wellington was run in November 1972. As well as BMR geologists, participants included representatives from the N.S.W. Geological Survey, several universities in N.S.W., and Dr R.A. Cooper from the New Zealand Geological Survey. Strusz attended the Symposium on the Tasman Geosyncline, held in Brisbane in May-June 1973, in honour of Prof. Dorothy Hill on her retirement from the Geology Department of the University of Queensland.

J. Gilbert-Tomlinson

J. Gilbert-Tomlinson made a short study tour to examine outcrops of Ordovician, Silurian, and Devonian rocks in the Lachlan Geosyncline of New South Wales. Discussions of stratigraphic, taxonomic, and palaeontological problems were held with several participants to the Gondwana Symposium. A palaeontological appendix to the Bulletin on the Sydney Basin was checked in proof, and manuscripts by J.H. Shergold (Cambrian trilobites of the Black Mountain structural belt) and G.C. Young (Ranges of Devonian Antiarchs) were read. The following manuscripts are in preparation:

1. Ordovician dikelokephalinid trilobites of northern Australia (Bull)
2. Early Palaeozoic ichnolites of central Australia (Bull)
3. The Cambrian mollusc Stenothecoides in New South Wales (Pal. Papers, 1973).

G.C. Young

G.C. Young spent six weeks in May/June in the Amadeus Basin, where known Devonian fish localities were revisited and a rich new locality was discovered near Stokes Pass in the western Macdonnell Ranges. Supposed Ordovician vertebrate remains from the Stairway Sandstone at Mt Watt were also collected.

Preparation of the material from Stokes Pass was commenced in September. Material so far prepared includes a number of complete specimens of the antiarch Bothriolepis and small lungfish skull almost identical to the European Middle Devonian genus Dipterus.

Antarctic Collection

Preparation of antiarch material from the collection made in Antarctica in 1970/71 was continued throughout the year, and was almost completed by September. About half the photography has been done. Little descriptive work was achieved apart from that done in conjunction with work on the Knobby Hills fauna (see below).

Collection from Knobby Hills, Billiluna, W.A.

This material was collected in 1972 and during the year was completely prepared and described. Descriptions will be published in Palaeontological Papers 1973.

In addition, considerable literature research on the biostratigraphy of Devonian fishes throughout the world was undertaken to enable a reliable age assessment for the Billiluna assemblage to be made. The results of this work are being prepared for publication in "Newsletters on Stratigraphy".

Canning Basin Gogo material

Preparation of the Gogo material has continued throughout the year, but because of the delicate nature of preservation and the time involved preventing disintegration of bone during acid treatment only a small number of specimens have been completed. Details of preparatory techniques developed in the British Museum for some material were obtained from Mr I. Macadie, Australian Museum, and several different methods have been tested. Best results have been obtained with weak acetic acid, and using this technique a Bothriolepis specimen has been prepared to show meckelian and palatoquadrate ossifications in the jaw apparatus, which have not previously been recognized in this group. One arthrodire skull has been completed and work is in progress on skulls of the lungfish Griphognathus, to be sent to GSWA for display purposes.

Taemas/Wee Jasper material

Almost all material collected from this area has been prepared. The vertebrate faunal list can now be extended to include acanthodians, ptyctodonts, palaeoniscids and struniiform crossopterygians, all of which occur in micro vertebrate assemblages obtained from acid residues. The most important result of this work has been the preparation and X-ray photography of two skulls which show a unique endocranial arrangement combining distinguishing features of two major groups of placoderms - the arthrodires and the antiarchs. As such this new genus appears to represent a new order within the class Placodermi.

Other collections

The type material of Bothriolepis gippslandiensis Hills was obtained on loan from the University of Melbourne and other Victorian Upper Devonian material was borrowed from the National Museum.

D.J. Belford

Foraminiferal work by D.J. Belford for the period was again connected mainly with regional mapping projects in Papua New Guinea. Examination of samples collected by the West Sepik Survey was completed; examination of samples from the Torricelli area continued, and is not yet completed. Samples submitted by the Papua New Guinea Geological Survey from the Port Moresby, Yule, Aroa, Kalo, Bogia, Madang, Markham, Karkar and Huon 1:250 000 Sheet areas, the New Ireland area, and the Nomane area, Chimbu District, were examined, and reports prepared. Samples collected by P.T. Kennecott (Indonesia) from the Naltja area, West Irian were examined. No detailed examination of the faunas has been made; a late middle Eocene or late Eocene fauna from the Wabag area, which contains the planktonic foraminiferal genus Hantkenina, had not been recorded previously.

As time permitted, compilation of foraminiferal studies from the Wabag-West Sepik area continued, but little has been done. Studies at present concern only Tertiary foraminifera and stratigraphy.

A computer retrieval program for curation of the foraminiferal collection has been developed, tested and proved. Data are now being entered into the program whenever possible.

The Inaugural Meeting of the Working Group on Stratigraphic Correlation between Sedimentary Basins of the ECAFE region was attended in Bangkok from 24-30 July. The offer by the Bureau to develop a repository of topotype and representative fossil species from the countries of the ECAFE region was reaffirmed and accepted. Organizations in Australia and New Zealand have been contacted, seeking their participation in the project. The Bureau has also agreed to assist with the preparation of a Stratigraphic Atlas for the sedimentary basins of the ECAFE region; this is to be submitted by the ECAFE Secretariat for approval as on IGCP Project.

P.J. Jones

P.J. Jones continued on the main project - systematic palaeontology of the Lower Carboniferous Ostracoda from the Bonaparte Gulf Basin; this work involves the description of ostracod species (with the use of simple biometrics and scanning electron microscopy), and their biostratigraphic and palaeoecologic analyses. Orders described include the Beyrichicopida and the Platycopida, and the descriptions of the suborders Bairdiocopa and Kirkbyocopa are close to completion. Many species are new, and others appear to be closely related to those previously described from the Lower Carboniferous rocks of Europe (the USSR, in particular), and North America.

A review paper on Australian Devonian and Carboniferous (Emsian-Visean) Ostracoda was prepared for the International Symposium of Micro-palaeontological Limits (Namur, Belgium, September, 1974); this is our account of previous investigations and their present biostratigraphic value.

A review paper on "The Silesian in Australia" was prepared jointly with E.C. Druce for the special meeting of the Belgian Geological Society on the Silesian (in honour of Prof. van Leckwijck) in November 1973. This gives a brief outline of the distribution of Upper Carboniferous rocks and their faunas, in Australia.

Preparation of a check list of Ostracoda recorded from Australia and Papua New Guinea (1845-1973) was started as a joint project with P. de Deckker (Dept. of Earth Sciences, Macquaire University, Sydney).

E.C. Druce

E.C. Druce continued work as Party Leader, West Canning Basin Field Party. Initial examination of the conodont faunas was completed in January and the fauna handed to R.S. Nicoll for completion.

Work continued on the general geology and geochemistry of the Devonian-Carboniferous sequence in the Canning Basin.

The conodont study of the Devonian reefs in the Canning Basin was completed. The hypothesis of horizontal layering of conodont faunas within a water body was propounded. This was used to interpret changes in relative sea level through time, and an attempt was made to elucidate the palaeobathymetry of the Lennard Shelf.

Lectures were given at the BMR Symposium, at an APEA luncheon, to the Geological Society of Australia (Territories Division) and the Universities of New South Wales, Sydney, and Newcastle.

D. Burger

D. Burger's activities were concentrated on detailed systematic stratigraphic palynology of the Cretaceous in northern Australia. The two areas of study are:

1. Queensland (Great Artesian Basin Project)

a. Stratigraphic study of the Neocomian of the Surat and Eromanga Basins was continued with examination of cores from stratigraphic drilling in the Roma area by the Geological Survey of Queensland. Detailed study of the (Aptian-Albian) Rolling Downs Group is under way; in view of the volume of work it is at present restricted to the Surat Basin. Together with stratigraphic aspects, detailed research on pollen, spores and microplankton systematics was carried out. Besides, this study includes considerations on climate, environment (in context with results of field data), and plant migration.

b. After initial examination of marginally developed sediments in western Queensland and adjacent parts of Northern Territory (BMR Record 1973/102), a more detailed study of the (late Mesozoic) Longsight Sandstone has been planned. Material from the formation in subsurface of the Springvale, Boulia, Winton and Brighton Downs Sheet areas, as well as from Northern Territory, is being examined.

c. A short paper is in preparation; it deals with the systematics of selected spore and pollen species from the Neocomian-Aptian in Queensland. Some of these had not been described before from Australia, and appeared to be useful stratigraphic indicators in the Lower Cretaceous of the Great Artesian Basin.

2. Northern Territory (Darwin region Project)

a. Study of the Cretaceous (Aptian-Cenomanian) in the region around and north of Darwin is in progress. A paper dealing with geological occurrence and systematics of Cenomanian spores, pollen grains and microplankton from Bathurst Island (co-author is M.S. Norvick) is in press.

b. Examination of subsurface and outcrop material from Melville Island and Cobourg Peninsula has so far demonstrated that sediments of Cenomanian age occur north of approximately latitude 12° south. Shallow drilling north and northeast of Darwin by the Mines Department of the Northern Territory has penetrated marine Aptian and Albian sediments. Further shallow stratigraphic drilling by the Bureau in these regions has provided further study material which is being examined.

Further activities include the following:

(i) An edge-punchcard system was developed for storage and retrieval of morphological and geological data of fossil microplankton; a collection of cards on Cretaceous and Jurassic Australian dinoflagellate genera is already being used. The system is being extended to include all described species from Australian Mesozoic and Tertiary sediments.

(ii) During May and June 1973 shallow stratigraphic drilling in the Boulia Sheet area (western Queensland) was supervised. Core samples were collected for petrological, stratigraphical, palaeontological and palynological study of the marine Lower Cretaceous in the western Eromanga Basin.

(iii) Advisory activities were low during the first six months of this year, due to reduced exploration drilling. Hematite Petroleum Ltd requested palynological age determination of sediments drilled in 2 wells in the Eromanga Basin (Lovelle Downs 1, Clyde 1). Geopeko Ltd drilled and mapped (Mesozoic?) strata in the Alligator River area, Northern Territory. As from July, 1973, requests for palynological advice were stepped up when Oceania Petroleum Ltd commenced drilling in the Carnarvon Basin (Tamala 1, Kalbarri 1); this work is being continued.

(iv) The Gondwana Symposium, held in Canberra (August, 1973) was attended.

Laboratory

During the year Mrs. L. Kracuik, Technical Assistant, processed 300 rock samples, mainly from Mesozoic and Palaeozoic sediments in Australia and Papua New Guinea, for palynological examination.

R.S. Nicoll

R.S. Nicoll continued work on the major project involving study of Devonian and Lower Carboniferous conodonts from the Canning Basin. The conodont fauna from the Fairfield Formation has been identified and preliminary descriptions written for about half the species. Identification of the conodont fauna of the Laurel Formation is in progress.

Samples from the Kuta Formation collected near Kundiawa, Chimbu District, PNG were processed for conodonts. Two specimens were obtained, both assigned to *Neospathodus hornsteini* which would place the Kuta in the Upper Norian substage of the Upper Triassic.

Approximately thirty conodont samples have been processed in connection with field mapping of the Tantangara 1:100 000 geological map. Samples of the Cooleman Limestone have yielded conodonts of Wenlock and Ludlow (Silurian) age. Large slump block of limestone in the Blue Water Hole Beds also contain conodonts of Ludlow age.

Samples from limestone lenses in the Peppercorn Beds contain a very good conodont fauna of Llandovery (Early Silurian) age.

Silurian rock samples from a number of localities in the A.C.T. and adjacent N.S.W. have been examined for conodonts in the past year. Recovery of specimens has been very low per kilogram of rock processed but yields do give indications that a general framework of Silurian conodont biostratigraphy may be worked out for this area of Australia. Work in this area continues.

Samples of Permian limestones and shales from the Carnarvon Basin were collected and processed. No conodont faunas were recovered but the number of samples is not considered to be a significant test of the presence or absence of Permian conodonts in that part of Australia.

E.M. Kemp

E.M. Kemp joined the BMR on April 9th, 1973. Work on material collected during operations of the Deep Sea Drilling Project has resulted in the completion of one manuscript for the Initial Reports volume of Leg 26, dealing with Miocene microfloras from the Ninetyeast Ridge, Indian Ocean, and the near-completion of another for Leg 28, concerning the sedimentology and palynology of sites offshore from Antarctica.

A paper entitled 'The palynology of late Palaeozoic glacial deposits of Gondwanaland' was prepared and presented at the 3rd International Gondwana Symposium in Canberra in August, and is now in press in the Proceedings volume for that conference.

Preliminary work has been undertaken on the palynology of core material from BMR boreholes in the Officer Basin, and with examination of samples selected from BMR Rason 2, Neale 2, Wanna 1, Yowalga 4 and Talbot 4 holes.

In June, a talk entitled 'Palynology and palaeoclimatology' was given to the Territories Division of the Geological Society of Australia in Canberra. Another, 'Continental positions, climates and Tertiary plant life', was given to the Botany Department, University of N.S.W., in September.

M.R. Walter

M.R. Walter joined the Bureau in March 1973. The two major projects commenced this year were studies of the Precambrian fossils of the McArthur and Amadeus Basins. These projects have three major aims: (1) investigation of the utility of Precambrian fossils (particularly stromatolites) in biostratigraphy; (2) delineating the course of evolution during the Precambrian, by the study of microfossils, body fossils, trace fossils and stromatolites; (3) furthering the use of Precambrian fossils in palaeoenvironmental interpretation. This latter is aimed especially at aiding in the study of possibly syngenetic ore deposits such as the HYC deposit in the McArthur Basin. Five weeks were spent collecting in the Amadeus Basin and a two week reconnaissance trip was made to the McArthur Basin.

In the Amadeus Basin collecting was concentrated in the Areyonga and Pertatataka Formations, the Arumbera Sandstone, and correlatives of these units, because fossils of the ages these rocks record are poorly known throughout the world. No new discoveries were made in the Areyonga Formation but a possible fossil found by A.J. Stewart near Jay Creek was collected. The Boord Formation is a possible correlative of the Areyonga Formation in the westernmost part of the basin. Two forms of columnar branching stromatolites and some pale grey cherts were collected from this formation (cherts commonly contain microscopic fossil algae and bacteria). The Inindia Beds of the southern Amadeus Basin are also correlated with the Areyonga Formation and stromatolites have been reported from the Inindia Beds in the Bloods Range 1:250 000 Sheet area. Outcrops in the vicinity of Mount Unapproachable and Longs Range were searched for stromatolites. Definite columnar branching stromatolites were found in an isolated outcrop northwest of Mount Unapproachable and probable linked cumulate stromatolites occur in a small outcrop in the bed of Lake Neale, near its eastern end. The sedimentary rocks in the large area of outcrop mapped as Inindia Beds immediately north of Mount Unapproachable closely resemble the upper Loves Creek Member of the Bitter Springs Formation. They consist largely of red siltstones and sandstones, some with white (bleached) spots, and rare interbedded grey, laminated dolomites (without stromatolites). No prospective cherts were found in the Inindia Beds.

Columnar branching stromatolites (probably Tungussia inna Walter) were collected from the Ringwood Member of the Pertatataka Formation near Limbla Homestead and northeast of Allambi Homestead. A few pale grey chert nodules were collected from the latter locality. New discoveries of columnar branching stromatolites and dark grey cherts were made in the Julie Member of the Pertatataka Formation near Acacia Well in the Alice Springs Sheet area.

The Pertatataka Formation and its correlative the Winnall Beds were searched for trace fossils at numerous localities: near Areyanga Settlement and Katapata Gap in the Gardiner Range, Mount Unapproachable, Long Range, Mount Conner, Henbury Craters, southeast of Ringwood Homestead and east-northeast of Allambi Homestead. Fossils were found only at the Henbury Craters. Trace fossils have been reported from many of the other localities but no structures were found which could not be interpreted as desiccation or syneresis cracks, ripple marks, food marks, groove casts or other nonbiogenic sedimentary structures. At Henbury Craters specimens of probable "seaweed" drag marks (first reported by Milton) were collected and one specimen of possible minute animal burrows was found.

The lower Arumbera Sandstone near Valley Dam yielded many specimens of what may be a new type of fossil metazoan resembling Erniettomorpha from the Precambrian of Africa.

The Heavitree Quartzite was searched at several localities from which possible trace fossils have been reported but no fossils were found. Black cherts were collected from the Bitter Springs Formation near Limbla Homestead, Ross River Tourist Chalet, Jay Creek, Ellery Creek, Katapata Gap and in the Erldunda and Bonython Ranges. These came from both columnar and stratiform stromatolites. The stromatolite Inzeria intia Walter was newly discovered at Katapata Gap. The impression gained in the field is that the black cherts that contain the famous Bitter Springs microbiota formed in a supratidal or upper intertidal environment.

During a reconnaissance of the McArthur Basin with K.A. Plumb stromatolites were collected from the Amelia Dolomite, Tooganinnie Formation, Emmerugga Dolomite, Amos Formation, Balbirini Dolomite and Karns Dolomite (all units of the McArthur Group) and from the Wollogorang Formation of the Tawallah Group. Black cherts were collected from many of these formations and the Reward Dolomite. Several kinds of columnar branching stromatolites were found, along with a wide variety of Conophyton-type stromatolites. Some small conophytons closely resemble modern forms in hot springs, although the McArthur Basin forms are probably marine. Black cherts were sampled from the Tawallah Pocket No. 1 drill hole core, courtesy of Carpentaria Exploration Company. Cores, maps and cross sections from the CEC lease areas near McArthur River were examined. In addition a rapid visit was made to this company's leases near Paradise Creek and advice was given on the interpretation of stromatolites.

Research on hot spring stromatolites and geyserite continued. Editing of a book on stromatolites commenced. Two manuscripts were reviewed for the American Journal of Science. Lectures were given to the Baas-Becking group, the BMR Symposium for industry, the IUGS Subcommission for Precambrian Stratigraphy, the Canberra branch of the Geological Society of Australia and the N.T. Geological Survey at Alice Springs.

In addition, Dr M. Muir of Imperial College, London, is studying Australian Precambrian microfossils as part of a cooperative project with the Bureau and the Baas Becking Laboratory. Important new finds of microfossils have been made in the McArthur Group of the McArthur Basin and the Bungle Bungle Dolomite of the Kimberley Basin. Additional discoveries have been made in the Roper Group of the McArthur Basin, the Hamersley Group of the Hamersley Basin and in the Archaean near Kalgoorlie. Microfossils of Tertiary or Quaternary age were found in silcrete at Southern Cross in Western Australia. The Amelia Dolomite of the McArthur Group contains an excellently well preserved microbiota of colonial unicellular and relatively large multicellular microfossils. This unit is about 1.6×10^9 years old and helps to fill a gap in the fossil record. The Bungle Bungle Dolomite may be of a similar age and contains an assemblage of unicellular and filamentous microfossils, less well preserved than those in the Amelia Dolomite but closely comparable taxonomically in some cases. These forms and those from Kalgoorlie and the Hamersley Basin are being used in a study of diagenetic and early metamorphic alteration of organic compounds and micro-organisms. The Hamersley Group microfossils are considerably altered, despite occurring in a rock sequence considered on mineralogical criteria to be virtually "unmetamorphosed". Microfossils from the McMinn Shale of the Roper Group will be contrasted with those in chert facies and compared with other shale assemblages, such as that from the Torridonian of Scotland. Poorly preserved microfossils have been found in the sulphide ores of the HYC deposit at McArthur River.

MICROPALAEONTOLOGICAL LABORATORY

Staff: F. Hadzel, A.T. Wilson, P.W. Davis.

Material was processed as follows:

Washing (soda, petrol, O_2, H_2O_2)	- 2736 samples
Sectioning	- 628 samples (1032 sections)
Polishing	- 98 samples
Dissolving in acid	- 1200 samples (2400 kg of material)
Drawing for illustrations	- 46 specimens (conodonts)

COMPUTING GROUP

by

W. Mayo

Staff: W. Mayo (part time), K.A. Summors (part time), A. Strezlecki (part time)

The major programming addition in 1973 was the Q-mode factor analysis program which may be used to analyse sample to sample relationships with multivariate data. This program has already been used successfully to classify samples from each of two projects into geologically significant groups. Several options for plotting, contouring and oblique factor rotation were added to the program by Miss Strezlecki.

Other programs written during 1973 included:

1. One-way analysis of variance for error analysis with triplicate sampling.

2. A "F-test" suggested by Garrett for error analysis with duplicate sampling.

3. Correlation and regression with test of significance plus X-Y plots of selected pairs of variables.

4. A program which will output details of all Branch programs in BMR Record format from computer card documentation.

Three computer programs written by W. Anfiloff (Geophysical Branch) are now available for handling storage, sorting and retrieval of geological data. These programs edit the sample submission data, determine latitude and longitude from the grid reference (or vice-versa), and allow for the addition of up to 96 alphabetic or numeric variables. The data may then be sorted onto magnetic tape using any two selected variables. Some extra programming was required to enable direct use of the sorted tape with any required program. Data from the Palaeontology Sub-section has been successfully tested with these programs and this group is in the process of storing their micro-fossil data under this system.

The new Cyber 76 computer at CSIRO has been operating since 17 July 1973 and for financial and operational reasons conversion of all major programs to this computer by early 1974 is essential. Complete documentation of these programs will be carried out during conversion with a view to eventually having the documentation of all available programs in one BMR Record. Miss Summers is concentrating on this conversion and documentation and two programs have already been converted.

STAFF TRAINING

Lectures on Carbonate Sediments

During the period 5 to 16 March 1973, Dr B.W. Logan of the University of Western Australia presented a course at BMR on the petrology and petrogenesis of carbonate sediments. The lecture course, supplemented by laboratory sessions and a field excursion, covered all aspects of carbonates. Illustrations and case histories were drawn from the Shark Bay province, Yucatan Reefs, and the Devonian sequence in the Canning Basin. The course was attended by about 35 BMR officers, an officer from the Geological Survey of South Australia, together with geo-scientists from the Australian National University and the Canberra College of Advanced Education.

Lectures on Sedimentology and Petroleum Geology

About 30 BMR officers from various branches in BMR attended two lectures given on 7 and 8 May by Dr A.R. Jensen on "Aspects of sedimentology and petroleum geology". The lectures, based partly on material presented at an APEA course on petroleum geology concentrated on lithostratigraphic analysis, fluvial and deltaic sedimentation, and the generation, migration, and entrapment of petroleum.

METALLIFEROUS SECTION

ARUNTA PROJECT

by

R.D. Shaw, A.J. Stewart, A.P. Langworthy, and L.A. Offe

Staff: R.D. Shaw, A.J. Stewart (in office), R.G. Warren, A.P. Langworthy, L.A. Offe, L.P. Black (part time), A.Y. Glikson (part time), B.A. Duff (to Jan., 1973); R.W. Marjoribanks, J.L. Funk, and M.J. Rickard, all from ANU, are associated with the project.

The purpose of the survey is to map systematically basement rocks examined in only a cursory way during mapping of the Amadeus and Ngalia Basins, and to assess their economic potential. The basement rocks have undergone exceptionally complex deformation brought about by large scale crustal movements. Areas of sparse or highly weathered outcrop were mapped at 1:250 000 scale. Mapping at 1:100 000 scale was required in areas of good outcrop. Post-graduate students from ANU assisted by continuing detailed studies in critical areas, especially the Arltunga and Ormiston Nappe Complexes.

Two papers on the regional geology and mineral deposits of the Arunta Block were written for the forthcoming AIMM volume on the 'Economic Geology of Australia and Papua New Guinea'. Several stereophotographs of the Arunta areas taken by the ERTS satellite were interpreted and commented on.

Areas so far mapped are shown in Figure M2.

ISOTOPIC DATING IN ARUNTA BLOCK (Black, Stewart)

Black continued Rb-Sr analysis and computation of results from samples collected during the 1972 field season, and collected further samples in 1973; his report on work completed so far appears in the 'Petrological, Geochemical, and Isotope Geology Laboratories' section of this Record. One important result of this work has been the dating of a migmatization event in the area north of Ormiston Gorge at about 1080 m.y.; the date sets an older limit for the time of deposition of the Heavitree Quartzite at the base of the Amadeus Basin sequence. Stewart computed K-Ar isochrons on micas from the Arltunga Nappe Complex; the results indicate that the spread of K-Ar dates between Carpentarian and Carboniferous is, in most cases, caused by excess argon, and that the true age of recrystallization of the minerals is Late Devonian to Early Carboniferous.

INVESTIGATION OF MINERAL DEPOSITS (Warren)

Warren completed a draft text and maps for a Record on 'Mineral Deposits of the Arunta Block'. Mineral deposits of the northern part of the Arunta Block include small occurrences of cassiterite, tantalite, columbite, and wolframite, in or near granitic rocks; several copper, lead, or zinc lodes, some of which are related to, or occur near, granitic rocks or pegmatites; and three very small gold lodes.

The copper lodes in the Bonya-Jervois district are associated with amphibolite. Scheelite also occurs throughout the district, generally in calc-silicate host rock near granite or pegmatite. Several quartz-fluorite-barite veins, with traces of chalcopyrite, cut the Jinka Granite northwest and southeast of the Elyuah Range.

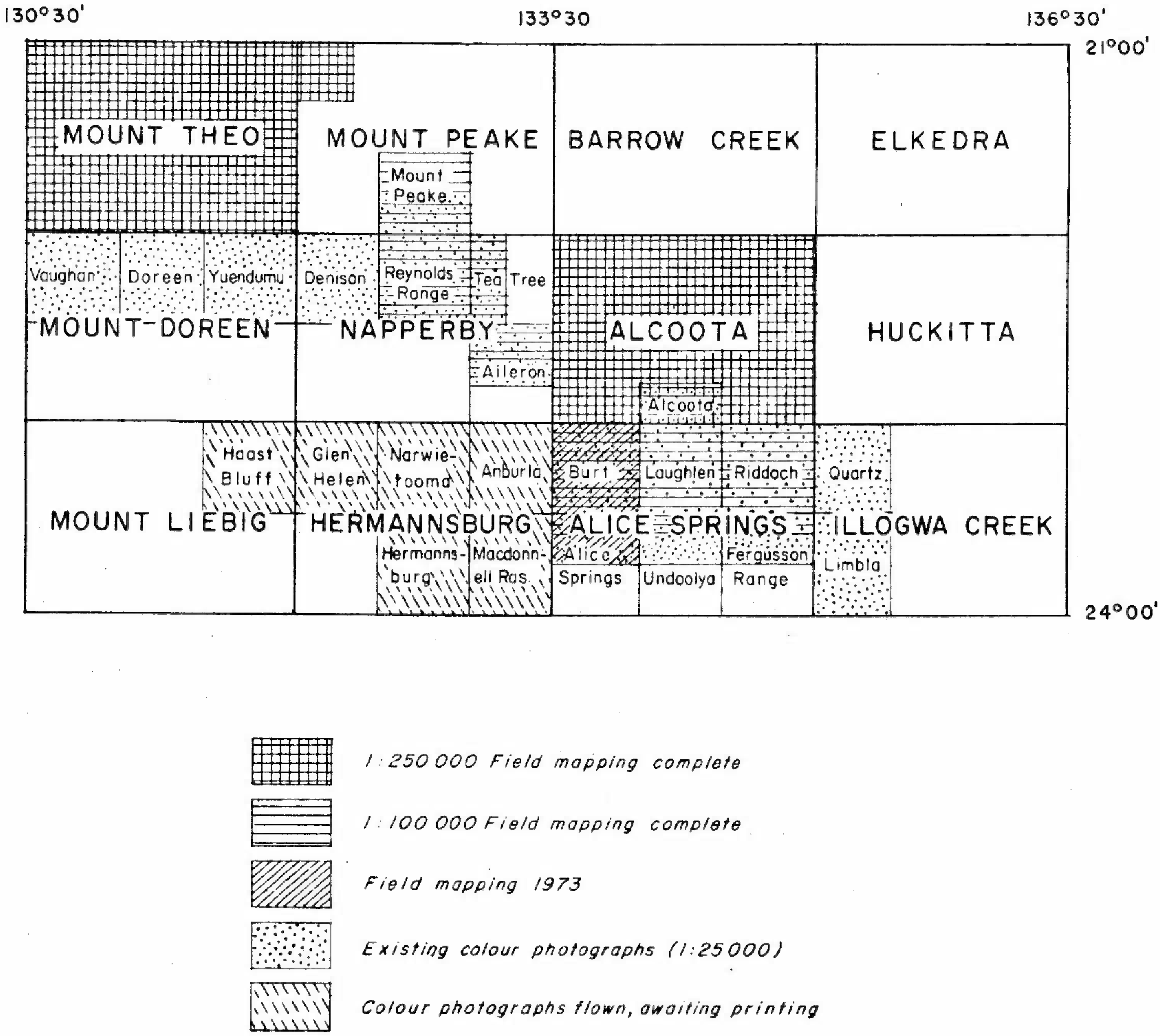


Fig. M2 Arunta project: coverage of mapping and colour photographs

The southern part of the Arunta Block contains metasediments and metamorphosed basic igneous rocks, but only a few granites. A number of small copper-bearing quartz lodes in the Pinnacles Bore area are believed to be related to nearby pegmatites and a small body of tourmaline-garnet orthogneiss. Several small copper lodes in the Harts Range area are closely associated with amphibolite. A third type of base-metal deposit with similarities to the deposits at Jervois, in both ore and country-rock mineralogy, includes the recently discovered Oonagalabie deposit in the Harts Range, and other similar deposits in the Harts and Strangways Ranges. It is possible that these deposits are related to a major regional unconformity, but this has yet to be substantiated. Various amounts of lead, copper, and zinc are closely associated with quartz-magnetic rock, feldspathic rocks containing magnesium-rich minerals such as phlogopite, anthophyllite, and cummingtonite, and, in some places forsterite marble. Both the Oonagalabie type of deposit and the Jervois lodes are stratabound.

Current exploration emphasis in the area is on base metals and, more recently, uranium, both in the basement and in the overlying sedimentary sequences.

ALICE SPRINGS 1:250 000 SHEET AREA

Arltunga Nappe Complex (Shaw, Funk, Duff, Stewart)

Recent mapping in the metamorphosed basement has revealed a number of east-trending faults of various ages, and allows a more accurate correlation of fault blocks. The Nappe Complex is now interpreted as a group of imbricate thrust sheets with individual thrust faults attaining maximum displacements of 10-15 km rather than as a single large basement nappe and a related thrust having a common root zone. The concept of the Nappe Complex as a series of shallow thrust sheets is supported by (1) the shallow dip of the refoliated zone in many places; (2) the patchy, low-grade (greenschist), dynamic nature of the associated metamorphic retrogression; and (3) the relatively flat Bouguer anomaly profile across the Nappe Complex shown by the detailed gravity traverse carried out in August, 1973, by the Geophysical Branch (W. Anfiloff, pers. comm.). The gravity profile shows no evidence of large upward displacements of the basement.

Compilation of overlays from the areas of metamorphic basement continued, and will be used in the production of the special map of the Nappe Complex at 1:100 000 scale.

Alice Springs 1:100 000 Sheet area (Offe) - Figure M3.

Rocks of the Sheet area have been metamorphosed to the upper greenschist and lower amphibolite facies, and are cut by several east-trending mylonite zones. Perhaps the most interesting of these is the Charles River Mylonite Zone, which separates two different metamorphic rock sequences. At Simpson's Gap, however, Heavitree Quartzite and Bitter Springs Formation are preserved immediately to the south of the mylonite zone, which is probably part of the root-zone of the Blatherskite Nappe.

North of the Charles River Mylonite Zone the rocks consist of strongly foliated biotite-quartz-feldspar gneiss interlayered with subordinate amphibolite, augen gneiss, and large-feldspar gneiss.

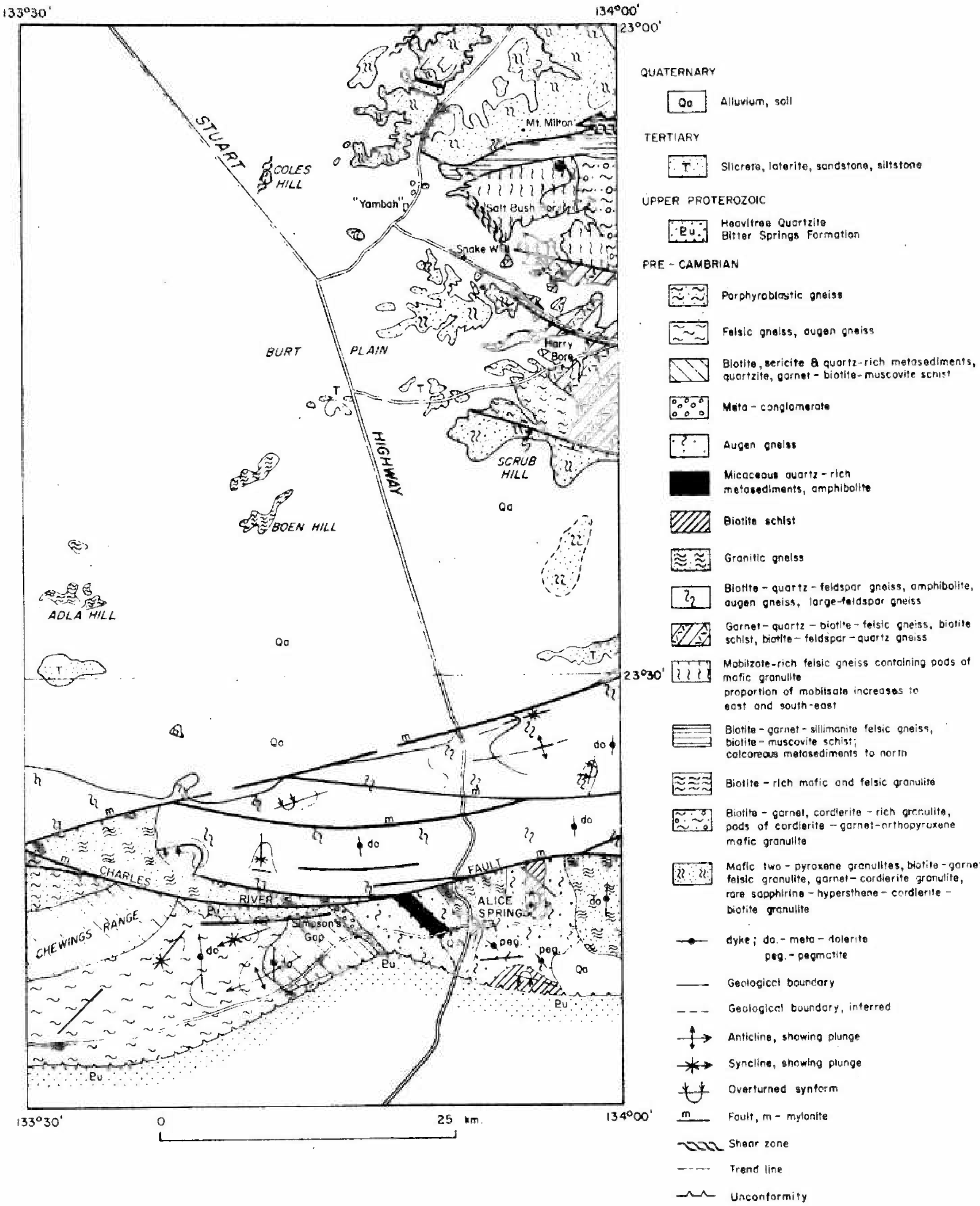


Fig. M3. Geological sketch map of the Burt and Alice Springs 1 : 100,000 Sheet areas.

South of the Charles River Mylonite Zone and east of Alice Springs, a poorly foliated granitic biotite-quartz-feldspar gneiss is in contact to the west with a schistose biotite augen gneiss. Biotite schist occurs in the cores of folds within the augen gneiss. North of Alice Springs the augen gneiss has been intruded by a magnetite-muscovite-biotite-quartz-feldspar orthogneiss. Micaceous quartz-rich metasediments and interbedded amphibolite crop out 1 km west of Alice Springs; these are succeeded farther west by an augen gneiss and a conglomerate, 5 m thick, containing pebbles and cobbles of quartzite, and quartz granules, in a micaceous, gritty and partly feldspathic matrix. The conglomerate grades westwards into biotite and sericite-bearing quartz-rich metasediments which are comparable to the interlayered quartzite and garnet-biotite-muscovite schist of the Chewings Range. Bedding in the more quartz-rich sediments suggests the sequence as a whole faces west. The westernmost member of the sequence is a fine to medium-grained mica-poor felsic gneiss which grades in places into coarse-grained augen gneiss.

Burt 1:100 000 Sheet area (Langworthy) - Figure M3

Mafic two-pyroxene granulites interlayered with biotite-garnet felsic granulite occur in prominent hills north of Yambah homestead, south-southwest of Snake Well, and in the Scrub Hill area. Granulites north of Yambah homestead include garnet-cordierite granulite, and at several localities sapphirine-enstatite-spinel-biotite granulite and sapphirine-hypersthene-cordierite-biotite granulite were found.

Granulites rich in biotite, garnet, and cordierite and small pods of cordierite-garnet-orthopyroxene granulite occur northeast of Saltbush Bore.

Possibly retrogressed granulites characterized by their high biotite content occur in the Adla Hill and Boen Hill areas.

Mobilizate-rich biotite-feldspar gneiss containing pods of mafic granulite crops out 5 km east of Yambah homestead. The gneiss is poorly foliated, and is progressively more enriched in mobilizate towards the east; 5 km southeast of Mount Milton it grades into a granitoid rock which has a discordant contact with granulites farther east. Migmatitic gneiss southeast of Salt Bush Bore contains numerous granitoid pods up to 1 km long and 500 m across.

Meta-pelites 5 km south of Harry Bore include garnet-quartz-biotite-feldspar gneiss, biotite schist, and biotite-feldspar-quartz gneiss; the gneisses are cut by small dolerite dykes, and intruded by a large porphyroblastic orthogneiss 7 km southwest of Harry Bore.

Major mylonite zones cut the region northeast of Yambah homestead and south of Scrub Hill.

Laughlen 1:100 000 Sheet area (Langworthy, Shaw)

Rock units in the northeastern part of the Sheet area were compared with the Harts Range sequence. The units are now considered to stratigraphically underlie the Harts Range sequence, although two were previously considered to be equivalent to part of the sequence.

HERMANNSBURG 1:250 000 SHEET AREA (Marjoribanks)

Mapping in 1972 covered most of the crystalline basement in the Hermannsburg 1:100 000 Sheet area and a small part of the Narwietooma Sheet area. A map has been compiled, and the work will be reported, in conjunction with L.P. Black, with a title of 'The Geology and Geochronology of the Arunta Complex north of Ormiston Gorge, central Australia'. Widespread migmatization and associated granite intrusion disrupt an older gneiss series south of a major west-trending deformed zone of dynamically metamorphosed rocks.

Rb-Sr isochrons yield dates of 1620 $\pm$ 70 m.y. for the formation of the older gneiss, and about 1080 m.y. for the migmatization event. The migmatites are unconformably overlain by the basal unit of the Amadeus Basin sequence, and so the 1076 $\pm$ 50 m.y. date provides a maximum age for the beginning of sedimentation along the northern margin of the Basin.

ALCOOTA 1:250 000 SHEET AREA (Shaw and Warren)

The preliminary 1:250 000 map was checked for coloured edition, and Explanatory Notes were prepared.

A comprehensive Record on the geology of the area will form the basis of the published Report. Additional data were added to the Tertiary section as a result of drilling in 1973, and the Quaternary units were considerably revised following interpretation of RC9 photographs. The results of BMR's airborne magnetic and radiometric survey were used in a structural interpretation. A reappraisal was made of the stratigraphy of the metamorphic units, and tentative regional correlations were suggested.

NAPPERBY 1:250 000 SHEET AREA

Napperby Party (Stewart, Warren, Offe (part time), Glikson (part time)

Office work by the Napperby Party in 1972-73 included compilation of field information, examination of thin sections, airphoto-interpretation, and report writing. A list of proposed geological monuments in the southern part of the Northern Territory was prepared with A.T. Wells, of the Sedimentary Section. Fifty-two aboriginal names of topographic features in the Mount Theo, Mount Peake, Mount Doreen, and Napperby 1:250 000 Sheet areas were submitted to the Northern Territory Place Names Committee, and forty were approved.

Offe transferred to the Alice Springs Party in April, and Warren and Glikson each spent six weeks mapping in parts of the Napperby Sheet area. Warren left on 10 September to take up a Public Service Board Scholarship at the Imperial College of Science and Technology, University of London, for twelve months.

Reynolds Range 1:100 000 Sheet area (Glikson, Warren)

The stratigraphic succession of the Reynolds Range comprises the Reynolds Range Group, consisting of the Mount Thomas Quartzite (1850 m, with a thin basal member of pebbly arkose and conglomerate), overlain by the Pine Hill Shale (570 m) which includes in its upper part a lenticular member of unfossiliferous dolomite and limestone, the Algamba Member (425 m). The

Reynolds Range Group unconformably overlies the Lander Rock Beds, a unit of slate, micaceous sandstone and hornfels, and mica schist, and is intruded by sills and bosses of quartz porphyry and by large elongate granite batholiths which have bent the Reynolds Range sequence into a tight to isoclinal syncline. The last movements of the granite masses caused the formation of drag-folds in the limbs of the syncline which are opposite in sense from normal flexural-slip drag-folds, and give the syncline a profile resembling an inverted spruce tree.

Three samples of laterite overlying the Algamba Member were analysed for base metals; the maximum values were: Mn 58%, Pb .12%, Zn .11%, Cu .07%, Ni .01%, Ag .0001%, and Se less than .0005%.

Aileron and Tea Tree 1:100 000 Sheet areas (Glikson, Warren)

The sediments of the Lander Rock Beds and Reynolds Range Group are metamorphosed to high-grade gneiss and granulite in the Aileron and Tea Tree 1:100 000 Sheet areas, and sapphirine has been identified at several localities along the contact between the two units. Felsic granulite which has the mineralogical composition of charnockite intrudes basic granulite and pelitic granulite in the Anmatjira Range, north of the Reynolds Range; the plagioclase in the charnockite forms large crystals which are mantled by orthoclase and thus have a rapakivi texture.

MOUNT PEAKE 1:250 000 SHEET AREA

Photoscale compilation sheets of the Mount Peake 1:100 000 Sheet area have been completed, and copies were distributed to lease-holders in the area and to the Northern Territory Geological Survey. Drafting of the Mount Peake 1:100 000 Sheet for preliminary edition was completed.

Laterite from Wilgibanda Hill (grid reference 341900E, 2369300N) in the northwestern part of the Mount Peake 1:250 000 Sheet area was assayed for base metals with the following results: Pb .75%, Cu .24%, Mn .24%, Ni .0065%, Zn .0045%, Ag .0012%, and Se .0005%.

MOUNT THEO 1:250 000 SHEET AREA

Drilling along The Granites-Billiluna Stock Route in the western part of the area intersected unconsolidated sand, silt, and clay up to 100 m thick overlying weathered basement rocks. Ferruginous layers a few metres thick were penetrated at about the middle of the sequence in two of the holes.

Correlation of the rocks exposed in the Mount Theo area with those in neighbouring areas suggests that the impure sandstone, slate, and sericitic quartzite at Mount Theo, McDiarmid Hill, Mount Patricia, and Surner's Dome are correlates of the Mount Charles Beds of The Granites-Tanami area, and may be a sandy facies of the Lander Rock Beds.

Airphoto-interpretation revealed numerous major faults up to 100 km long, mostly in the northern part of the area; the faults contain brecciated vein quartz, in places accompanied by hematite. Thin-section examination of the vein quartz revealed evidence of several episodes of quartz deposition, brecciation, and recrystallization.

A cellular quartz-limonite gossan crops out at Keyser Hill, in the southeastern part of the area, on strike with one of the large faults; analysis of the gossan yielded the following results: Cu .13%, Pb, .054%, Mn .029%, Zn .003%, Se .0025%, Ni .001%, and Ag less than .0001%.

Airphoto-interpretation of the Sheet area is complete, and compilation of the map.

REPORTING OF RESULTS

1. "Geology of the Reynolds Range and Adjoining Parts of the Arunta Block, Northern Territory", by A.J. Stewart, R.G. Warren, L.A. Offe, and A.Y. Glikson: MS 20% complete (Record).

2. "Geology of the Mount Theo 1:250 000 Sheet Area", by A.J. Stewart: MS 20% complete (Record).

3. "Mineral Deposits of the Arunta Block", by R.G. Warren: first draft of MS completed, and being revised by A.J. Stewart.

4. "Petrographic and Geochemical Study of the Ringwood Evaporite Deposit", by A.J. Stewart: MS 90% complete (Record).

5. "Rubidium-strontium dates and excess argon in the Arltunga Nappe Complex, Northern Territory", by R.L. Armstrong (University of British Columbia) and A.J. Stewart: MS 90% complete (outside publication).

6. Records on various aspects of the geology of the Alice Springs 1:250 000 Sheet area, and the Hermannsburg 1:100 000 Sheet area will be prepared; Explanatory Notes for a second edition of the Alice Springs map will then be produced, and a Bulletin on the Arltunga Nappe Complex is also planned.

THE GRANITES-TANAMI PROJECT, W.A. & N.T.

by

D.H. Blake & I.M. Hodgson

Staff: D.H. Blake (Party Leader), I.M. Hodgson.

INTRODUCTION

The party has been engaged in reconnaissance geological mapping of The Granites-Tanami region, an area of mainly Precambrian rocks between the Kimberleys to the northwest and the Arunta region to the southeast. The project was started in 1971, mapping was finished in 1973, and the whole project is expected to be completed in 1974.

During office work from October, 1972, until June, 1973, preliminary editions of the Billiluna, Lucas, Stansmore, and The Granites 1:250 000 Sheets were compiled, and a BMR Record (73/171) on the 1972 field work was completed.

Reconnaissance mapping of Highland Rocks and the Precambrian areas of Webb 1:250 000 Sheet areas was carried out, mainly by helicopter, during July, 1973. Neither Sheet area has any known mineral deposits of economic significance. Parts of Mt Ramsay and Mt Bannerman Sheet areas were visited in August 1973 for the purposes of correlating formations in The Granites-Tanami region with those in the Kimberley region. Visits were also made to parts of The Granites, Tanami, and Birrindudu Sheet areas to check outcrops previously mapped by photo-interpretation, and to the Billiluna Sheet area to resolve problems that arose during interpretation of field data collected in 1972. A BMR drilling party under A. Zoska drilled 40 stratigraphic holes in The Granites and Lucas Sheet areas during July, August, and September, 1973.

GENERAL GEOLOGY

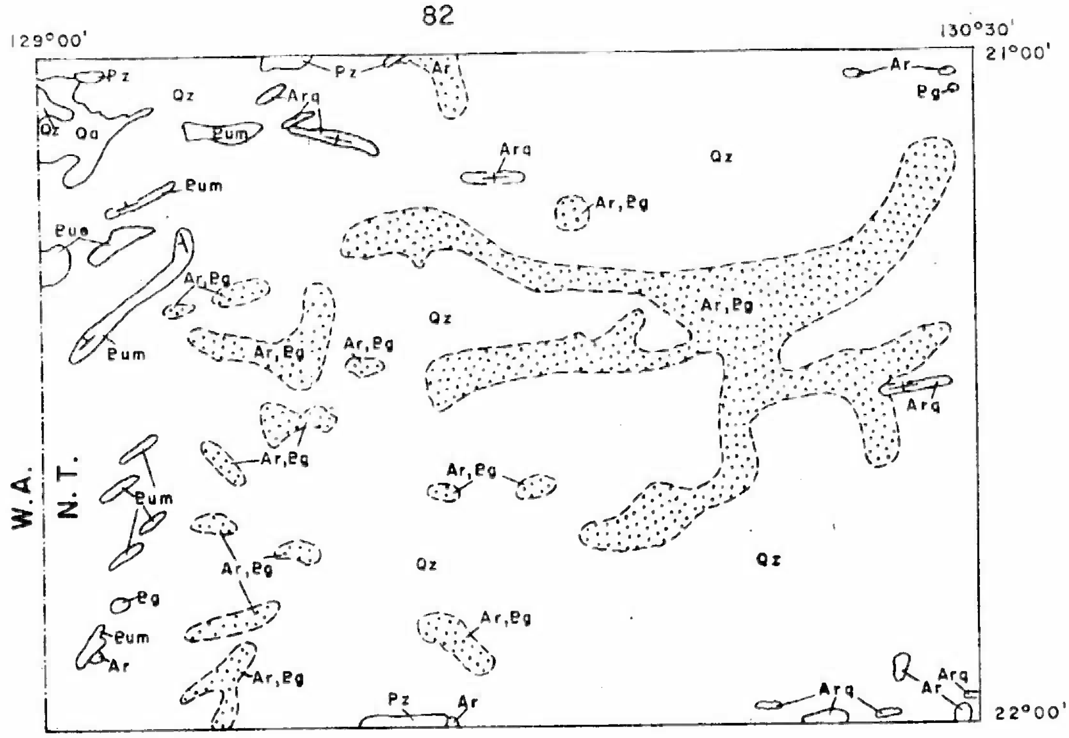
Webb Sheet area

Precambrian and some probably Palaeozoic and Mesozoic rocks are exposed as low ranges in the northern and southern parts of the Sheet area, and also as isolated low rises and mounds (Figure M4). The outcrops are separated by expanses of superficial aeolian sand and, in the east, by the alluvium and salt deposits of Lake Mackay. The Sheet area is crossed by numerous east-west trending longitudinal sand dunes.

The oldest rocks exposed are metamorphics that may be related to the Arunta Complex. They consist of quartzite, schist, and gneissic rocks showing bedding plane schistosity. These rocks, mapped as Archaean, are intruded by granite which is locally strongly sheared, as near Mt Webb. Both the granite and the metamorphic rocks are cut by quartz veins, and the granite is also cut by basic dykes (basalt to gabbro) which postdate the shearing. Specimens of granite and dyke rocks have been collected for isotopic dating.

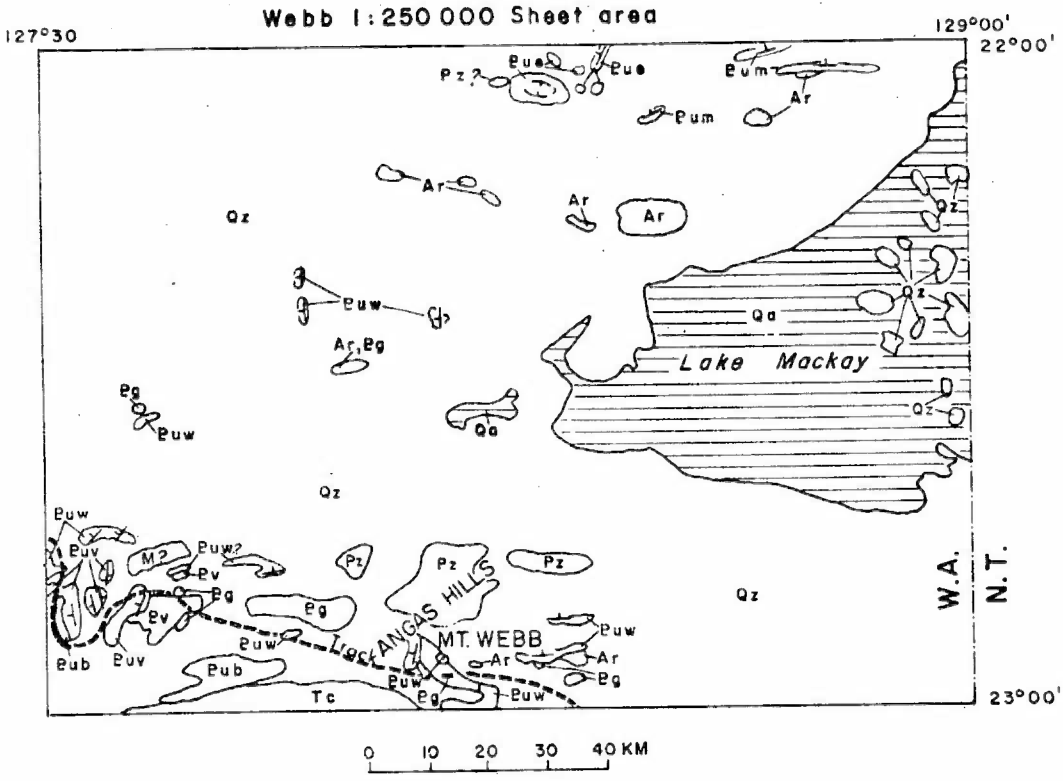
In the southwest the granite has intruded and thermally metamorphosed porphyritic dacite lava flows (Ev). These flows are overlain conformably by tuff and agglomerate and associated tuffaceous and quartzose sandstones (Euv). The volcanic sequence is overlain by a formation of quartzose sandstone (Euw) which is unconformable on the granite. This sandstone, well exposed on Mt Webb, is correlated with the Heavitree Quartzite in the adjoining Macdonald Sheet area to the south, and hence is probably Adelaidean. The lower part of the formation consists of medium to thin-bedded cross-bedded sandstone; the upper part is thin to very thin-bedded, and passes up into a formation consisting mainly of crystalline limestone. This latter formation (Eub) may be equivalent to the Bitter Springs Formation. No stromatolites were recognized, but thin seams of dark chert are present locally, and specimens of this were collected for laboratory examination for microfossils.

The sandstone forming Mount Webb may be equivalent to the quartzose Munyu Sandstone, which forms the Alec Ross Range in the northeast. The Munyu Sandstone includes at least one lens of limestone similar to that exposed in the southern part of the Sheet area. The sandstone is locally tightly folded and faulted, and is unconformable on granite and metamorphic rocks. West of the Munyu Sandstone, outcrops of folded Erica Sandstone extend south from the Stansmore Sheet area.



Highland Rocks 1:250 000 Sheet area

Webb 1:250 000 Sheet area



Laterite rises

QUATERNARY

Qa	*Alluvium*
Qz	*Aeolian sand*

TERTIARY

Tc	*Calcrete*

MESOZOIC (?)

M?	*Sediments*

PALAEOZOIC (?)

Pz	*Pedestal Beds*

PROTEROZOIC

Pue	*Erica Sandstone*
Pum	*Munyu Sandstone*
Pub	*Bitter Springs Fm ?*
Puw	*Mount Webb sandstone*
Pg	*Granite*
Puv	*Tuffaceous sandstone*
Pv	*Dacite lava*

ARCHAEAN

Ar	*Schist, gneiss, quartzite*
Arq	*Quartzite*

To accompany Record 1973/174

F 52/A/12

Fig. M4 Geological sketch maps of the Webb and Highland Rocks 1:250 000 Sheet areas

The Precambrian rocks are gently to steeply dipping, and are inferred to be overlain unconformably by mainly flat lying, clayey quartzose sandstone and conglomerate provisionally correlated with the Pedestal Beds, mapped as possibly Palaeozoic, of the Stansmore Sheet area. These rocks crop out most extensively north of Mt Webb, where they form part of the Angas Hills. Also present, mainly in the western part of the Sheet area, are isolated outcrops of poorly consolidated clayey sandstone, claystone, and pebble to boulder conglomerate. These are mapped as possible Mesozoic, and may be comparable with the Cretaceous Hazlett Beds of the Stansmore Sheet area.

Highland Rocks Sheet area

Most of the Highland Rocks Sheet area has a very low relief, consisting mainly of low rounded laterite rises separated by sand plains with longitudinal sand dunes. Few of the rises are higher than the level of the dunes. However, some higher strike ridges, mostly of Upper Proterozoic sandstone, are present in the west, northwest, and south (Figure M4).

Outcrops of rocks mapped as Archaean consist of steeply dipping to vertical, medium to very thin-bedded metaquartzite, which forms low strike ridges, and gneiss and minor schist which are almost invariably strongly lateritized. The metamorphic rocks are intruded by granite. Both they and the granite are unconformably overlain in the west by Munyu Sandstone, and in the north and south by possibly Palaeozoic clayey sandstone and conglomerate correlated with the Pedestal Beds of the Stansmore and The Granites Sheet areas.

AGE DETERMINATIONS

Several outcrop and drill core samples from the Lucas Beds (Palaeozoic?) and outcrop samples of the Hazlett Beds (Cretaceous?) collected from The Granites, Lucas, Stansmore Sheet areas in 1972, have been examined in the palaeontological laboratory. No datable microfossils or macrofossils were found in the samples, and the ages of the Lucas and Hazlett Beds remain uncertain.

Glauconite from samples of Gardiner Sandstone, collected in 1972 from The Granites, Tanami, Lucas, and Billiluna Sheet areas, has been isotopically dated by AMDL (Rep. 3473/73) using the K-Ar method. The results indicate that the Gardiner Sandstone, the basal formation of the Birrindudu Group, has a minimum age of 1550-1600 m.y., i.e., middle Carpentarian.

Several samples of acid volcanics and granitic rocks collected in The Granites-Tanami area in 1972, mainly by R.W. Page, have been dated isotopically using the Rb-Sr method. Results to date (Page, pers. comm.) indicate that the age of both the Winnecke Granophyre and Mount Winnecke Formation, in the Birrindudu Sheet area, is 1800 million years, i.e., late Lower Proterozoic.

REPORTING OF RESULTS

The results of the 1973 project will be written up as a Record, and later incorporated in a Bulletin describing the geology of The Granites-Tanami region. They will also be summarized in Explanatory Notes for the Webb and Highland Rocks 1:250 000 Sheet areas. A separate Record will be prepared on the stratigraphic drilling carried out in The Granites-Tanami region during 1971, 1972, and 1973.

VICTORIA RIVER BASIN PROJECT, N.T. & W.A.

VICTORIA RIVER BASIN, N.T. by I. P. Sweet

Staff: I.P. Sweet.

The project, for which field work was carried out from 1967 to 1970, was undertaken to provide basic geological information for a previously unmapped area of some 100 000 km^2 comprising the whole or parts of nine 1:250 000 Sheet areas in the Northern Territory.

Seven of the nine Explanatory Notes and maps have been issued, and three reports are being printed.

During the year a draft was written of a Bulletin summarizing the results of the investigations. Isotopic age determinations carried out by AMDEL on samples from three shale formations gave somewhat unexpected results, but if they can be regarded as significant, they indicate that the Precambrian sequence extends back into the Carpentarian. The results are:

(a) Angalarri Siltstone: 838 ± 142 m.y.

This is younger than expected, as the Angalarri Siltstone is confidently correlated with the Helicopter Siltstone in the East Kimberley region, which overlies the Wade Creek Sandstone, from which shales have yielded an age of 1128 m.y. No explanation for the apparent discrepancy has been put forward.

(b) Stubb Formation: 1,347 + 298 m.y.
(c) Wondoan Hill Formation: 1,431 + 440 m.y.

These ages are greater than expected, and the errors are such that there is a great degree of uncertainty about the significance and relevance of the ages. However, even if the ages are too great, they introduce the possibility that the lower part of the sequence in the Victoria River Region could be of Carpentarian age. The oldest sedimentary unit, the Limbunya Group, is almost certainly Carpentarian, and is tentatively correlated with the McArthur Group. This is important from an exploration viewpoint, as the McArthur Group and its equivalents farther east contain major base metal ore deposits.

REPORTING OF RESULTS

The Bulletin "The Precambrian Geology of the Victoria River Region, Northern Territory" has been written in draft.

ANTRIM PLATEAU VOLCANICS AND CORRELATIVES, N.T., W.A., & QLD.

by R.J. Bultitude

Staff: R.J. Bultitude

The year was spent preparing a Record dealing with the field occurrence and petrography of the Antrim Plateau Volcanics. A short paper for the AIMM volume was also prepared in conjunction with I.P. Sweet on mineralization in the Victoria River region.

The Antrim Plateau Volcanics is a very widespread but hitherto little investigated sequence of basaltic lavas and interbedded sediments and agglomerate covering large areas in the Ord-Victoria region of northern Australia. Small outcrops of volcanics correlated with the Antrim Plateau Volcanics in the central and eastern parts of the Northern Territory and north of Camooweal in northwestern Queensland are the Helen Springs, Nutwood Downs, Peaker Piker and Colless Volcanics. The distribution of the volcanics is shown in Figure M5. All the formations occupy similar stratigraphic positions. They unconformably overlie Precambrian rocks, and are disconformably overlain by lower Middle Cambrian sediments. Smith & Roberts considered that the Peaker Piker Volcanics are interbedded with the lower Middle Cambrian Burton Beds along the northern margin of the Georgina Basin. However, the writer disagrees with this interpretation. Basic volcanics correlated with the Peaker Piker Volcanics have been intersected below lower Middle Cambrian sediments in drill holes in the Alroy and Rankin 1:250 000 Sheet areas.

The Antrim Plateau Volcanics unconformably overlie the Precambrian rocks of the Ord-Victoria region. The lavas were extruded over an uneven surface. In some areas lava fills valleys, up to 60 m deep, eroded in Upper Proterozoic sediments. The dissected nature of the surface indicates a considerable time lapse between the deposition of the Upper Proterozoic sediments and the initial outpourings of basalt. Few sediments resulting from this erosional break have been recognized, suggesting that most of the area was land in late Upper Proterozoic and early Cambrian times. Locally the lavas rest conformably on thin layers of basal sandstone and conglomerate which are regarded as Lower Cambrian, and have been either included in the Antrim Plateau Volcanics or distinguished as separate formations.

The Antrim Plateau Volcanics are separated from the overlying lower Middle Cambrian Negri Group in the Ord Basin and from the Montejinni Limestone exposed along the western margin of the Wiso Basin by a minor erosional unconformity. In places the volcanics are overlain by a thin layer (less than 7 m thick) of red-brown calcareous siltstone with minor interbedded fine to coarse-grained sandstone and coarsely crystalline limestone, commonly containing numerous angular clasts of intensely altered vesicular basalt derived from the tops of lava flows. Elsewhere the Negri Group directly overlies extensively altered vesicular basalt without any detectable angular discordance.

The inferred age of the Antrim Plateau Volcanics and its correlatives from the stratigraphic evidence is Lower Cambrian. In the East Kimberley region, volcanics unconformably overlie shale - the Timperley Shale in the Albert Edward Group - dated at 666 + 43 m.y.. Isotopic dates obtained by the K-Ar (whole rock) method on ten specimens, range from 395 ± 10 m.y. to 506 ± 10 m.y. (i.e., from Upper Silurian to Upper Cambrian), the majority being grouped between 468 and 500 m.y. (i.e. Lower Ordovician). The most likely explanation for the discrepancy between the ages determined by the K-Ar whole rock method and the age inferred from the stratigraphic evidence is that the lavas have lost different amounts of radiogenic argon since their formation in the Lower Cambrian.

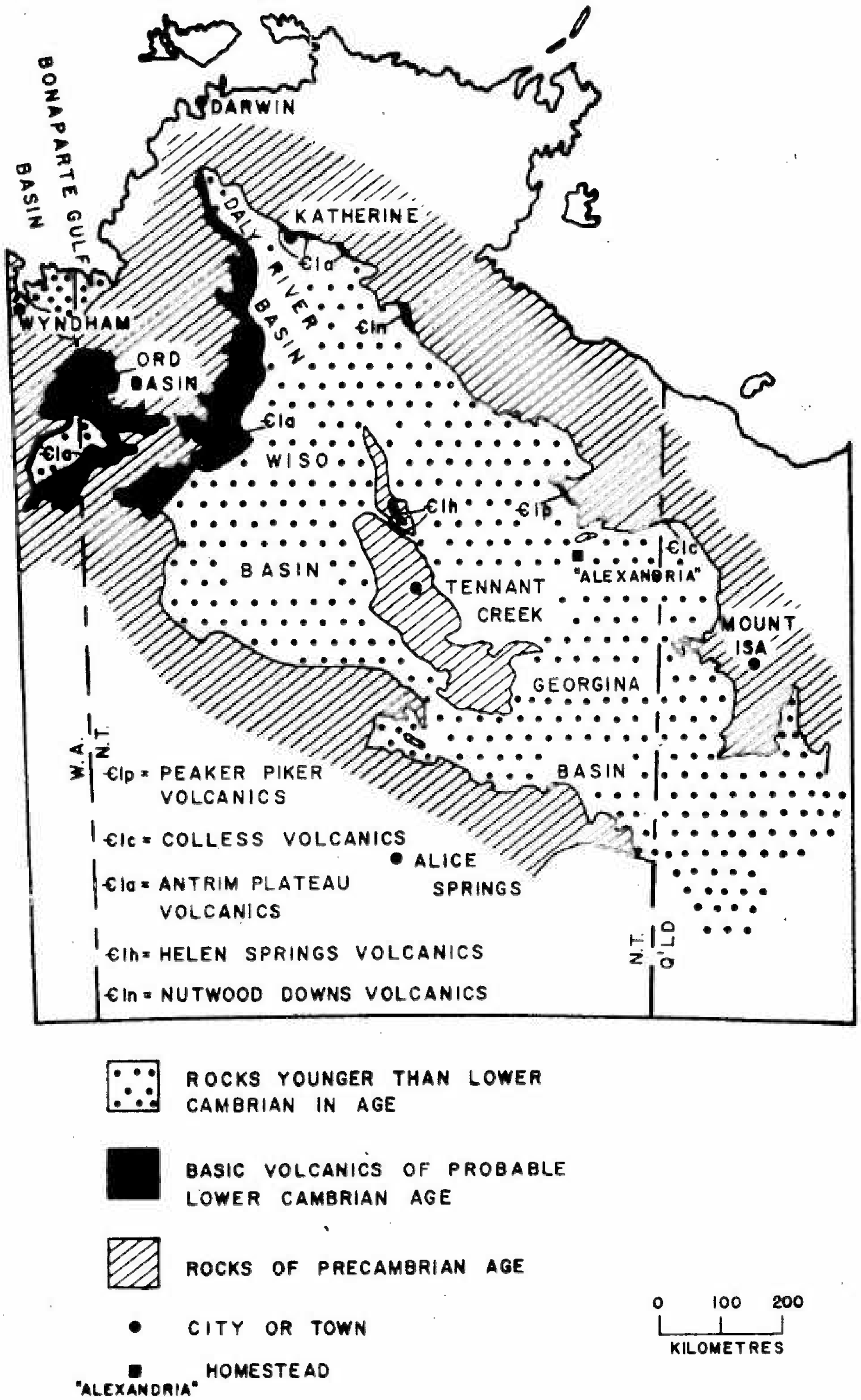


Fig. M5 Distribution of Lower Cambrian basic volcanics, Northern Australia

To accompany Record 1973/174 *Aus 2/204a*

Most flows consist of an extensively altered, highly vesicular or amygdaloidal upper part, comprising up to 30 percent of a flow, and a slightly to moderately vesicular basal part generally accounting for less than 5 percent of a flow. The average thickness of the Antrim Plateau lava flows is about 35 m. Labradorite, clinopyroxine (augite and pigeonite), opaque oxides, devitrified glass and a quartzo-feldspathic residuum account for a high proportion of the total volume of the little-altered massive basalts. Coarse grainsize and minor amounts of interstitial quartz are characteristic of the little-altered basalt. Vesicles, amygdales and geodes are commonly filled and lined with a variety of secondary minerals, the most common being chlorite, quartz, amethyst, smoky quartz, agate, prehnite, and calcite; semi-precious varieties of some of these minerals have been found in places, but in general they are rather scarce. Pumpellyite and analcime have also been identified.

The lavas are tholeiitic basalts, the majority containing quartz in the CIPW norm. The average chemical composition of forty-five fresh and little-altered specimens is:

	wt %
SiO_2	54.0
TiO_2	1.12
Al_2O_3	14.9
Fe_2O_3	3.49
FeO	6.91
MnO	0.17
MgO	6.17
CaO	8.30
Na_2O	3.06
K_2O	1.76
P_2O_5	0.12

Many of the basalts have been altered, the alteration being most extensive and intensive in the vesicular upper and basal parts of flows. Plagioclase in the massive basalts is commonly extensively sericitized; more rarely it has been albitized or partly albitized, or replaced by prehnite and pumpellyite. Clinopyroxene generally shows only slight alteration to chlorite. Secondary hematite and goethite are common replacements of magnetite. The secondary mineral associations have resulted from low-grade burial metamorphism. Chemically the altered basalts are characterized by high Na_2O or K_2O contents or both, high Fe_2O_3/FeO ratios, high volatile contents, and low CaO and SiO_2 contents compared with fresh specimens.

Veins and lenses of barite, commonly with associated quartz and calcite, intersect the volcanics in numerous places in the southwestern part of the Victoria River district. Two adjacent veins on Inverway Station have been mined, but production ceased in 1971. Some lavas contain native copper either as sparse interstitial disseminations of apparently primary origin in massive basalt, or as secondary infillings of geodes and amygdales in vesicular flow tops. Malachite, azurite, chalcocite, and chrysocolla are commonly associated with native copper in amygdales and geodes, and also occur in the basal beds of overlying limestone. There is little doubt that these deposits are related directly or indirectly to the Antrim Plateau Volcanics, the copper probably having been leached from vesicular, relatively porous flow tops by connate or meteoric waters and reconcentrated in joints, fractures, certain amygdaloidal zones, and overlying limestone beds, which appear to have acted as stratigraphic traps.

The results of this study will be presented in a Bulletin. This will be preceded by a Record containing all available information.

PINE CREEK GEOSYNCLINE, N.T.

DARWIN URANIUM GROUP

Staff: C.E. Prichard, R.S. Needham, P.G. Smart, A.L. Watchman, P. Fuchs (draftsman).

OFFICE AND GENERAL

The Darwin Uranium Group continued to provide administrative services for most Bureau activities within the Northern Territory. Operations Branch members of the Group operated the store and/or accounts for fifteen Bureau field parties. Vehicles used by the Group and by several field parties received inter-season overhauls at the Group workshop.

Geophysical staff operated the Manton Seismic Station, provided geophysical advice to the public, and carried out field surveys (report in Summary of Activities of the Geophysical Branch).

Geologists continued mapping the Alligator River uranium field (a separate report follows), and assisted in the fact-finding studies for a proposed National Park.

Sales of geological maps continued to increase, and averaged over seventy per month. During the year an addition to the office was built to improve storage and displays of maps and publications and to provide for sales of maps.

Interest in the Alligator River uranium field continues. Geologists from many exploration companies called to discuss the environment of the uranium occurrences and the results of Bureau geological mapping and airborne geophysical surveys of the areas.

Changes in policies regarding aborigines and aboriginal reserves, the proposed national park in the Alligator Rivers region, and heightened environmental consciousness have necessitated increased liaison with a number of authorities. Requirements for field work differ on different types of reserves administered by these authorities. Harmonious relations have been maintained with the authorities concerned, and in general the field operations of Bureau parties have not been restricted.

ALLIGATOR RIVER PARTY by R.S. Needham.

Staff: R.S. Needham, P.G. Smart, A.L. Watchman.

Introduction

The discovery of uranium at Nabarlek in 1970 provided the stimulus for undertaking semi-detailed geological mapping of the Alligator Rivers uranium province; this area had previously been mapped by BMR in very broad reconnaissance style. The object of the semi-detailed mapping at 1:100 000 scale, which started in 1971, is to obtain a clearer picture of the geological history of the area and to establish, if possible, the environment of deposition and the origin of the uranium mineralization.

Two draft progress Records on the 1972 fieldwork have been written; they include 1:50 000 scale maps of Junction Bay SW & SE, Goomadeer NW & NE, Wellington Range SW & SE, Oenpelli NW & NE, East Alligator NE, Jim Him NW & NE, and Mundogie NE Sheet areas.

During 1973, the Goomadeer SW & SE, Oenpelli SW & SE, Howship, Gilruth, Jim Jim SW & SE, Field Island, and Kapalga NW & NE areas were mapped; the mapping of most of these areas, some of which are virtually inaccessible by foot, was greatly speeded up through the use of a helicopter. P. Wilkes (Geophysical Branch) also used the helicopter to check radiometric anomalies in the Arnhem Land Plateau which had been detected by the BMR Airborne Survey of 1972.

Twelve scout holes were drilled by a BMR Rotary drilling party in poorly exposed areas in the East Alligator Sheet area.

General Geology (Figure M6)

In the Field Island and Kapalga (northern half) 1:100 000 Sheet areas, limbs of a broad southward-plunging synclinal structure are exposed as wooded ridges of arkose, pebble arkose, quartzite, siltstone and phyllite. Cross-bedding in the quartzite indicates that the beds are overturned in places. At the coast, the siltstone commonly contains intraformational breccia made up of fragments of siltstone. This series of sediments is possibly equivalent to Mount Partridge Formation; farther south (southern half of Kapalga Sheet area) arcuate ridges of hematitic siltstone have been assigned to the Koolpin Formation by earlier workers, and they appear to overlie the arkose and siltstone. However, drilling by Water Resources Branch, N.T., near the South Alligator River has intersected massive magnesite up-dip from the arkose and siltstone. At present the relationship between this magnesite and the postulated Koolpin Formation which includes a carbonate unit is not clear; it is possible that the magnesite may be a unit not previously recognized in the Alligator Rivers region.

A major structural break is postulated along the South Alligator River valley to explain the disparity of metamorphic grade (lower greenschist/ almandine-amphibolite facies) of the rocks either side of the river, and the stratigraphic position of the rock units involved. This structure may form the western edge of a large block composed of migmatized Lower Proterozoic rocks.

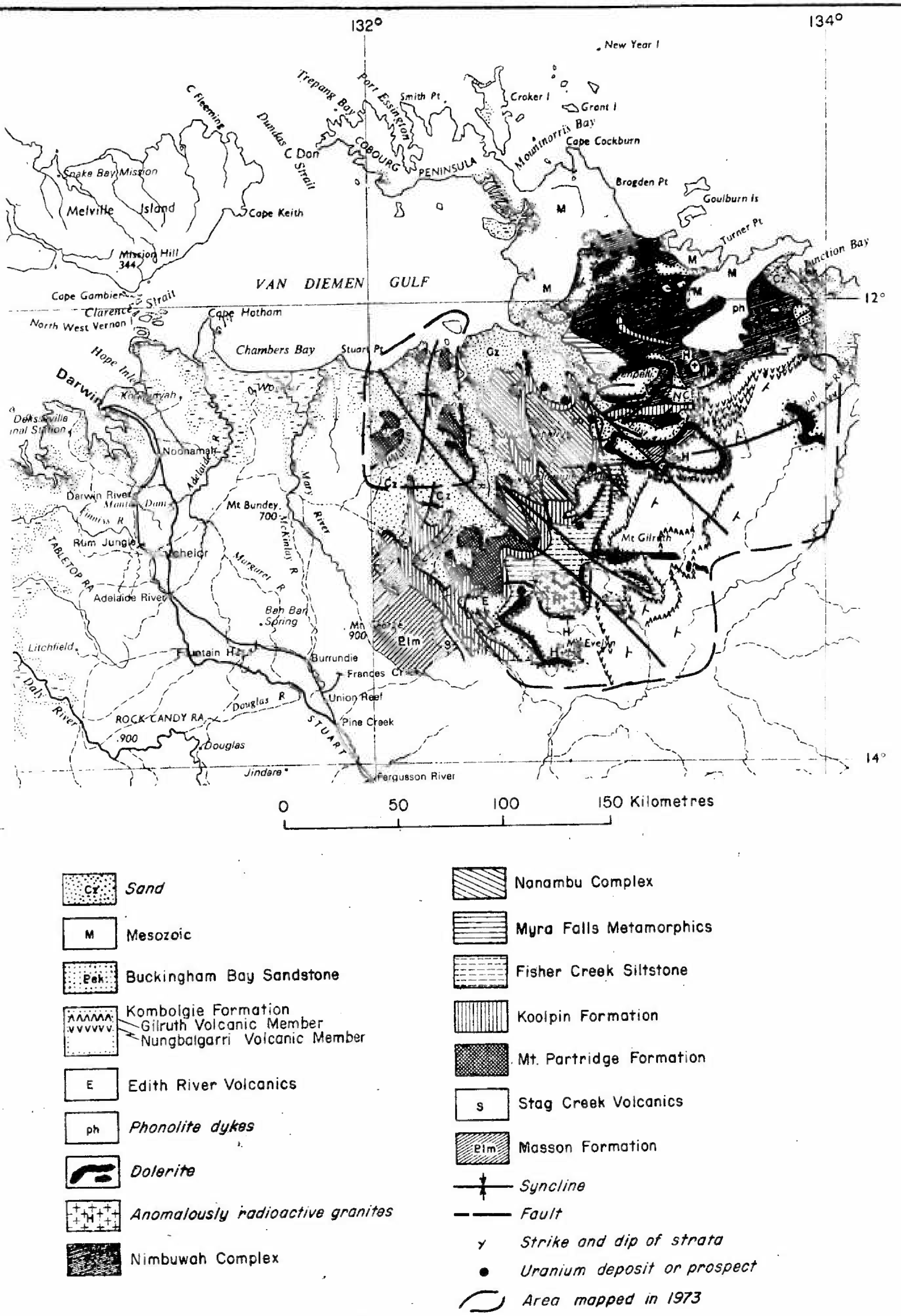


Fig. M6 Area mapped by Alligator River Party during 1973 Field Season

To accompany Record 1973/174

NT/A/367c

Mapping of the Myra Falls Window yielded important results; nowhere else in the uranium province are exposures so continuous and the rocks so fresh as in the eastern part of the window. The window consists of rugged ridges and dissected hills of quartz-mica schist, quartzite, lit-par-lit gneiss (quartz-feldspar leucosome bands and pods developed parallel to schistosity in garnet-biotite schist), amphibolite, granitoid migmatite, and minor marble. The lower grade schist and quartzite in the western end of the window can be traced along strike through increasing grades of metamorphism and progressive stages of migmatization (metamorphic differentiation) into granitoid migmatites typical of the Nimbuwah Complex. The high percentage of interbedded garnet-biotite schist, amphibolite, and quartzite, together with occasional marble, suggests that the rocks of the Myra Falls Window are metamorphic equivalents of the Koolpin Formation (similar successions have been intersected by drilling postulated Koolpin Formation in the Nanambu Complex). Other windows southeast of Myra Falls (the Caramal East Window) and south of Myra Falls (the Beatrice Window) are also considered to belong to the Nimbuwah Complex; they are granitoid migmatites higher in grade than the rocks of the Myra Falls Window. The migmatites in the extreme northeast of the Beatrice Window are typified by clusters of garnet up to 5 cm in diameter.

A number of anomalously radioactive granites have been mapped. All have radioactivity of 150-300 cps, which is up to ten times that of the Nimbuwah Complex. They are altered pink biotite granites, sometimes porphyritic characterized by the presence of approximately north-trending quartz breccia zones which are not anomalously radioactive. The largest is the Jim Jim Granite; others have been identified 10 km east-northeast of Nabarlek, 8 km east of Myra Falls, and 15 km southeast of the Beatrice Prospect. The granites are probably late-stage products of migmatization, i.e., mobilized deep-seated melts formed by complete anatexis of Lower Proterozoic rocks.

The basic to intermediate intrusive rocks have been divided into the Ooenpelli Dolerite, the Mudginberri and Maningkorrirr Phonolites, and the Zamu Complex. The Oenpelli Dolerite is an extensive sub-horizontal composite sheet of porphyritic and ophitic alkali dolerite, granophyric dolerite, granophyre, and minor gabbroic pegmatite. It has been penetrated by drilling at Nabarlek and Black Rock where it is 250 m thick. It has been traced as far east as the Blyth River (as basement highs sporadically exposed in the Arnhem Land Plateau), as far south as Fisher Creek, and as far west as Graveside Gorge. Its northern extent is not known, but it is represented by mafic inclusions in the Migmatite Zone and Granitoid Core of the Nimbuwah Complex. The dolerite is in fact younger than the Complex, but was intruded before the migmatite complex had completely cooled. Hence, the dolerite has been assimilated in the centre of the Complex, and has no contact effects farther from the centre of the Complex (where there was no appreciable thermal gradient at the time of dolerite intrusion), but has extensively hornfelsed (generally to cordierite hornfels) the country rock near the margins of the Complex, and away from the Complex where the country rock has relatively cool when the dolerite was intruded. It is believed that hydrostatic pressure played an important role in dictating the geometry of the Ooenpelli Dolerite during intrusion. Either it was intruded as one extensive sheet of uniform thickness, or as a series of lopoliths at the same depth. Outcrop ridges suggest that the dolerite occupies a series of shallow ellipsoidal basins.

The Mudginberri and Maningkorrirr Phonolites are probably related to the Oenpelli Dolerite; their peralkaline character suggests that they may also have been derived from an alkali basalt parent magma, and may thus be closely related in time to the Oenpelli Dolerite.

The Zamu Complex consists of metadolerite, and is best exposed at Graveside Gorge and in the South Alligator Valley. It was intruded before formation of the migmatite complexes, and within the Nanambu Complex crops out as isolated boulders and pavements of metadolerite and amphibolite. It has been extensively hornfelsed by Oanpelli Dolerite 16 km east of El Sherana. Farther south the Zamu Complex is less altered, and granophyric dolerite, gabbroic pegmatite, microdiorite, syenite, adamellite, and hornblende granophyre differentiates can be identified.

Edith River Volcanics crop out in a window 20 km northwest of El Sherana, and are unconformably overlain by the Kombolgie Formation. The unit is composed of a variety of pyroclastic rocks and intermediate lavas.

The Kombolgie Formation does not appear to be more than 500 m thick over the Arnhem Land Plateau. Basement highs of Ooenpelli Dolerite have been found through most the plateau. During 1973 the Nungbalgarri Volcanic Member was examined in several localities between the Goomadeer River and Gimbat Creek, where it is faulted off and cannot be traced farther south. The member may consist of one or a number of basalt flows, and may contain intercalated sediments. It appears to thin markedly near Deaf Adder Gorge, and between Deaf Adder Gorge and Jim Jim Creek it is altogether absent in places, although still apparent as a bedding trace on air photos.

A second volcanic member has been recognized in the Kombolgie Formation; it lies approximately 100 m above the Nungbalgarri Volcanic Member, and although no more than 3-5 m thick, is apparent on air photos through the development of thick vegetation over it. It is poorly exposed, and mostly masked by scree from the overlying sandstone; laterite and sand commonly cover the bottom of the scree slope. Scattered tuffaceous rubble, amygdaloidal and scoriaceous material, and jasper pebbles characterize the lithology of the member. Laterite developed adjacent to the member may give rise to strong radiometric anomalies; some detected by the 1972 BMR airborne survey had uranium:thorium ratios of up to 10. Some of these anomalies were examined on the ground by P. Wilkes, of the Geophysical Branch.

Structure

Structures in the Nanambu Complex and the surrounding sediments are roughly concordant with those in the neighbouring sediments, suggesting that a simple vertical updoming was involved during migmatization. The same is not true for the Nimbuwah Complex however; in the Myra Falls Window the strike of the metamorphosed Lower Proterozoic rocks is perpedicular to the migmatite complex zonation. This may reflect either the attitude of the sedimentary rocks before migmatization or a complicated structural evolution of the complex which may have involved squeezing up of mushroom-shaped bodies during migmatization. Isoclinal folding is apparent in most lit-par-lit gneisses east and southeast of Ooenpelli and on further study may provide data for construction of a structural model of the migmatite complex. Folding is more intense towards the Migmatite Zone of the Nimbuwah Complex, and progressive stages through development of S2 (schistosity in isoclinally folded sediments), to isoclinally folded S2 and development of S3 have been observed. In the Migmatite Zone classic migmatite interpenetration fabrics have obliterated folding, and finally the rocks grade through several stages into nebulitic and homogeneous rocks characteristic of the Granitoid Core.

The extent of the Nimbuwah Complex is unknown. It may be continuous at depth with the Nanambu Complex to the west and the Gunbatgarri Granite (composed of rocks typical of the Migmatite Zone of the Nimbuwah Complex) to the east. Even farther east the Mirrarmina Complex, Bradshaw Granite, and Giddy Granite are parts of migmatite complexes. The Nanambu Complex does not extend west of the South Alligator River, however, and it appears likely that a structure trending south along the river marks the western edge of the migmatite complexes. This structure may be a major fault, suggesting that the complexes form a large block extending at least as far east as the Gunbatgarri Complex.

The anomalously radioactive granites, and perhaps all massive granites within the Pine Creek Geosyncline, may well be late-stage products of migmatization, reflecting complete anatexis at the root zones of the orogens and intrusion of the migma into country rock progressively farther away from the centres of the orogens.

Long curvilinear faults are dominant features of the area. It is difficult to judge their influence on Lower Proterozoic units, and they have caused only minor vertical displacements in the Carpentarian Kombolgie Formation. However, lateral displacement of up to 35 km of the Nungbalgarri Volcanic Member has taken place near Deaf Adder Creek, where the overall dip of the formation is less than 5°.

Economic Geology

The distribution of uranium deposits corresponds closely with that of the postulated Koolpin Formation or its metamorphic equivalents. The major deposits lie near and within the migmatite complexes, and can all be related to a fault, shear, or collapse structures. The country rock is retrogressively metamorphosed along the structure, and mineralization is closely associated with massive or schistose sericite-chlorite rock.

Aeromagnetic (and radiometric) surveys carried out by BMR in 1971-2 suggest that the uranium deposits and prospects do not altogether follow the margins of the migmatite complexes, as had been previously suggested, but many appear to follow the Koolpin Formation or its postulated metamorphic equivalent. This new information points up the necessity for further consideration of the problem of the source, mode of emplacement, and geological history of the uranium deposits, and the outcome will also depend partly on final results of Rb-Sr, K-Ar, and U-Pb age determinations.

Reports of Results

The following reports are being prepared:

Alligator River Party, N.T.: Progress report Oenpelli region - BMR Record Series.

Alligator River Party, N.T.: Progress report Jim Jim region - BMR Record Series.

Migmatite complexes of the Alligator Rivers region, N.T. - External publication (Search).

Environmental fact finding study, Alligator Rivers region, N.T. - BMR Record Series.

Regional Geology of Alligator Rivers uranium province, N.T. - External Publication (AIMM volume).

BMR Reports will accompany coloured 1:100 000 scale maps when published. A BMR Bulletin accompanied by a 1:250 000 scale map of the uranium province will summarize results of field work from 1971-4.

McARTHUR BASIN, N.T.

CARPENTARIAN AGE DETERMINATION PROJECT

by K.A. Plumb

Staff: K.A. Plumb, in association with A.W. Webb (AMDEL).

Samples collected during 1972 have been analysed by Webb.

Eight total-rock samples of Cliffdale Volcanics have given an excellent Rb-Sr isochron of 1770 ± 20 m.y., all variance being attributable to experimental error, and the Norris Granite is in close agreement at 1773 ± 24 m.y.. These data effectively fix the base of the Carpentarian at 1770 ± 20 m.y..

The Nicholson Granite has given a less precise isochron of 1843 ± 83 m.y., which may be at variance with field relations; further work is contemplated.

The Hobblechain Rhyolite Member, at the top of the Tawallah Group, has given a preliminary isochron of about 1600 m.y., and further samples were collected during 1973 to improve the precision of the isochron. Glauconites from the underlying Aquarium Formation have been updated to 1473 ± 56 m.y..

Carbonate is proving a problem in dating shales of the Barney Creek Formation, McArthur Group, and further analyses are to be carried out.

The shales from the Roper Group, the dolerite sills intruding the Roper Group, and the Peters Creek Volcanics of the Tawallah Group, have all proven to be unsuitable for age determination.

Basement rocks from Arnhem Land (the Bradshaw Granite) previously considered to be of possible Archaean age, have given a whole-rock Rb-Sr isochron of 1944 + 75 m.y.. This may well correlate with the high-grade metamorphic complexes of the Alligator Rivers area.

Reporting of Results

Preparation of a report, for publication by Webb and Plumb, has been delayed by the need for further analyses of the Hobblechain Rhyolite Member and Barney Creek Formation samples.

NORTHWEST QUEENSLAND PROVINCE

CLONCURRY/MOUNT ISA PROJECT

by I.H. Wilson

Staff: I.H. Wilson (GSQ, Party Leader); R.M. Hill, B.A. Duff, D. Ellis, M.R. Little; T.A. Noon (GSQ).

INTRODUCTION

The project is part of systematic geological mapping at a scale of 1:100 000 of the Cloncurry-Mount Isa Region. Mapping of an east-west strip across the Precambrian rocks from Cloncurry to Mount Isa was completed in 1971, and the results compiled in 1972 and the early part of 1973. (Figure M7) During the 1973 field season the Prospector 1:100 000 Sheet area was mapped in detail, and some detailed reconnaissance was done in the Quamby 1:100 000 Sheet area.

Contract diamond drilling for stratigraphic and geochemical information was carried out during the year by Rockdrill Pty Ltd. Three holes totalling about 520 m were drilled during September and October; core recovery was nearly 100 percent.

Liaison was maintained with BMR ground geophysical parties which carried out surveys in 1972 and 1973 to test E.M. and I.P. responses of known mineralized zones, and with the BMR Airborne geophysical party which carried out aeromagnetic surveys of the Cloncurry 1:250 000 Sheet area at 1.5 km line spacing, and the Prospector 1:100 000 Sheet area at 0.5 km line spacing.

The BMR geochemical party took orientation stream sediment and soil samples from areas of known mineralization. Further samples for age determination were collected from the Kalkadoon Granite, Leichhardt Metamorphics, Argylla Formation, Ewen Granite, Naraku Granite, and the Mount Isa Group. The curator of the BMR Museum collected mineral, ore, and fossil specimens whilst with the field party.

A 3-day excursion was conducted between 25 and 27 July for company and university geologists who were shown the geology of the previously mapped Sheet areas. It was attended by about 80 geologists who provided their own transport (30 vehicles) and camping equipment. Stops were made at 26 outcrops located near the Barkly Highway from 10 km west of Mt Isa to near Cloncurry. The Saturday following the excursion was an open day at the Cloncurry Party Base Camp.

RESULTS OF FIELD WORK

General Geology

Most mapping was confined to the Prospector 1:100 000 Sheet area which includes excellent exposures of the volcanic-granitic basement (Leichhardt Metamorphics, Magna Lynn Basalt, Argylla Formation, Kalkadoon Granite, and Wonga Granite), the western sedimentary succession (Mount Guide Quartzite, Eastern Creek Volcanics, Myally Beds, Mount Isa Group, and Surprise Creek Beds),

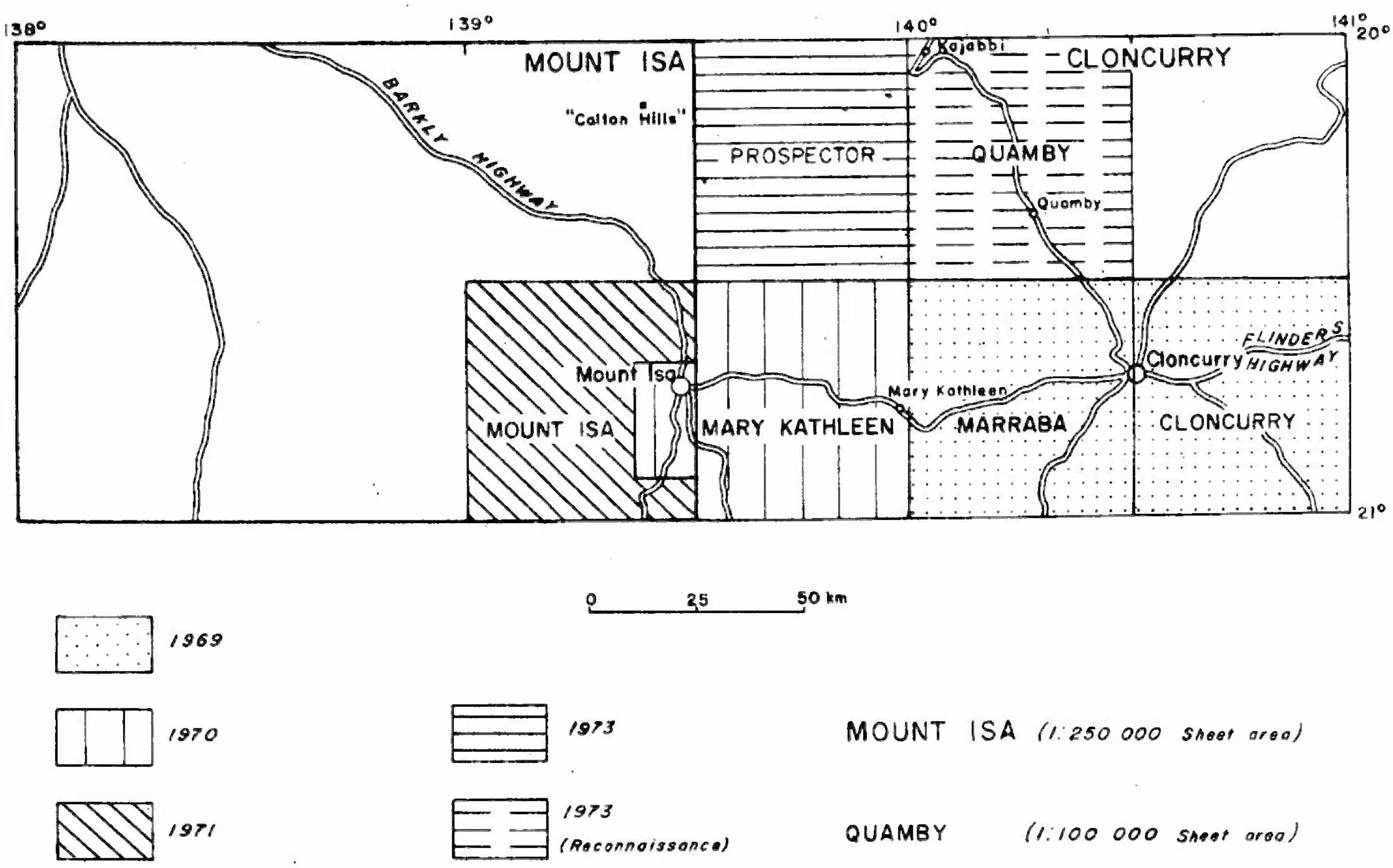


Fig. M7 Progress of mapping, Cloncurry – Mount Isa project

To accompany Record 1973/174

F54/A/49

and the eastern sedimentary succession (Ballara Quartzite, Corella Formation, and Deighton Quartzite). The emphasis was on stratigraphic relations, subdivision of units, and correlation of informal units previously defined by Carter et al. (1961). Photo-interpretation was facilitated by good quality 1:25 000 colour air photographs, and detailed traverses were made of complex areas and representative sequences. Specialized collections were made of basic rocks and the basement sequence for petrology and geochemistry; granites and volcanic rocks were collected for age determination. Some detailed strucutral studies were undertaken.

Proterozoic rocks are exposed in less than one third of the Quamby 1:100 000 Sheet area, the rest being covered by alluvial deposits and Mesozoic sediments. The older Proterozoic rocks belong to the Argylla Formation, Wonga Granite, Corella Formation, Knapdale Quartzite, and Naraku Granite. Fault blocks of Upper Proterozoic Quamby Conglomerate were also mapped.

Stratigraphic Relations

The Prospector Sheet area contains excellent exposures of the unconformity between the Argylla Formation and the Ballara Quartzite in the east and the Surprise Creek Beds unconformably overlying the Leichhardt Metamorphics and Kalkadoon Granite in the west. An important unconformity has also been mapped between the Mount Isa Group and the Myally Beds (Figure M8).

Previously mapped units have been subdivided as shown in Table M1.

The subdivisions of the Mount Isa Group made by Bennett in 1965 have been retained, but the base of the group has been redefined to include the uppermost unit of the Myally Beds (Warrina Park Quartzite). The Warrina Park Quartzite has been divided into 3 subunits: a basal quartzite, a middle ferruginous sandstone or calcareous sandstone, and an upper conglomeratic orthoquartzite.

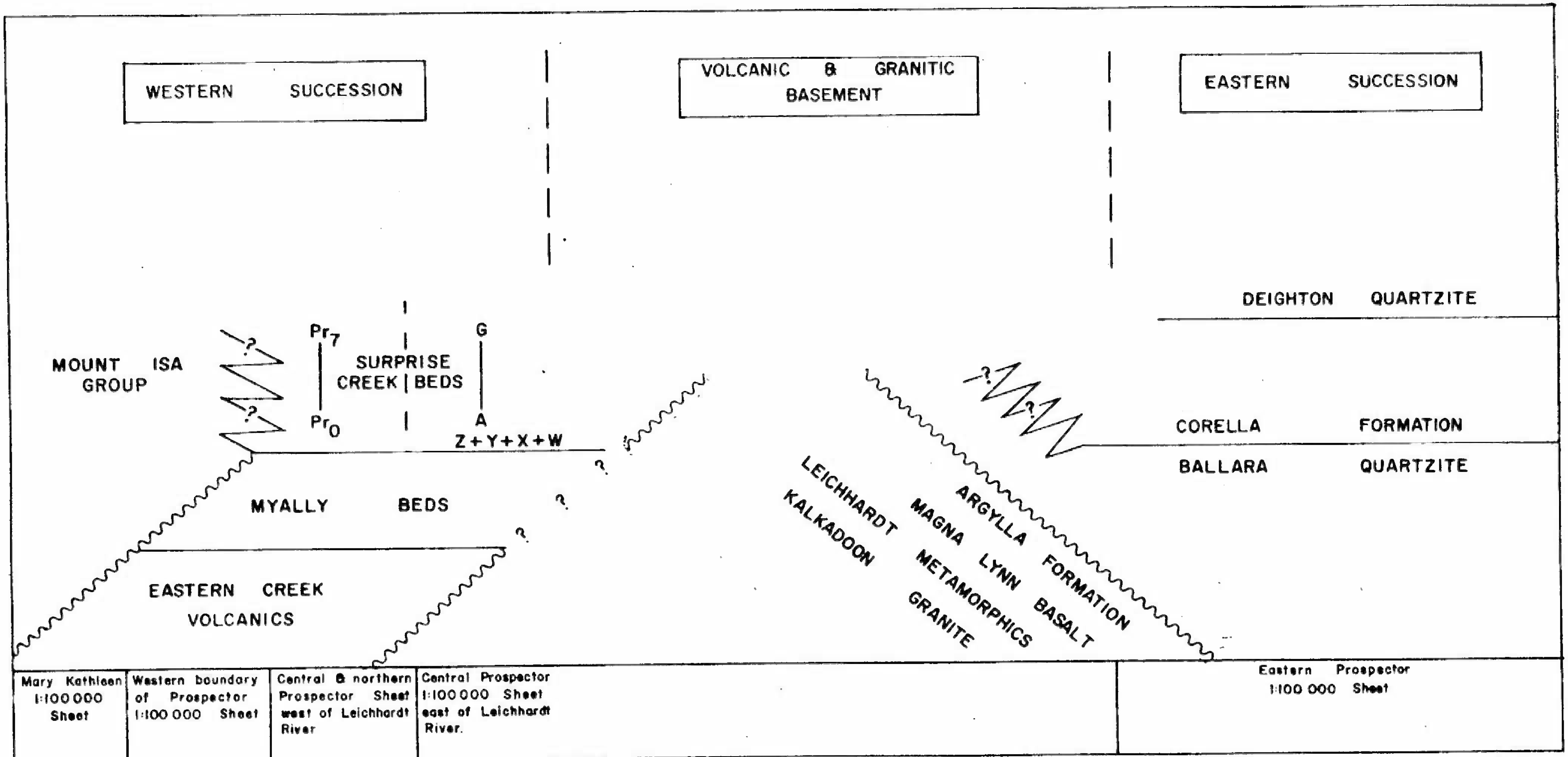
The subdivisions of the Ballara Quartzite (lower siltstone and conglomerate, upper feldspathic quartzite) and Corella Formation (basal calcareous siltstone, middle quartzite, and top calcareous siltstone and impure limestone) that were mapped on the Mary Kathleen Sheet have been continued north. Basic volcanics in the Corella Formation in the Quamby Sheet area occupy a stratigraphic position similar to that of the volcanics in the Marraba Sheet area. The Corella Formation has been brecciated in deformed areas, especially adjacent to dolerite and granite intrusions.

Regional Correlations

In the western sedimentary succession, the Surprise Creek Beds and the Mount Isa Group are lithologically similar, occupy similar stratigraphic positions, and are probably correlatives.

The eastern and western sedimentary successions are not contiguous, and only a tentative correlation can be made between the basal section of the Surprise Creek Beds and the Ballara Quartzite on the basis of similar lithology, air-photo pattern, and stratigraphic position.

The sediments of the western succession onlap Kalkadoon Granite and Leichhardt Metamorphics of the basement complex; those of the eastern succession overlie, in addition, the Argylla Formation and the Magma Lynn Metabasalt.



(1) ——— conformable succession (2) ∿∿∿ unconformable succession (3) possible time equivalents

Fig. M8 Stratigraphic relationships in the Prospector 1:100 000 Sheet area.

To accompany Record 1973/174

F 54/A2/125

TABLE M1.

PRELIMINARY SUB-DIVISIONS OF PREVIOUSLY MAPPED UNITS OF THE WESTERN SUCCESSION SHOWING CORRELATIVES

UNIT	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
		Undeformed Sequence		Deformed Sequence
SURPRISE CREEK BEDS	Br_7	f.g. ferrug. sandst; convol. siltst. & shale		
	Pr_6	pebbly feldspathic quartzite	G	limest., marl, shale, & sandst.
	Pr_5	siltst., shale, f.g. sandst.	F	red to grey lam. shale & siltst.
	Pr_4	brown feldspathic & conglom. sandst.	E	massive f.g. feldspathic qtzite; minor pebble beds
	Pr_3	lam. siltst. & shale; f.g. sandst; limest.	D	interbedded siltst., shale & f.g. felds. sandst.
	Pr_2	cross-bed. feldspathic qtzite & orthoqtzite	*C	white orthoqtzite, felds. qtzite, siltst.
	Pr_1	limest., siltst., grey to purple shale, ferrug. sandst., algal mats	B	as D - more convoluted
	Pr_0	m.g. felds. qtzite, cross-bed., ripples	A	felds. qtzite & jasper clast conglom.
			Z + Y + X + W	felds. qtzites
MYALLY BEDS	Bhm_5	buff to purple/grey poorly bedded siltst.		
	Bhm_4	red to brown f.g. convoluted felds. qtzite with interbed. kaolinitic siltst.		
	Bhm_3	pink cross-bedded f.g. felds. qtzite		
	Bhm_2	brown to pale grey lam. f.g. ferrug. felds. qtzite & some siltst.		
	Bhm_1	white to pink thin-bedded, cross-bedded, f.g. felds. sandst.		

* This unit is characterized by two prominent strike-ridges of quartzite

Metamorphism

The rocks of the region generally belong to the low greenschist facies, but amphibolite facies rocks occur in a narrow belt extending north from Mary Kathleen in both the Quamby and Prospector Sheet areas. Contact metamorphic aureoles and garnetiferous skarns are developed around the Naraku, Mt Godkin, and Wonga Granites.

Structure

The main structural elements are north-trending folds ranging from isoclinal in the eastern part of the Prospector Sheet area to open folds to the east and west. Basin-and-dome structures mapped in the east probably continue into the basement area.

North trending faults with east-block-up displacement commonly repeat the eastern sedimentary succession. A conjugate set of northeast-trending (dextral) and southeast-trending (sinistral) strike-slip faults is present throughout the area. Minor structural features are consistent with the major ones.

REPORTING OF RESULTS

The following reports and maps are being, or will be, prepared:

Reports: Geology of the Marraba 1:100 000 Sheet area, NW Qld : G.M. Derrick, I.H. Wilson, R.M. Hill, and J.E. Mitchell.

Geology of the Cloncurry 1:100 000 Sheet area, NW Qld : A.Y. Glikson and G.M. Derrick.

Records: Geology of the Mt Isa 1:100 000 Sheet area: I.H. Wilson, G.M. Derrick, and R.M. Hill.

A geochemical comparison of Precambrian acid volcanics from the Argylla Formation and Leichhardt Metamorphics, NW Qld.: I.H. Wilson, G.M. Derrick, and R.M. Hill.

Geology, palaeogeography, and correlation of black shale beds in the Mt Isa region, NW Qld.: G.M. Derrick.

Preliminary geochemical investigation of the Corella Formation, NW Qld : R.M. Hill, G.M. Derrick, and I.H. Wilson.

Geology of the Prospector 1:100 000 Sheet area: I.H. Wilson, G.M. Derrick, B.A. Duff, T.A. Noon, and D.J. Ellis.

Explanatory Notes and Maps:

Cloncurry 1:250 000 Sheet area (2nd edition).

WESTMORELAND PROJECT

by

I.P. Sweet

Staff: I.P. Sweet, J.E. Mitchell, C.M. Gardner (petrologist), J. Mifsud (draftsman) - BMR; P.J. Slater (GSQ)

INTRODUCTION

Aim and methods

The Westmoreland Project is part of a joint BMR-GSQ undertaking to assess the mineral resources of the Mt Isa - McArthur River Geological Province with the ultimate aim of providing a guide for future mineral search. Semi-detailed geological mapping using colour air-photographs at 1:25 000 scale is being carried out to provide the necessary stratigraphic and structural framework for exploration.

Concurrently with the mapping, an inventory is being made of known mineral occurrences, and their geochemical expression is being studied in order to assess the usefulness of geochemistry as an exploration tool.

Because major base metal orebodies are known at both McArthur River and Mt Isa, it is desirable to be able to correlate the rocks of the two areas in order to locate more exploration targets. The Westmoreland area, midway between these occurrences holds the key to such correlations, because rocks of both the McArthur Basin, and platforms adjacent to the Mt Isa Geosyncline, crop out there.

Progress

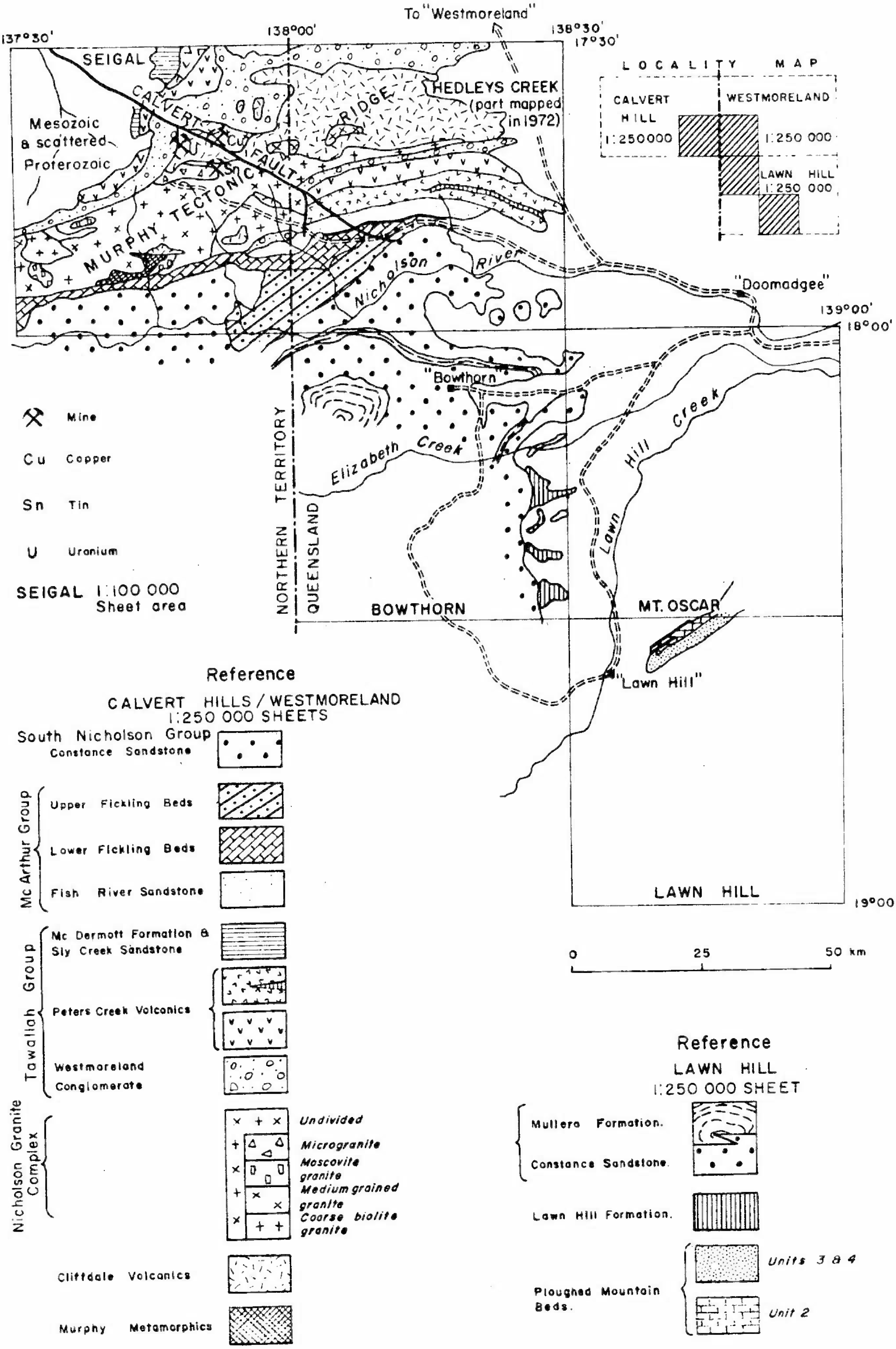
Mapping began in 1972 with semi-detailed mapping of Hedleys Creek 1:100 000 Sheet area, and regional mapping of the remaining Precambrian areas of the Westmoreland 1:250 000 Sheet.

During the 1972 field season mapping of Hedleys Creek was completed, the Seigal 1:100 000 Sheet area (Northern Territory) was also mapped and reconnaissance traverses were carried out in the Bowthorn and Lawn Hill 1: 100 000 Sheet areas (Fig. M9).

GEOLOGY

Seigal-Hedleys Creek Area

The Seigal-Hedleys Creek area includes parts of four major tectonic units, namely, the Murphy Tectonic Ridge, the McArthur Basin, the "Lawn Hill platform" and the South Nicholson Basin (Fig. M9).



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To accompany Record 1973/174

Fig. M9 Westmoreland Project: area mapped during 1973.

The Murphy Tectonic Ridge is an east-northeast-trending belt of igneous and metamorphic rocks flanked to the north and northwest by younger sediments and volcanics of the McArthur Basin, and to the south by rocks of similar age which occupy the "Lawn Hill platform". Overlying the rocks of the latter with marked unconformity, is the South Nicholson Group which occupies the South Nicholson Basin.

The various stratigraphic units mapped are shown in Table M 2.

Previous workers recognized two granites in the area - one older than the Cliffdale Volcanics (the Nicholson Granite), and one younger (the Norris Granite). Because our work shows that probably all granites intrude the Cliffdale Volcanics, the term Norris Granite has been abandoned, and all granites described as phases of the "Nicholson Granite Complex" (tentative name). Several mineral occurrences within the Murphy Tectonic Ridge are within, or related to, the later phases of the granite.

The Tawallah Group (Table M2) overlies the rocks of the Murphy Tectonic Ridge with pronounced unconformity. Although occurring both north and south of the ridge, the Group is much thinner in the south. This has led to difficulties in correlation across the ridge, but it seems likely that the Peters Creek Volcanics in the south are equivalent to most of the Tawallah Group in the north (Table M 2).

The Redbank copper deposit is located in breccia pipes in the upper part of the Tawallah Group (north of the area mapped), so the Peters Creek Volcanics in the south could warrant investigation, particularly for copper mineralization.

The main units occupying the Lawn Hill platform south of the Murphy Tectonic Ridge are the Fish River Formation and the Fickling Beds, which have been tentatively subdivided into two units (Table M 2), both of which contain scattered lead-zinc-copper mineralization, particularly in the upper part of the lower unit.

Overlying all formations in the Lawn Hill platform (including those in the Lawn Hill area discussed below) with pronounced angular unconformity is the Constance Sandstone, the basal unit of the South Nicholson Group, which was laid down in the South Nicholson Basin. Two siltstone members of the Constance Sandstone thin out eastwards, and are absent from most of the Bowthorn 1:100 000 Sheet area. A third siltstone is overlain by sandstone in Bowthorn, but by more siltstone and shale to the west; this is interpreted as intertonguing of Mullera Formation and Constance Sandstone. The Constance Range iron ore deposits are south of the area mapped.

Lawn Hill Reconnaissance

Outcrops of rocks below the South Nicholson Group in the Lawn Hill area are isolated from those of the Seigal-Hedleys Creek area. Correlations between these two areas are difficult but critical, as the rocks in the Lawn Hill area form a belt which is virtually continuous with the Mt Isa region.

Table M2 Summary of the stratigraphy of the Hedleys Creek and Seigal 1:100 000 Sheet areas.

UNIT NAME		DESCRIPTION	REMARKS
South Nicholson Group			
Mullera Formation		Siltstone and shale; sandstone and iron-rich interbeds	
Constance Sandstone		Quartz sandstone and grit; minor siltstone	Contains 3 siltstone members, 2 of which lens out eastwards
McArthur Group			
"Upper Fickling Beds"		Laminated sandstone; minor conglomerate and dolomite	Unconformably on "Lower Fickling Beds"
"Lower Fickling Beds"		Dolomite, siltstone, and shale	Conformable on Fish River Formation
Fish River Formation		Quartz sandstone, minor siltstone	Unconformable on "Upper Peters Creek Volcanics"
Tawallah Group			
Sly Creek Sandstone		Quartz sandstone	
McDermott Formation		Siltstone, dolomite, sandstone	Absent in southwest owing to lensing or local unconformity
Peters Creek Volcanics		"Upper": Intermediate or acid volcanics, minor basalt, limestone, and sandstone	Recognized only south of Murphy Tectonic Ridge
		"Lower": Amygdaloidal basalt; minor siltstone and sandstone	Present both north and south of Murphy Tectonic Ridge; thicker in north
Westmoreland Conglomerate		Sandstone and conglomerate	Four members recognizable in much of the area; finer-grained and thins westwards and southwards
"Nicholson Granite Complex"			All granites appear to intrude Cliffdale Volcanics
Temporary symbols only	Ego$_1$	Biotite adamellite	A minor phase, known only at Crystal Hill
	Ego$_2$	Eg2-type cut by abundant microgranite dykes	Corresponds approximately to the late phase of the former Norris Granite
	Egn$_3$	Muscovite granite	Near contacts of, and within, Murphy Metamorphics
	Egn$_1$	Muscovite granite	A minor phase
	Egn$_2$	Porphyritic granite; no biotite	Includes parts of both former Nicholson and Norris granites
	Eg$_1$	Porphyritic biotite granite	Formerly Nicholson Granite; formerly thought to be unconformably overlain by Cliffdale Volcanics
Cliffdale Volcanics			
Temporary symbols only	Unit 5	Red rhyolite	
	Unit 4(a)	Massive blue-black ignimbrite	Units 4 and 5 are common to both Hedleys Creek and Seigal areas
	(b)	Banded reddish-brown ignimbrite, tuff, and lava	
	Unit 4g	Granofels	Recrystallized by intrusion of granite
	Unit 3	Coarse ignimbrite and crystal tuff	Units 1 to 3 recognized only in Hedleys Creek area
	Unit 2	Fine leucocratic ignimbrite	
	Unit 1	Coarse crystal tuff and lava	
Murphy Metamorphics		Feldspar-mica schist; minor gneiss	Oldest rocks exposed in the region

One correlation scheme is proposed in Table M3 but it must be regarded as tentative, because of the differences in thickness and in facies of the units in the two areas.

Table M3: Tentative Correlation Chart

SEIGAL-HEDLEYS CREEK AREA		LAWN HILL AREA
North of Murphy Tectonic Ridge	South of Murphy Tectonic Ridge	
	Constance Sandstone	Constance Sandstone
	Upper Fickling Beds	Lawn Hill Formation (4) Sandstone
	Lower Fickling Beds Fish River Formation	(3) Siltstone, shale (2) Dolomite (1) Sandstone
Masterton Formation and other units above Peters Creek Volcanics in Tawallah Group	Upper Peters Creek Volcanics	Myally Beds
Peters Creek Volcanics	Lower Peters Creek Volcanics	
Westmoreland Conglomerate	Westmoreland Conglomerate	

Economic Geology

Uranium, copper, and tin have been mined from small lodes in Seigal, but no production is recorded from Hedleys Creek, although several lead prospects are known.

The Pandamus Creek uranium mine - The mineralization is located in a shear-zone within Cliffdale Volcanics, and consists of secondary minerals with minor pitchblende. The mineralization is thought to have been introduced by a late phase of the "Nicholson Granite Complex", and it is proposed to conduct trace element studies on the various granite phases to determine which phase, if any, was the likely source of the mineralization.

The Norris' copper mine is a small, but rich, mine from which malachite and secondary sulphides are being won from above, and primary sulphides (chalcopyrite and bornite) from below, the water table. The mineralization occurs in a steeply-dipping quartz reef occupying a splay fault of the Calvert Fault. Although the fault cuts granite, there is no obvious genetic relationship between the mineralization and the granite.

The Crystal Hill tin mine - a vein of altered granite at the foot of Crystal Hill carries several percent of cassiterite, together with wolframite, cuprite and manganese oxides. The vein is within a late phase of the Nicholson Granite (Table M2 Bgo_1), which is known only from Crystal Hill; the potential for more finds seems low.

Lead prospects in Hedleys Creek fall into two categories. In the first category are several prospects in which small crystals and aggregates of galena and subordinate sphalerite and chalcopyrite are scattered through bedded dolarenite, some of which is silicified. The base metals are probably syngenetic, and have undergone only minor concentration.

Only one prospect, Lead Hill, shows evidence of appreciable concentration. The prospect consists of a vertical zone, a few metres wide, of brecciated dolomitic siltstone containing irregular coarse-grained aggregates of galena. The breccia probably results from solution of underlying dolomite which caused collapse of overlying sediments, and provided cavities for concentration of the base metals. Similar dolomites (Table M2 see "lower Fickling Beds") crop out as a narrow belt across Seigal sheet area, and it seems likely that more such mineralization exists. Geochemical sampling has been carried out at Lead Hill to test the geochemical expression of such a body. This type of mineralization will be very difficult to locate if geochemistry is not a useful tool, and as yet no clues exist as to whether certain areas are more favourable for mineralization than others.

REPORTING OF RESULTS

The following publications resulting from the 1972 and 1973 mapping are being prepared.

Records

Precambrian geology of the Hedleys Creek and Seigal 1:100 000 Sheet areas, Queensland and Northern Territory by I.P. Sweet, J.E. Mitchell, P.J. Slater, and C.M. Gardner.

Explanatory Notes and Maps

Westmoreland 1:250 000 Sheet area (in co-operation with Sedimentary Section)

Seigal 1:100 000 Sheet area } maps only
Hedleys Creek 1:100 000 Sheet area } maps only

GEORGETOWN INLIER, QUEENSLAND

GEORGETOWN PROJECT

by

J.H.C. Bain

Staff: J.H.C. Bain, B.S. Oversby (absent on sick leave from 17 April until 29 October), I.W. Withnall (GSQ); K. Armstrong (BMR).

INTRODUCTION

Aims

The aims of the Georgetown Project, which started in 1972, are to produce revised geological maps at 1:100 000 scale, and to assess the mineral resources and potential of the Georgetown Inlier, north Queensland, (Locality map Fig.M10). Particular attention is being paid to the locating and cataloguing of all mines, prospects, and mineral occurrences in the Inlier. Regional geochemical and geophysical surveys are being co-ordinated with the geological mapping.

Officework

During the interfield season Withnall examined the files of the Queensland Dept of Mines, and extracted and collated all data relating to past and current company activity in the Georgetown Inlier. These data (in tabular form) and summaries of the more important or interesting reports on open file will be presented in progress reports on the project. Furthermore, all relevant geological information from Geological Survey reports dating back to the first activity in the Georgetown Inlier are being collated and summarised.

FIELDWORK

Reconnaissance mapping was carried out in the Red River 1:250 000 Sheet area during a 14-day helicopter-supported survey. The results are shown in Fig. M11.

Mapping on a scale of 1:100 000 was confined to the Forsayth Sheet area, which was covered except for a small part in the southeast. The results are shown in outline in Fig. M12 and the more important ones are briefly described below.

A prominent geological and topographical feature coincides with the Newcastle Range Volcanics which occupy a large fault-bounded cauldron-subsidence area/that extends north into the Georgetown and Galloway 1:100 000 Sheet areas; rhyolite dykes occupy many of the peripheral faults. Up to 200 m of coarse arkosic sediments covers the floor of the cauldron, and is overlain by massive sheets of acid pyroclastics - mostly rhyodacite welded tuff with a total thickness of up to 500 m. The welded tuff sheets commonly have well developed ignimbritic textures.

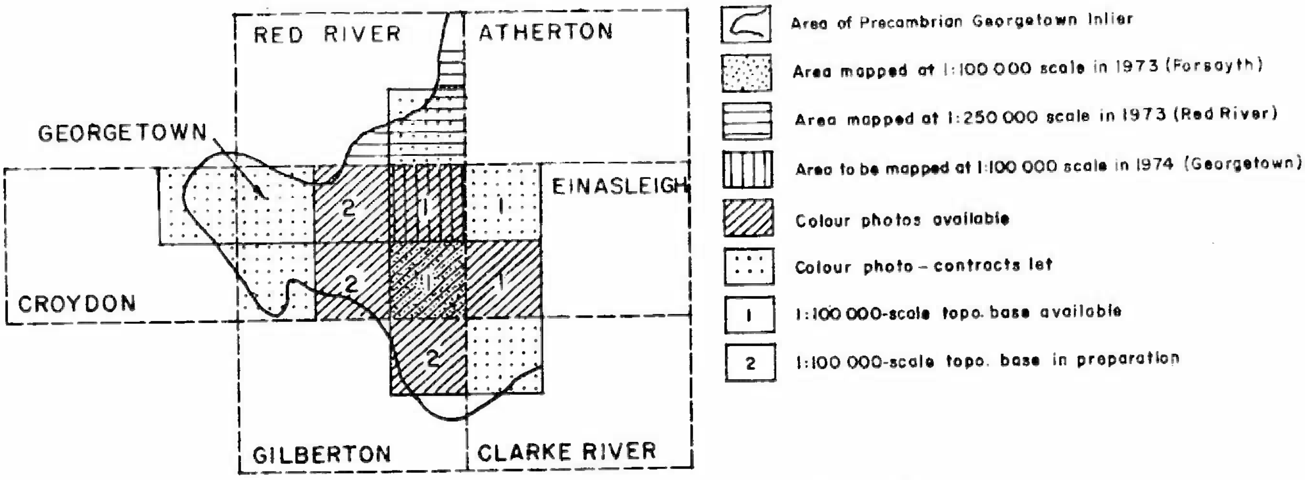

Fig. M10-Mapping, colour photography and basemaps, Georgetown project

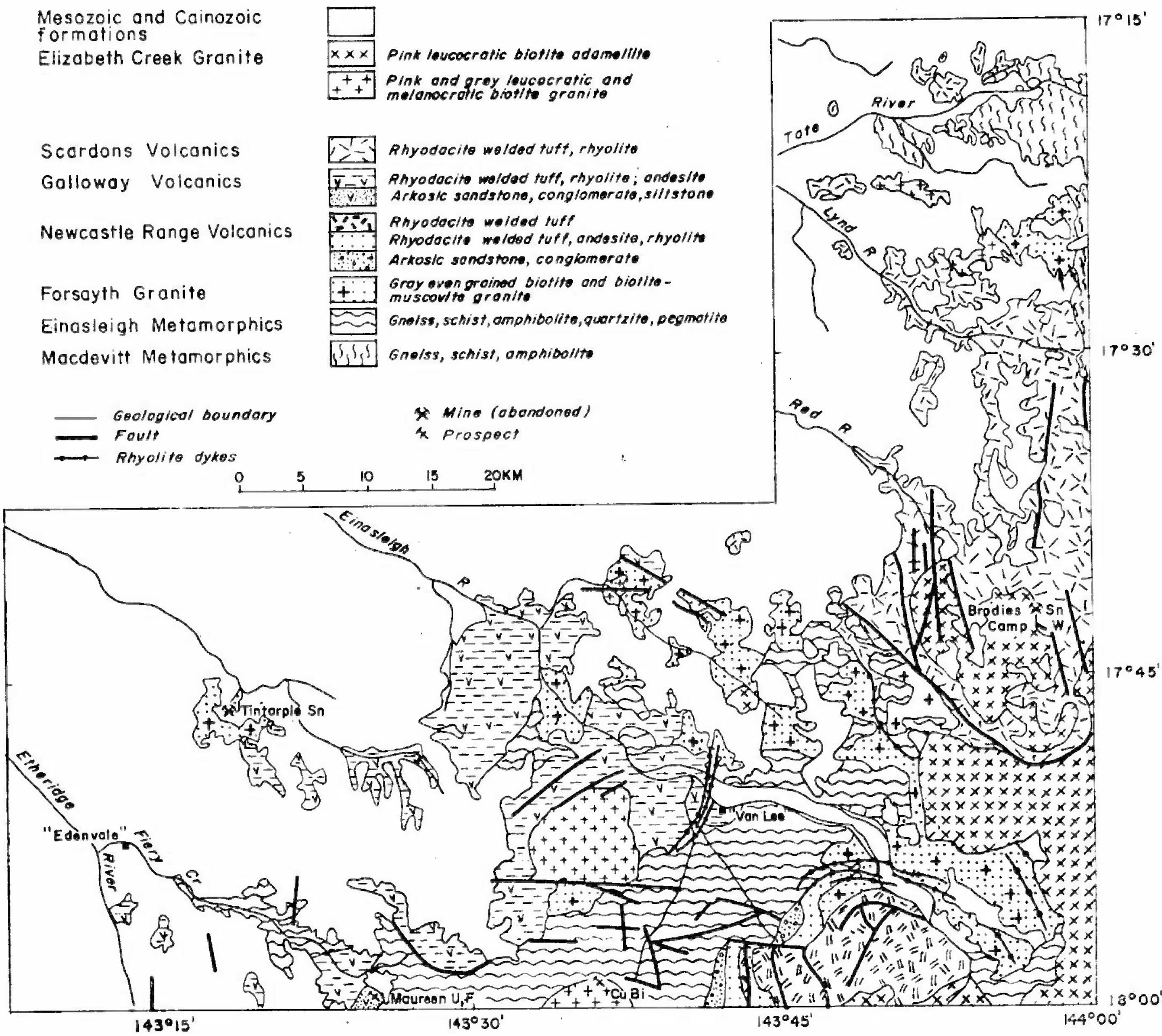

Fig. M 11-Pre Mesozoic geology, Red River 1:250000 Sheet area

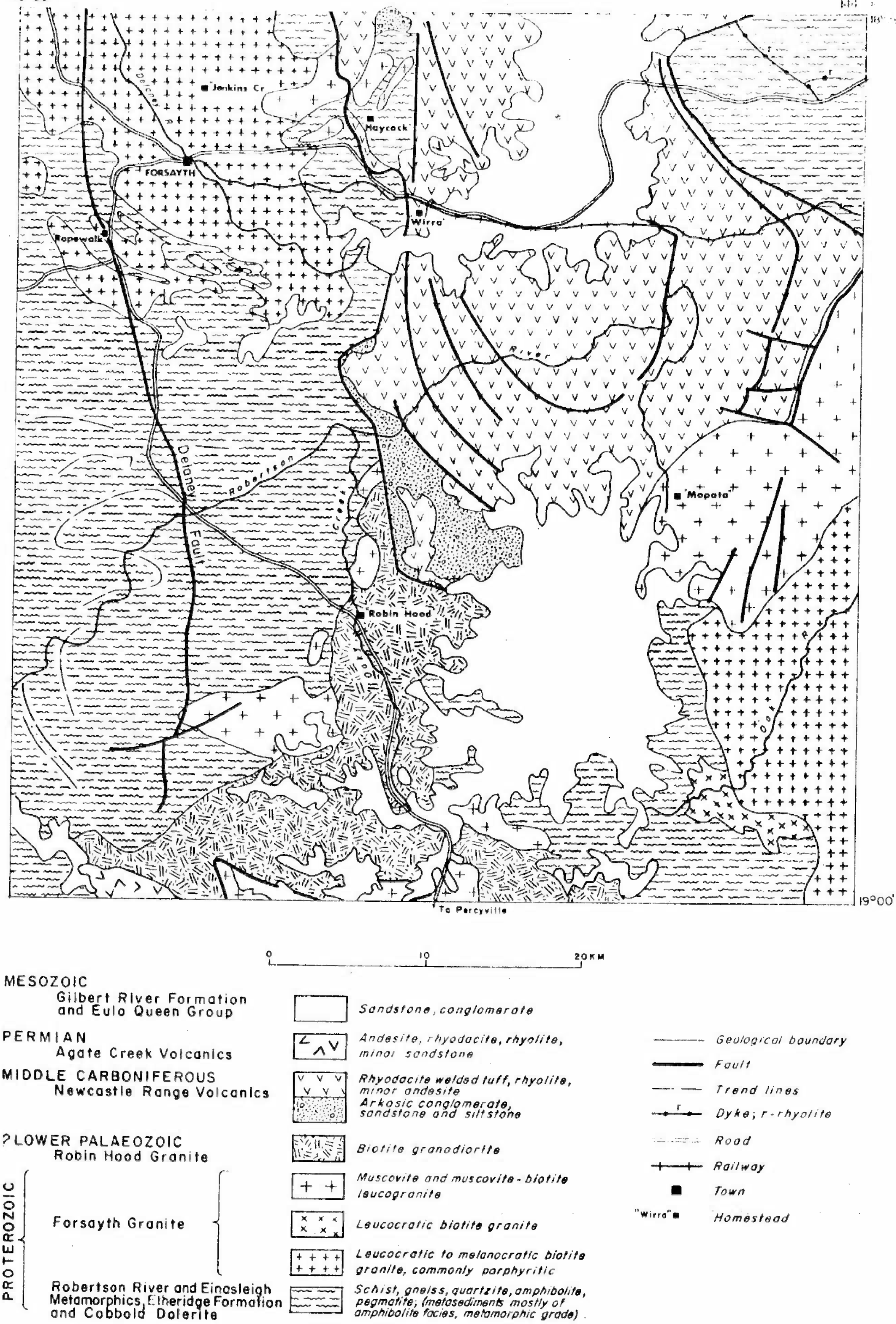

Fig. M 12 - Generalised geology of the Forsayth 1:100 000 Sheet area

To accompany Record 1973/174

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Basic or intermediate lavas, although uncommon, are present near the base of the volcanic sequence on the eastern side of the cauldron. Concentric faults within the main body of cauldron volcanics commonly separate different rock types and individual pyroclastic sheets. Numerous large and small fractures cross the volcanics, many reflecting the main structures in the underlying granites and metamorphics (e.g., those trending west-northwest). The isotopic age of the volcanics is 320 m.y. (Middle Carboniferous).

White, who mapped the area in 1964 regarded a pink(biotite)-muscovite leucogranite phase of the Precambrian Forsayth Granite as part of the Robin Hood Granite. The latter is a distinctive and particularly uniform grey biotite granodiorite with rounded quartz phenocrysts. It is not foliated, intrudes the muscovite granite, and is itself intruded only by Palaeozoic rhyolite dykes and rare small quartz veins; it is believed to be of early Palaeozoic age. The granodiorite may have introduced the gold and copper lead sulphides that fill fissures (commonly greisenised) in the muscovite granite in the Percyville Goldfield. Greisenous veins are also common in the granodiorite. Several small vein-type silver-lead deposits and very small uranium deposit ("Limkins") occur in the granodiorite.

What has previously been termed the Forsayth Granite is in fact an acid intrusive complex. At least three separate and mappable phases of the Forsayth Granite are present within the Sheet area. In order of intrusion they are: (1) foliated, commonly porphyritic grey biotite granite in the Forsayth and Oak River areas; (2) leucocratic biotite granite in the Oak River area; and (3) leucocratic (biotite)-muscovite granite and pegmatite south-west of Robin Hood homestead (previously mapped as Robin Hood Granite), and in the Percyville area and in the Haycock and Mopata homestead areas. The muscovite granite occurs as small irregular bodies in the Robertson River Metamorphics; pegmatite veins and pods are present in the muscovite granite, and pegmatite dykes commonly form stockworks in the metamorphics. The absolute age of the Forsayth Granite is not known; it is most likely Precambrian, but some parts of it may be early Palaeozoic.

The relationships between the Robertson River and Einasleigh Metamorphics, the Etheridge Formation and the Cobbold Dolerite (schist, gneiss, quartzite, phyllite, slate, amphibolite, and pegmatite; the grade of metamorphism ranges from greenschist to almandine amphibolite facies) are not clear, but it does appear that the Robertson River Metamorphics may be a more highly deformed (three or more phases of deformation) and, in part, a more highly metamorphosed part of the Etheridge Formation. The same may be true of the even more highly deformed and metamorphosed Einasleigh Metamorphics; alternatively they may be older than the Robertson River Metamorphics. Detailed structural analysis of many small domains and a large amount of petrographic work will be necessary to determine the nature of these relationships. The Cobbold Dolerite (inappropriately named within the Sheet area as it is almost entirely amphibolite - some garnetiferous - intrudes the other three formations). Although these units are almost certainly Proterozoic, their isotopic ages have not yet been determined.

AGE DETERMINATION

Dating of granites and acid volcanics by L.P. Black, of the Geochronology Group, continued throughout the year, and further specimens of Einasleigh Metamorphics, Robertson River Metamorphics, Forsayth Granite, and various unnamed intrusives were collected by Black during the field season.

REPORTING OF RESULTS

A progress report (Record) on the geology of the Forsayth 1:100 000 Sheet area will be prepared. Explanatory Notes and a 1st Edition map of Red River 1:250 000 Sheet area are to be prepared jointly with the Sedimentary Section.

CAPE YORK PENINSULA, QUEENSLAND

by

W.D. Palfreyman

A section on the geology of the Coen and Yambo Inliers was prepared for inclusion in a paper dealing with the Precambrian and Palaeozoic geology of northeastern Queensland; the paper is for the forthcoming A.I.M.M. volume on the Economic Geology of Australia and PNG.

Some time was spent on editing text and figures and on proof-reading the Bulletin on the igneous and metamorphic rocks of Cape York Peninsula and Torres Strait.

PAPUA NEW GUINEA

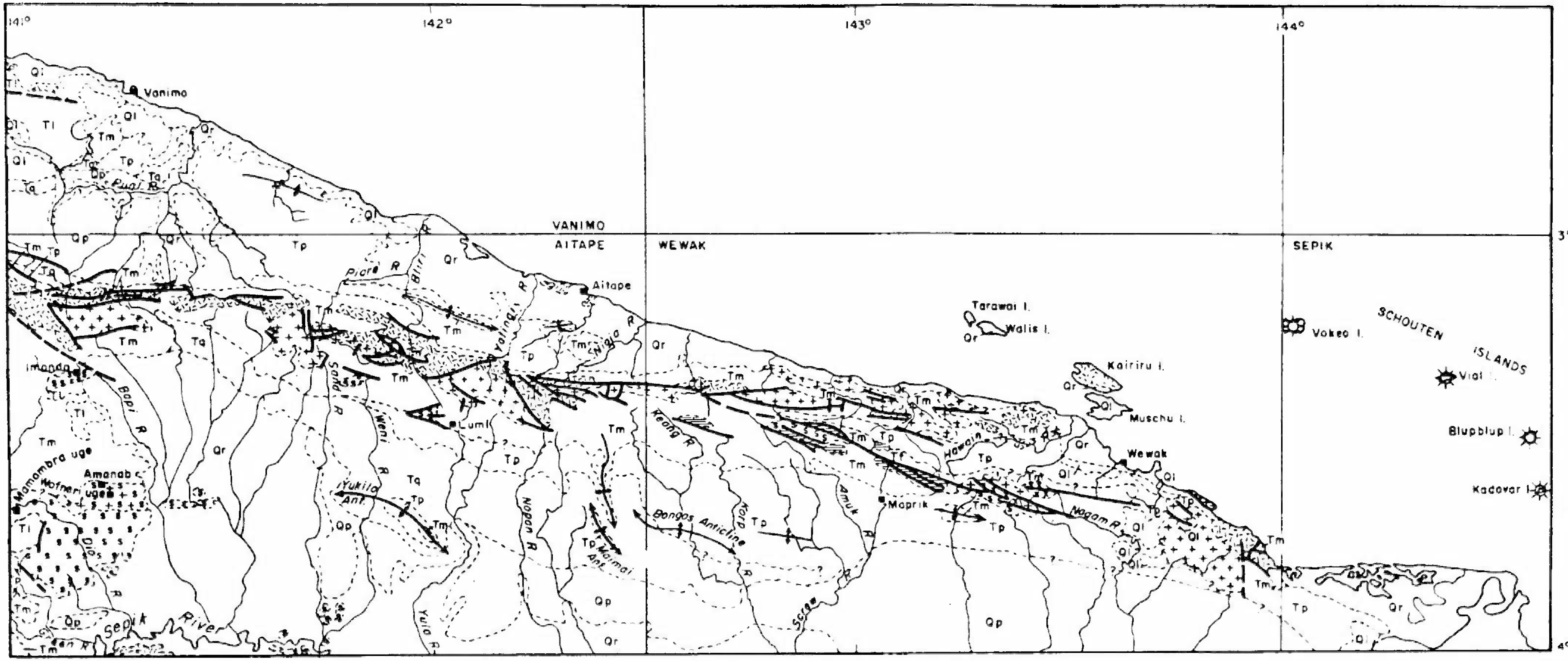
NORTH SEPIK PROJECT by D.B. Dow, D.S. Hutchison, and M.S. Norvick.

Staff: D.S. Hutchison (Party Leader), M.S. Norvick, and D.B. Dow; D.E. Mackenzie and B.J. Dawes (J.I.O.) (part time).

INTRODUCTION

Geological mapping of the mountains north of the Sepik River, which remained the largest unmapped area in Papua New Guinea, was completed during 1973.

The project, which was begun in 1972, had as its main aim the mapping of the pre Miocene igneous and metamorphic basement rocks which form the cores of the mountain ranges. Though the overlying Neogene sediments had been mapped in considerable detail by petroleum exploration companies, the results were not generally available, so a second objective was to become familiar enough with the succession to enable all the information from the various sources to be compiled and published.



BASEMENT

U. EOCENE — L. OLIGOCENE	+ + +	Granodiorite, diorite gabbro, dolerite
M. EOCENE — L. MIOCENE		Basic to intermed. volcanics and derived sediments, limestone
?	x x x	Gabbro, pyroxenite, peridotite
?		Crush zone, mixture of intrusives and metamorphics
U. CRETACEOUS to EOCENE	s + s +	Altered diorite, granodiorite, gabbro, minor serpentinite
	s s s	Slate, phyllite, quartz-mica-schist, garnet schist, minor metavolcanics and marble
? PERMIAN	P	Granodiorite, diorite

COVER

QUATERNARY	☼	Active basaltic volcanoes
HOLOCENE	Qr	Alluvium, reef limestone
PLEISTOCENE - HOLOCENE	Ql	Raised reef limestone
PLEISTOCENE - EARLY HOLOCENE	Qp	Older alluvium, terrace gravels
PLIO-PLEISTOCENE	Tq	Estuarine sandstone, siltstone minor coal
?	Tf	Intermontane fanglomerate
PLIOCENE	Tp	Siltstone, sandstone, conglomerate minor limestone
PARTLY MIOCENE	Tl	Limestone, marl, minor siltstone
MIOCENE	Tm	Siltstone, sandstone, conglomerate, limestone lenses, flysch

0 20 40 60 80 100 km

Major faults

Anticlines

Fig. M13 Geology of North Sepik Region

To accompany Record 1973/174

P/A/412

Description of region

The area north of the Sepik River is dominated by a narrow east-west-trending mountain range flanked by coastal plains on the north and the Sepik Plains on the south. The western end of the range is called the Bewani Mountains, the central portion the Torricelli Mountains, and the eastern end the Prince Alexander Mountains. Though of moderate elevation(up to 1800 m), the mountains are very rugged in most places.

A mountainous massif up to 750 m high forms the southwestern part of the map area along the Irian Jaya border between Amanab and Imonda. Deeply incised streams and karst topography developed on large areas of limestone capping the mountains make access in this area particularly difficult.

The whole of the area mapped, with the exception of the grassy Sepik Plains, is covered by dense tropical rain forest, and as most of the mountain chain is unpopulated, there are only a few rough walking tracks for ground access. Therefore a helicopter was the only means of access used for the whole survey, except for the area between Wewak and Maprik which has a network of roads, and was mapped using a four-wheel-drive vehicle.

1973 Field Season

During 1972 the western half of the region comprising the Aitape and Vanimo 1:250 000 Sheet areas was mapped from base camps established at Amanab, Vanimo, and Aitape (Fig. M13).

The project was completed in May and June, 1973, by mapping the Wewak Sheet area and the small portion of land . the Sepik Sheet area. Wewak town was used as a base, except for one week spent in Aitape, when field checks were made in critical localities in the Aitape Sheet area.

GEOLOGY (Fig. M13).

The geology of the North Sepik region falls naturally into two major subdivisions: (1) Cretaceous to lower Tertiary basement of igneous and metamorphic rocks which are overlain with profound unconformity by (b) thick Neogene sediments. Eocene to lower Oligocene plutons intrude the basement rocks.

(a) Basement Geology

South of the main range the basement rocks form a belt of metamorphosed sedimentary rocks, but the core of the main range and the sporadic inliers along the north coast are composed of basic and intermediate marine volcanics and derived volcanolithic sediments which were the product of island volcanism. Though most of the rocks are faulted to an extraordinary degree, two volcanic and volcanolithic units can be distinguished in places: a dominantly volcanic Eocene succession, and a younger unit containing a greater proportion of sediment.

Lenses of detrital limestone are common throughout both units, and contain abundant foraminifora which show that the lower unit ranges in age from middle to upper Eocene and the younger from middle Oligocene to lower Miocene. No fossils of lower or middle Oligocene age have been identified, and a hiatus is assumed between the two volcanic episodes.

Complex plutons consisting mainly of granodiorite, diorite, and gabbro intrude the volcanics, and samples processed to date give isotopic ages ranging from upper Eocene to lower/Oligocene. Thus, though field evidence in such a structurally complex area is lacking, it is almost certain that the plutons were intruded at the end of the first volcanic epoch.

The basement rocks south of the main range are known only from sporadic small inliers along its southern flank and in the Amanab massif. They consist almost entirely of low to medium-grade metamorphics - mainly slate, phyllite, and quartz-sericite schist - and minor metavolcanics and limestone. Orthogneiss is seen in places, but seems to be related to the crush zones discussed below.

The metamorphics were originally a thick sequence of arenaceous and pelitic sediments, part of which was laid down at the same time as the island arc volcanics to the north, and it seems likely that most of the detritus was supplied by the volcanics.

Possible Permian rocks

Samples from granodiorite and diorite boulders collected in 1972 in the Amanab region near the Irian Jaya border gave isotopic ages between 242 and 249 million years, the same as the Permian Kubor Granodiorite of the Central Highlands. The area was revisited in 1973 and though no fresh granitic rocks were found in situ, a comprehensive collection of river boulders was made for further isotopic age determination.

Pebbles of dacitic volcanics in streams originating across the Irian Jaya border could be the equivalent of the Triassic Kana Volcanics found in the South Sepik region to the south-east, and if so, the presence of a fragment of Australian continental crust in Irian Jaya is indicated.

Crush-zones

Remarkable Crush-zones several kilometres wide separate the metamorphics from the basement volcanics in the eastern half of the region. The rocks in the zones are mostly intensely crushed plutonic rocks (granodiorite, diorite, and gabbro), though cataclasite of unknown origin, and mylonite, are common. Orthogneiss is also commonly associated with the zones near Maprik.

The crush-zones probably mark a major crustal dislocation which could be the north-western extension of the boundary between the New Guinea Mobile Belt and the Melanesian Oceanic Province.

(b) Sedimentary Cover

Sedimentation in the coeval Lumi, Aitape, and Wewak troughs (Fig.M14) is characterised by very thick sequences of poorly consolidated, dominantly immature clastic rocks, which range in age from Lower Miocene to Recent. The elongate troughs were supplied largely from sources in the adjacent basement, and include a high proportion of lithic fragments, similar to rock types known from the Bewani and Torricelli basement. Sedimentary structures indicate that deposition was at least partly by turbidity currents, and some sections contain rocks typical of flysch deposits. Aggregate measurable thicknesses exceed 6000 m in the Aitape and Lumi troughs (Fig.M15) but uplift and erosion are thought to have proceeded at the same time as deposition, and the higher parts of the succession were probably derived partly by cannibalisation of older deposits within the succession. Although sediments of the Lumi trough are very thick close to the mountain front, they thin rapidly towards the Sepik plains to the south. The Oenake-Serra and Amanab uplifts were also positive areas during the Neogene. Many units thin or cut out over these massifs, which at various times were sites of shallow-water carbonate sedimentation.

In the Lumi trough the basal unit is a thick, but laterally discontinuous, polymict conglomerate, which commonly contains lenses of arenaceous bioclastic limestone. Overlying these are poorly consolidated deep-water siltstone containing Miocene fossils, graded-bedded sandstone and minor limestone, all of which are interbedded with shallow-water, channel-bedded, lithic and conglomeratic sandstone. In the uppermost Miocene or early Pliocene, renewed uplift and erosion resulted in the deposition of a second polymict conglomerate which is overlain by marine sandstone, and by deepwater siltstone with abundant planktonic foraminifera. East of Maprik, upper Miocene to Pliocene calcareous siltstones overlap earlier formations, and rest directly on basement.

In the west, the marine Miocene is overlain by a regressive sequence of Plio-Pleistocene shallow-water lithic sandstone, carbonaceous leaf-bearing siltstone, and very minor coal. South of Lumi and Maprik the succession is topped by non-marine Quaternary terrace gravels of the Sepik Plains.

A much thinner sedimentary cover has been deposited over the Amanab-Imonda basement block. Most of the basement area is unconformably overlain by basal polymict conglomerate and by Miocene foraminiferal siltstone and sandstone. In the Border Mountains to the west and also south of Imonda, almost flat-lying limestone of probable Middle Miocene age rests directly on basement.

The basal polymict conglomerate is also present at the base of the succession in the Aitape trough. It is overlain by thick Miocene and Pliocene graded-bedded siltstone, lithic sandstone, and Globigerina marl and limestone, which were probably deposited in a deeper-water environment than the rocks of the Lumi trough. In the far west the succession is capped by regressive Plio-Pleistocene shallow-water lithic sandstone containing abundant plant material.

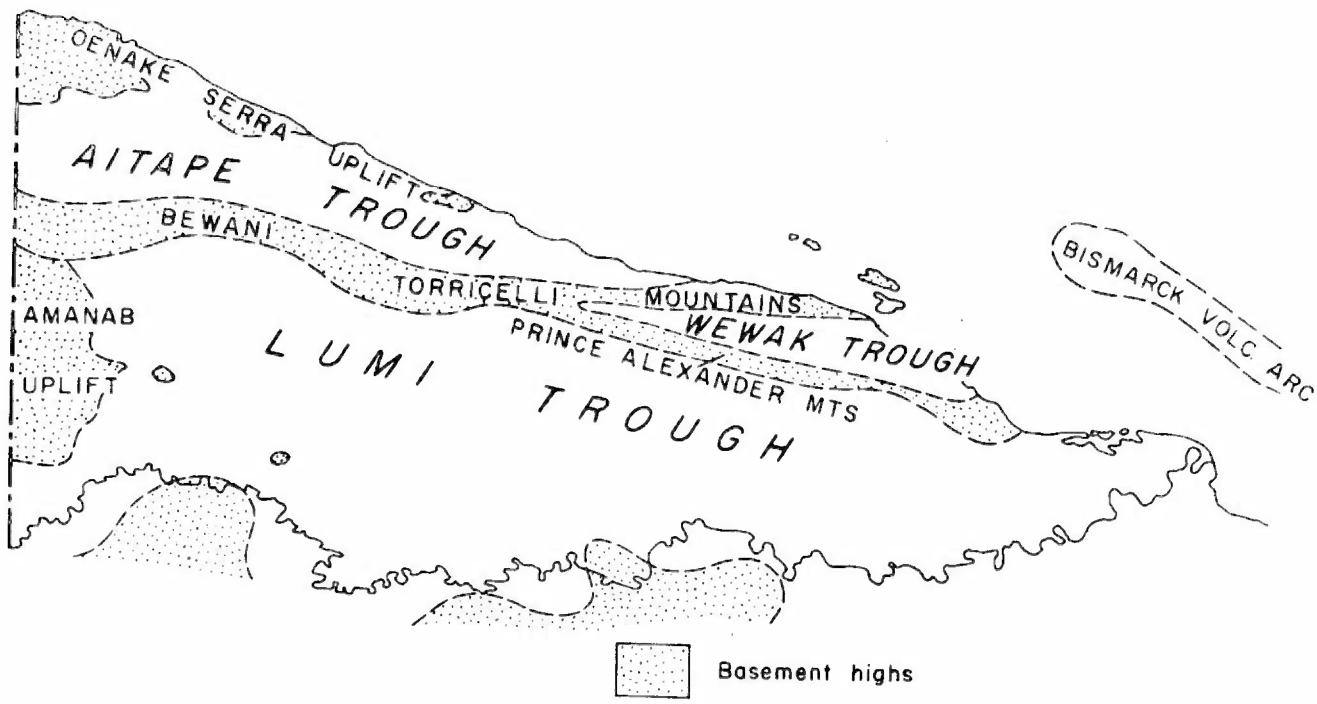


Fig. M14 Principal structural features of the North Sepik Region

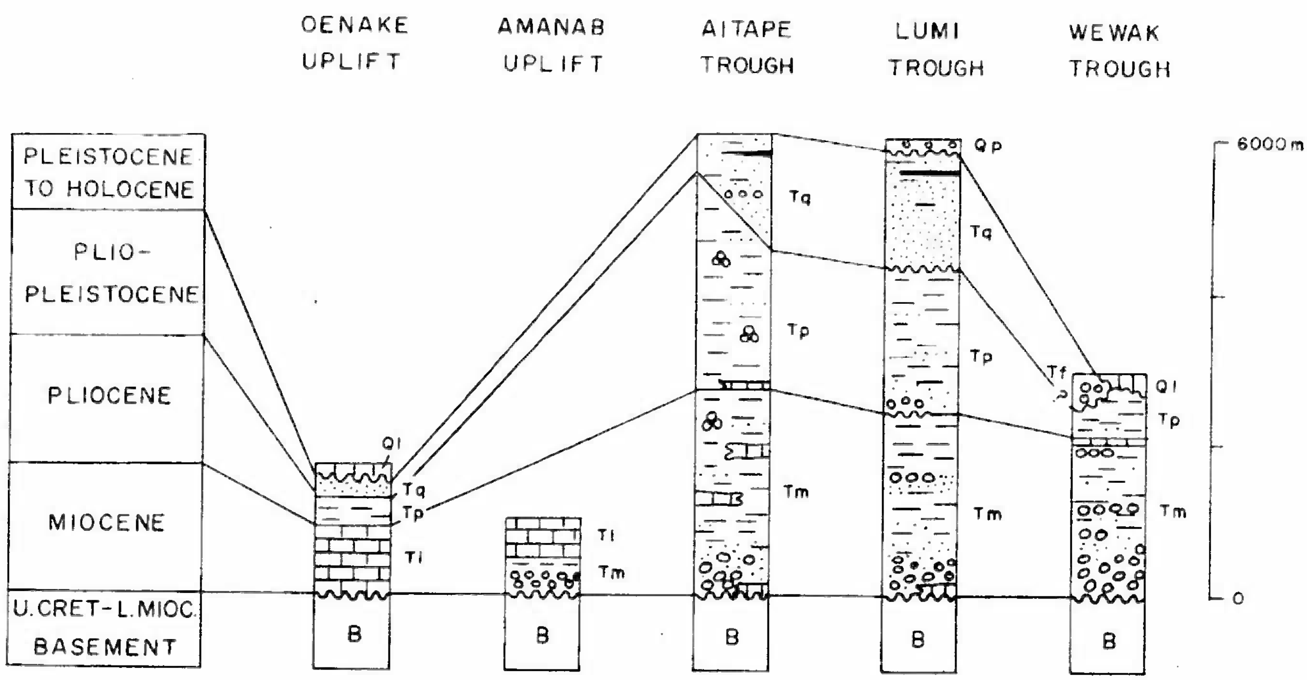


Fig. M15 Typical Neogene sedimentary successions in the North Sepik Region

The Neogene sediments thin northwards over the Oenake-Serra uplift. Southwest of Vanimo the Miocene is represented by shallow-water carbonates, which can be tentatively correlated with the Hollandia limestone in adjacent parts of Irian Jaya. Pleistocene raised reefs occur in both the Oenake Mountains and the Serra Hills.

During the Miocene, the Wewak trough received a thick accumulation of polymict conglomerate, followed by lithic sandstone, graded-bedded siltstone, and minor sandy limestone. Sedimentation continued in the Pliocene with deeper-water graded-bedded foraminiferal siltstone and sandstone. Cropping out along the northern flanks of the Prince Alexander Range is a coarse conglomerate of uncertain age, which contains fresh angular clasts in an arkosic matrix. This has been tentatively interpreted as an intermontane fanglomerate. Almost flat-lying Pleistocene raised reef deposits occur south of Wewak and on Muschu Island.

STRUCTURE

The lower Tertiary rocks are broken into a very complex system of fault wedges by closely-spaced anastomosing shear-zones, trending from east-southeast to east-northeast. The shear-zones are vertical or steeply dipping, and, although most have large vertical displacements, slickenslides are almost invariably within 30° of the horizontal, indicating a large lateral component to the faulting. Some minor faults cut across the main range at a high angle to the regional trend, but most show only small vertical displacements.

Most of the displacement on the faults took place before the cover rocks were laid down, but very substantial movements since the Pleistocene have been proved, and the region is still tectonically active.

Almost all the rocks of the main range, including the younger sedimentary cover, dip steeply, and are commonly overturned. However, south of the Bewani, Torricelli, and Prince Alexander Mountains, the cover sediments are only broadly folded. In the Lumi trough the cover rocks are exposed in a little-disturbed homocline with minor strike faulting. Broad east-west and north-south anticlines were probably controlled by pre-existing basement horsts. The cover rocks of the Aitape and Wewak troughs have been somewhat more disturbed by tectonism, and fold axes are commonly breached by faults.

ECONOMIC GEOLOGY

The only minerals so far produced in the region have been alluvial gold and very minor platinum which were recovered from recent stream gravels. The region has been the object of spasmodic petroleum exploration since the early 1920's, so far without success.

Apart from strongly pyritic siliceous zones which may contain gold mineralization, no mineralization of any economic significance was found during the survey.

Gold

Considerable quantities of alluvial gold were produced before World War II from streams draining the basal Miocene conglomerate in the Maprik region, and small quantities of gold are still being taken from these streams by native miners.

The gold was derived from the basal conglomerate, and concentrated by recent stream action; the original source of the gold was probably primary lodes introduced by the pre-Miocene acid and intermediate intrusions.

In recent years native miners have been working alluvial gold in the Amanab area for good returns. Most of the gold is being won from two streams - Yuva Creek near Wofneri Village, and the headwaters of the Dio River near Mamambra Village. The gold is little worn, indicating a nearby primary source. The country rock consists of slate and phyllite, but diorite boulders, common in the gravels, suggest a primary source related to intermediate intrusives in the headwaters of the streams.

Traces of gold can be panned from streams draining the basement rocks of the mountain range, and small quantities of gold have been won from some localities.

Copper

The geological setting of the basement rocks - island of volcanics intruded by acid and intermediate plutons - is construed as favourable for porphyry copper deposits, and several geochemical surveys have been carried out by exploration companies, but without success.

Extensive hydrothermal alteration typical of porphyry copper provinces appears to be lacking in the north Sepik region, and the only copper mineralization seen during the survey occurs in small quartz veins.

REPORTING OF RESULTS

A Record, accompanied by Preliminary Edition maps, will deal with the results of the 1972-3 mapping, and Explanatory Notes and maps will be prepared for the Vanimo, Aitape, Wewak, and Sepik 1:250 000 Sheet areas.

EASTERN PAPUA

I.E. Smith (A.N.U.) and H.L. Davies (Geological Survey of PNG) revised the first draft of a Bulletin on the geology of eastern Papua.

VOLCANOLOGICAL RESEARCH by

W.D. Palfreyman and W.B. Dallwitz

Staff: R.W. Johnson (on P.S.B. Scholarship at Imperial College, London), D.E. Mackenzie (on P.S.B. Financial Assistance at University of Melbourne), W.D. Palfreyman (part-time); in co-operation with I.E. Smith (A.N.U.).

All these geologists continued laboratory and writing projects on Quaternary volcanoes and volcanic rocks in various parts of Papua New Guinea. Johnson and Smith were concerned with the Bismarck Sea area, Mackenzie with the Highland volcanic area, Smith with volcanic islands of eastern Papua. Smith produced a B.M.R. Record on his project, as well as a paper for outside publication, with Johnson as senior author, on the volcanic islands near St Andrew Strait, in the Bismarck Sea. Mackenzie also prepared a long report for the B.M.R. Record series on the Highland volcanoes.

As opportunity permitted, Palfreyman, in co-operation with R.J.S. Cooke, of the Central Volcanological Observatory, Rabaul, worked on a project to gather all published material relating to Manam volcano; information from as far back as 1875 has been traced. Initially some time was spent sorting material held by the late G.A.M. Taylor; subsequently a thorough search was made for information not held by B.M.R., and copies of this were obtained on inter-library loan. As most of the older texts are in German, some time was spent arranging for, and checking, translations. Time was also spent at the National Library studying material in serial publications not available on inter-library loan.

Dallwitz translated a German paper on Manam Island and other volcanic islands off the north coast of P.N.G. Copies of the text were sent to geologists working on volcanoes in the P.N.G. area.

ANTARCTICA

by

R.J. Tingey

<u>Staff</u>: R.J. Tingey, R.N. England, J.W. Sheraton (BMR); P.A. Arriens, geochronologist (A.N.U.)

INTRODUCTION

Geological mapping of the southern Prince Charles Mountains at 1:250 000 scale was continued in 1973. Geological fieldwork was given high priority in the 1973 ANARE field operation, and during the five-week field season three Hughes 500 helicopters were used almost exclusively to transport the geologists in the field. All rock outcrops in the southern Prince Charles Mountains were mapped, and some localities in the northern Prince Charles Mountains were visited. The camping-out style of fieldwork previously adopted in ANARE Prince Charles Mountains mapping seasons was abandoned in 1973, and the geologists returned to base camp each day after fieldwork. This resulted in more efficient and economical use of aircraft, and allowed for very full consultation and cooperation between geologists; all geolo ists visited every outcrop, and each gained comprehensive information from the whole area. Gravity meter and barometer readings were also made by the geologists; traverse loops were completed each day, and good-quality data were obtained. In addition, a collection of lichens was made for the ANARE biologist.

The planning and execution of fieldwork was hindered by the lack of adequate aerial photographs, but excellent photographs were obtained by ANARE surveyors who flew systematic photographic missions during the field season. ERTS imagery of the area is also now available.

Preparation of 1:250 000-scale geological maps of the southern Prince Charles Mountains awaits base maps being prepared by the Division of National Mapping using the 1973 photography. Geological observations made in 1973 will be recorded on photo overlays when the photographs are received. At present, data are recorded on 1:250 000-scale enlargements of the planimetric 1:500 000-scale base compilation of the southern Prince Charles Mountains.

Since returning to Canberra, Tingey has made some petrographic studies of 1973 specimens, and completed Records on the 1971 and 1972 (England co-author) seasons' work. A short note on access to, and the geology of, the McDonald Islands is being prepared. Barometric heighting and gravity observations have been submitted for calculation. England has made petrographic studies of most of the 1973 thin sections received, and has also attended to other work. Sheraton has worked mainly on other projects.

In August, 1973, Professor Ravich and Dr Grikurov of the USSR Institute of Arctic and Antarctic Geology visited Canberra to discuss geological problems in mapping the southern Prince Charles Mountains. During the 1973 field season, Soviet geological field parties mapping Mount McCauley and Mount Rymill in detail, and briefly visited the Goodspeed Nunataks. Soviet aircraft flew aeromagnetometer and airborne gravity traverses during the season. Airborne ice-thickness radar-profiles were flown by both the Soviet and Australian Expeditions.

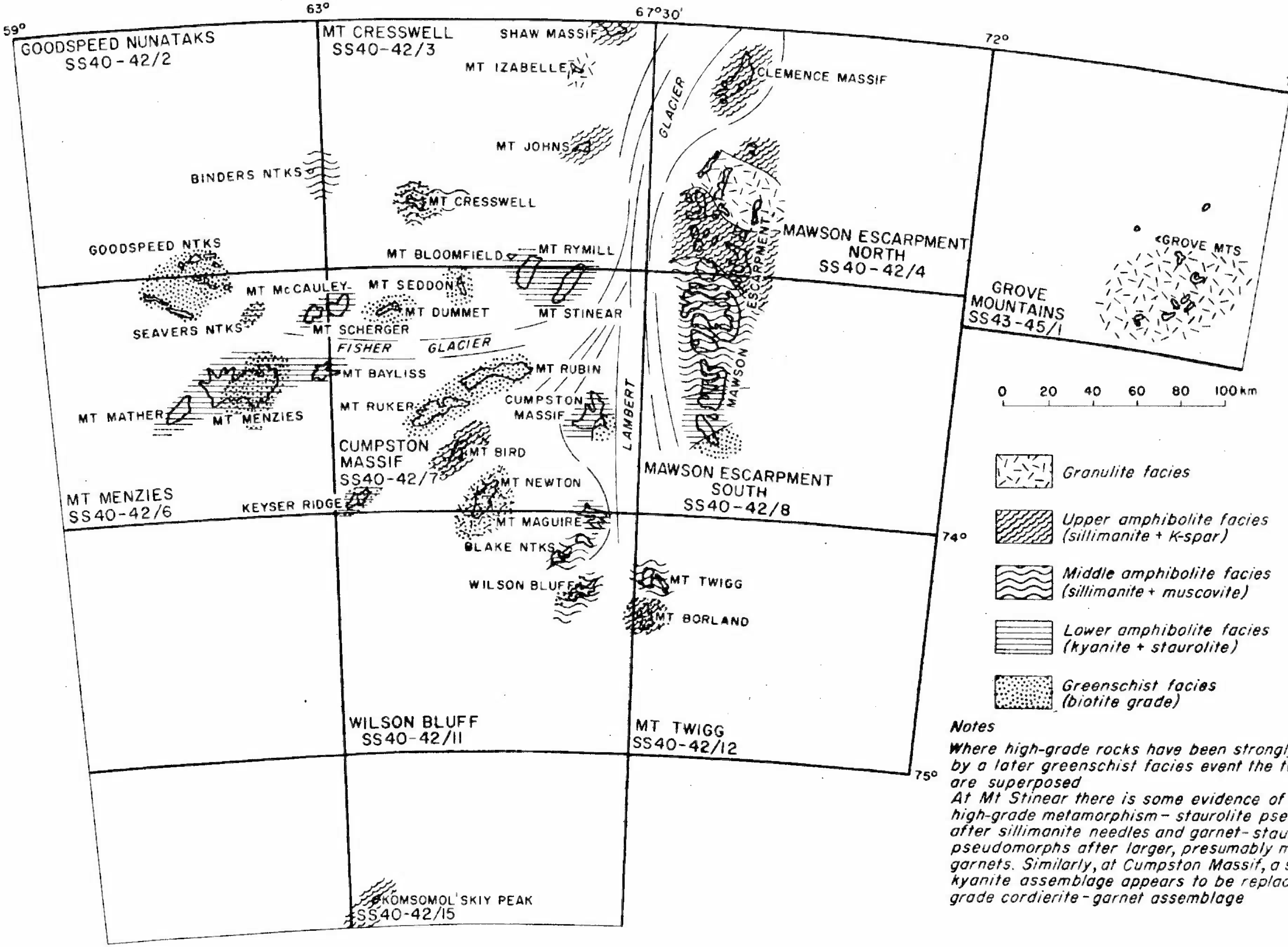
GEOLOGY

The 1972 reconnaissance of the southern Prince Charles Mountains was a useful guide to the 1973 party. Most of the rocks mapped in 1973 were similar to those mapped in 1972; however several hitherto unrecorded intrusive granites and granulite facies rocks at Mawson Escarpment were found. Glacial striae and roches moutonees are preserved at many localities: the striae indicate that the direction of ancient ice movement was roughly parallel to the present-day direction. Till is preserved on some glaciated mountain tops; the local profusion of certain types of debris was noticed at several places. For example, at Mount Rymill, fragments of a red marl with Glossopteris imprints are common in an area about 60 m long and 20 m wide, but are not found elsewhere. Such a rock would not be expected to survive prolonged glacial transport, and is presumably of local origin: no outcrops were found despite extensive searching. The modern glaciers that drain the southern Prince Charles Mountains are almost devoid of surface debris, and have prominent boundary-layer shears at their margins.

As in 1972, local areas of intense retrograde metamorphism were discovered. Other polymetamorphic effects were seen, and high-grade anatectic metamorphism with associated acid intrusives is widespread. Fig.M16. is a preliminary metamorphic facies map of the southern Prince Charles Mountains.

It is not possible to properly define stratigraphic units in the area. Recent work by Soviet geologists has shown that some of the southern Prince Charles Mountains stratigraphic groupings established by Soloviev are probably not valid. The 1973 Australian work has shown that Soloviev's Menzies Series is very widely distributed; the characteristic metaquartzite unit (locally rich in fuchsite), first mapped by Trail at Mount Menzies, and later found at Edwards Pillar on Mount Stinear (Tingey & England), was mapped in the southern part of Mount Stinear, at Mount Rymill, Compston Massif, Mount Borland, Mount Mather, Binders Nunatak, and near Rooster Point at the southern end of the Mawson Escarpment. A quartzite among the granulites at the northern end of Mawson Escarpment may be related to the other quartzites. Other typical Menzies Series rock-types are widely distributed, and it is apparent that areas previously thought to consist of basement rocks older than the Menzies series are composed of Menzies Series rocks more intensely metamorphosed than in the type area.

The Menzies Series also includes distinctive conglomerates that contain quartzite clasts in a grey argillaceous matrix. These were found at southern Mount Stinear where they overlie the fuchsitic quartzite unit and at the Goodspeed Nunataks. Orthoamphibolites, originally intruded as basic dykes, intersect the Menzies Series rocks at many places, but their distribution is irregular. No orthoamphibolites were seen in the Goodspeed Nunataks.



Notes

Where high-grade rocks have been strongly overprinted by a later greenschist facies event the two symbols are superposed

At Mt Stinear there is some evidence of an earlier high-grade metamorphism – staurolite pseudomorphs after sillimanite needles and garnet-staurolite-chlorite pseudomorphs after larger, presumably more magnesian garnets. Similarly, at Cumpston Massif, a staurolite-kyanite assemblage appears to be replacing a higher grade cordierite-garnet assemblage

Fig. M16 Metamorphic map of southern Prince Charles Mountains

To accompany Record 1973/174

AN 2/114

Jaspilites and associated low-grade siliceous metasediments discovered at Mount Ruker by Soloviev in 1965 were re-examined. Their relationships with the granite at the eastern end of the mountain is not clear as the contact is poorly exposed. The jaspilite sequence is apparently exposed only on Mount Ruker, although jaspilite debris is locally abundant in moraines elsewhere. Orthoamphibolites intersect the Mount Ruker sequence.

Soviet geologists formerly grouped the Mount Ruker rocks with low-grade metasediments exposed at Mount Rubin. Mount Rubin consists of low-grade metamorphosed calcareous sandstones and minor conglomerates. Intense folding is seen in the central part of Mount Rubin, where sandstones and marls are interbanded. No orthoamphibolites have been reported from Mount Rubin: Soviet geologists have indicated that they have discovered possible fossils in some of the conglomerates. Other possible fossils are illustrated by Tingey & England in Record 1973/161. Calcareous metaquartzites found at Mount Dunnett are tentatively correlated with the Mount Rubin sequence; wider correlations are not yet possible.

Sedimentary structures are preserved in some medium-grade metamorphic rocks in the southern Prince Charles Mountains. Ripple marks were found at Cumpston Massif and Goodspeed Nunataks, and mudcracks are preserved at Goodspeed Nunataks. These features, together with the presence of conglomerates, indicates a shallow-water depositional environment. Cross-laminations were seen in the 'Menzies' Quartzite at Mount Menzies and in calcareous metaquartzite at Goodspeed Nunataks. The Menzies Quartzite is very pure, and was also probably deposited in shallow water.

The season's mapping showed that Permian sediments are not exposed in southern Prince Charles Mountains. Permian sediments in the area evidently occur at low topographic levels, and are probably intermontane basin deposits like the Amery Group sediments at Beaver Lake.

REPORTING OF RESULTS

A preliminary report on the 1973 Prince Charles Mountains work will be available for the 1974 Antarctic geological party. A Record on the 1973 work awaits completion of petrographic studies and new base maps of the area, and will probably not be complete before April, 1974.

A Record on the geology of the northern Prince Charles Mountains has been issued, (Tingey) and will serve, together with the Record on the 1973 mapping, as a basis for a Bulletin on the Geology of the Prince Charles Mountains which is scheduled for completion in September, 1974.

Explanatory Notes and 1:250 000-scale geological maps for the Prince Charles Mountains will be prepared as base maps become available.

PETROLOGICAL, GEOCHEMICAL, AND GEOCHRONOLOGICAL LABORATORIES

Professional Staff: K.R. Walker, A.D. Haldane, A.Y. Glikson, R.W. Page, S.E. Smith, L.P. Black, J.W. Sheraton, R.N. England, D. Wyborn, (part time, transferred to Tantangara Party in July), S. Henley (resigned December), D.J. Ellis (commenced January), C.M. Gardner (commenced January), B.I. Cruikshank (commenced February), A.G. Rossiter (commenced April).

Technical Staff: M.W. Mahon, T.I. Slezak, J.C.W. Weekes, A. Maenner (resigned October), S.E. Heggie (resigned September), G.C. Willcocks, I. Johns (Baas Becking, commenced April), R.B. Hawkins (Baas Becking, resigned January), G.H. Berryman (resigned May), and C. Robison (commenced September), T. Zapasnik (transferred from Sedimentary Section in October)

Trainee Technical Officers: R.W. Powell (transferred to Management Services in April), G.F. Sparksman, and B.G. West

INTRODUCTION

by

K.R. Walker

The year has been one of steady progress. The most notable change has been in the Chemistry Group, where the progressive fill-up in the establishment, with the appointment of 2 geochemists and 2 analytical chemists, has enabled attention to be given to geochemical survey work as well as analytical services. Walker, Haldane, and D.B. Dow prepared a proposal for a continuing program of geochemical survey work, and a moderate effort has been mounted by combining laboratory and field resources.

Haldane is undertaking general supervision of all geochemical work in the Geological Branch. Survey projects recently begun cover parts of the Georgetown Inlier, Westmoreland, and Mount Isa regions, where stream sediment, soil, and heavy mineral samples were systematically collected this year. Analytical work and interpretations are being done in the Laboratory. Lithogeochemical projects for Georgetown and Tennant Creek, in progress over the last couple of years, are continuing, as is the pollution study of the Molonglo River system.

Project work in the Petrological Laboratory has involved mainly studies of acid and basic igneous rocks, and high grade metamorphic rocks. Work is in progress on rocks from Mount Isa, Westmoreland, Arunta, and Antarctica. In addition, Glikson has been carrying out Archaean Crustal Studies, mainly on Western Australian rocks.

In the Geochronological Group work has proceeded vigorously on dating of rocks from the Arunta, Mount Isa-Cloncurry, Georgetown Inlier-Hodgkinson Basin, Granites-Tanami, and Alligator River areas and Papua New Guinea.

Most Laboratory staff now spend some time in the field, assisting with mapping and collecting samples where petrological, geochemical, or geochronological work is needed. Indeed, Laboratory support is now being provided in all areas the Metalliferous Section is engaged in mapping, and some additional support has been given to other Sections and Branches as required, in particular, a large proportion of X-ray diffraction work has met the needs of the Phosphate and Marine Groups, and the Museum.

During the year eight professional staff spent an aggregate of 45 man-weeks on field work, and another two, who were seconded to ANARE, spent 28 man-weeks in Antarctica. Haldane and Rossiter participated in geochemical survey sampling of Georgetown, Westmoreland, and Mount Isa; Glikson, Ellis, and Gardner contributed to geological mapping, and collected samples for petrological work in the Reynolds Range, Mount Isa, and Westmoreland areas, respectively; Page and Black visited mapping parties in the Granites-Billiluna, Alligator River, and Mount Isa areas, and in the Arunta, Tennant Creek, and Georgetown areas respectively, collecting material for dating; England and Sheraton, who were in Antarctica from 7 December to 12 March, did reconnaissance geological mapping and sampling in the Southern Prince Charles Mountains and along the Mawson coast. Walker made supervisory visits to Georgetown, Mount Isa, Reynolds Range, and, in company with Smith, to Tennant Creek.

Another feature of the year in the Laboratory has been the progress toward up-dating major items of equipment, mainly with modifications to input and output systems to enable more rapid analysis and computation of data to be made than previously. A new Atomic Absorption Spectrophotometer was installed. An automatic sample loader was added to the X-ray fluorescence equipment, and tape outputs, including a link to the BMR Hewlett-Packard 2100A computer, were ordered for the Direct Reading Optical Spectrograph and the new Atomic Absorption Spectrophotometer. The on-line connection between the Mass spectrometers and Hewlett-Packard mini-computer in Geochronology has resulted in a more than twofold increase in work output. An increase in mineral analysis is expected when a Li-Si energy dispersive X-ray detector and multichannel analyser are added to the electron probe microanalyser at the end of the year.

Laboratory staff produced 18 Records, 94 Laboratory Reports, and 16 papers for external publication. A Report and two Bulletins reported last year as being with the editors are in, or nearly in, press. Nine manuscripts are in various stages of preparation.

Various Laboratory Staff attended and contributed papers to scientific meetings. Four lectures were presented to the BMR Wednesday morning lecture series. Laboratory staff meetings were held regularly throughout the year to discuss current projects. Page and Ellis attended and presented papers to the symposium "Volcanics in Eastern Australia" conducted by the S.G.G.M. in Melbourne from 13 to 19 January. Smith and Cruikshank attended the 2nd Analytical Chemical Symposium in Sydney from 14 to 18 May. Walker, Page, and Glikson participated in ANZAAS and the concurrent S.G.I.G.O.D. and I.A.G.O.D. Symposium on "Metallization Associated with Acid Magmatism" in Perth from 13 to 18 August, and at these Page, Glikson, Sheraton, and Black presented papers.

Some staff had the opportunity of attending training courses. Gardner attended "Carbonate Sedimentation" conducted by Dr B.W. Logan from 5 to 16 March, and Walker an A.D.P. Appreciation Course for Managers conducted by the P.S.B. from 12 to 16 March. Smith and Cruikshank participated in a computer systems course presented by Hewlett Packard from 3 to 14 September, and Rossiter attended a gossan identification and interpretation course at A.N.U. on 12 and 13 September. Technicians J.C.W. Weekes and G.C. Willcocks attended the BMR course in Basic Geology.

Haldane continued his involvement in an I.D.C. Subcommittee on water quality control in the A.C.T., in the joint Australian/N.S.W. Governments working group on pollution in the Molonglo River System, and in the Standards Association of Australia Sub-committee for the Analysis of Aluminium Ores.

Assistance with training programs also continued. The Laboratory contributed to a course in Administration of Mining Exploration, to BMR Induction Courses, and to providing facilities for Technical Officer Trainees to obtain practical experience. Haldane this year again presented a course and practical classes at C.C.A.E. on atomic absorption spectrophotometry in applied geochemistry. Such assistance remains an important contribution to training, as the Laboratory is still experiencing great difficulty in obtaining suitably qualified and experienced technical staff. Three additional technical staff positions were created during the year.

The results of project work done by the three laboratory groups - (i) petrology and mineralogy, (ii) geochemistry, and (iii) geochronology - are reported below.

PETROLOGY AND MINERALOGY

Professional Staff: A.Y. Glikson, J.W. Sheraton, R.N. England, D.J. Ellis, and C.M. Gardner.

Technicians: G.H. Berryman (to May), T.O. 2 (X-ray diffraction) and T.A.2 (thin sectioning) - Vacant. I.A. Johns - shared with Baas Becking Laboratory.

Major projects completed or in progress in the Petrological Group are as follows:

PETROLOGICAL AND GEOCHEMICAL STUDY OF BASIC IGNEOUS ROCKS MOUNT ISA-CLONCURRY AREA by A.Y. Glikson and D.J. Ellis

Phase 1 - Basic volcanic sequences (Glikson): A manuscript entitled 'Geochemistry of Proterozoic basic volcanic belts, Mount Isa-Cloncurry area, northwestern Queensland' is being prepared by Glikson. Some of the principal conclusions are: (1) the tholeiitic metabasalts of the Eastern Creek

Volcanics have continental affinities; (2) the Eastern Creek Volcanics have undergone a 'wet' middle greenschist facies metamorphism which contrasts with the 'dry' greenschist to middle amphibolite facies metamorphism of the Soldiers Cap Formation; (3) cyclic geochemical trends occur in the Eastern Creek Volcanics; (4) lead in the Eastern Creek Volcanics is well above the world average for tholeiites whereas copper and zinc are about average; and (5) copper and zinc in the Eastern Creek Volcanics are close to the world average for tholeiites but are much more abundant than in the Marraba Volcanics and the Soldiers Cap Formation.

Phase 2 - Basic igneous and other rocks (Ellis): Further petrological study of the basic igneous rocks within the Mount Isa-Cloncurry area is in progress. This is an extension of the earlier work done by Walker and Glikson. The additional work commenced with a contribution to the mapping of the Prospector 1:100 000 Sheet area in which units of the western succession, including the Eastern Creek Volcanics, Myally Beds, Surprise Creek Beds, and the basal units of the Mount Isa Group are present.

The various volcanic units, including the pillow lavas within the Corella Formation, and the numerous dolerite dykes were sampled in some detail; the dykes have been divided into six different groups on field evidence.

These rocks are being studied, with special regard to their original compositions, variations in metamorphic grade (both spatially and with time), and the relationship between metamorphism and sulphide mineralization.

PETROLOGICAL STUDY OF GRANITES AND VOLCANICS IN THE WESTMORELAND AREA, Q. & N.T. by C.M. Gardner

For this study about 400 samples were collected in the 1973 field season during 10 weeks' mapping and sampling. Most of the samples are from the Nicholson Granite, Norris Granite, and the Cliffdale Volcanics and associated dykes (microgranite, quartz-feldspar porphyry, dolerite). The remainder are from the Peters Creek, Gold Creek and Settlement Creek Volcanics, Hobblechain Rhyolite, and Packsaddle Microgranite. Field observations show greater variation within the granites than previously described (see Westmoreland mapping party summary). Preliminary petrographic examination of the volcanics has started.

PETROLOGY AND GEOCHEMISTRY OF ACID IGNEOUS ROCKS OF NORTHEAST QUEENSLAND by J.W. Sheraton

About 580 samples of extrusive and intrusive acid igneous rocks have been analysed for Na, Mg, Al, Si, P, K, Ca, Ti, Mn, Fe (total), Fe^{2+}, H_2O, Li, Be, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Sn, Ba, La, Ce, Pb, Th, and U, and some samples were also analysed for CO_2, F, Cr, and Co. The trace element results are now being evaluated, and a Record on trace element geochemistry and relationships of the rocks to mineralization is nearing completion.

Some of the more important conclusions reached on the geochemical relations of the rocks to mineralization are:

1) there is a general lack of correlation between the geochemistry of the granitic rocks of northeast Queensland and Pb-Zn or Cu mineralization. Granites with associated Pb-Zn or Cu mineralization do not show any systematic enrichment or depletion in Pb, Zn, or Cu; nor do deposits of these metals appear to be preferentially associated with particular granitic rock-type (e.g., granodiorite, adamellite, etc).

2) granitic rocks with associated tin mineralization have relatively well-defined geochemical characteristics. In common with stanniferous granites from many other parts of the world, they are high-level strongly fractionated granite or adamellite, enriched in volatile elements such as B, Be, Li, and F. They are characterised by tin contents which are significantly higher than those of non-stanniferous granites, although average tin concentrations are lower than values reported for many stanniferous granites elsewhere. A feature of granitic rocks with associated tin mineralization, is their high tin content relative to background values for the area, and this is a characteristic feature which should be detectable in such cases.

PETROLOGY OF HIGH GRADE ARUNTA ROCKS by A.Y. Glikson

Traverses in the Aileron Sheet area were carried out to examine petrological problems relevant to the mapping of this Sheet area, and to undertake further sampling. In particular, the problems of progressive and retrogressive metamorphism were investigated, and the latter type was found to be much more extensive in the Mount Freeling-Annas Reservoir-Woodforde River area, than was originally expected. The problem of the origin of granites and their relationships to the granulites of the Aileron area has been examined, and sampling carried out accordingly. Numerous outcrops in this area are particularly well suited for the study of granite-granulite relations. There are indications that the granites are derived from the granulites by their partial melting and dehydration. This possibility, as well as the study of prograde and retrograde metamorphic changes, will be examined during a petrological study involving also an interpretation of gravity, seismic, and magnetic data in terms of granite-granulite distribution patterns. A report covering the geology and petrology of the Reynolds Range-Aileron-Tea Tree area is being prepared.

A short traverse was made in the Mount Hay area in preparation for field work proposed for 1974, and this indicated the predominance of intermediate to basic granulites, and the exceptionally 'dry' nature of these rocks. Hydrous minerals, granitic phases, and quartz veins are very scarce in this terrain. Because of the scarcity of mappable units on the one hand, and the petrographic complexity of an outcrop scale on the other, the study of this area appears to be a petrological rather than a mapping problem.

ANTARCTIC GEOCHEMISTRY AND PETROLOGY by R.N. England and J.W. Sheraton

Sheraton sampled extensively for a geochemical study of the metamorphic rocks in the Prince Charles Mountains and along the Mawson coast. England collected samples for an electron probe study of granulite and amphibolite facies basic rocks from the northern part of the Mawson Escarpment. He also collected a number of samples of pelitic gneisses in the high-grade areas for an electron probe study of cordierite-garnet equilibria. To date only petrographic work has been done on some of the rocks. Further details of the field work are given in another part of this report, and a progress report on 1973 reconnaissance geology is currently being prepared.

STUDIES OF ARCHAEAN ROCKS by A.Y. Glikson (joint study with I.B. Lambert).

A geological interpretation of gravity and seismic data from the Yilgarn Shield, Western Australia, was carried out, and the conclusions were presented in two papers, entitled: (1) Vertical metamorphic and age zonation of the early Precambrian Western Australian crust, and the origin of protocontinents; and (2) Relations in space and time between major Precambrian shield units: an interpretation of Western Australian data. The principal suggestions advanced are: (1) that high-grade Archaean terrains are the coeval infracrustal roots of the low-grade granite-greenstone system; (2) that the lower ultramafic-mafic units of greenstone belts are relics of a primordial oceanic-type crust; and (3) that the sialic shields evolved through a three-stage partial melting model, involving oceanic crust, sodic granites, and anatectic potassic granites.

The proposal for a project entitled 'Archaean crustal evolution' within the IGCP (created jointly by UNESCO and the IUGS) was prepared and submitted to the Australian National Committee for the IGCP.

ROCK AND MINERAL REFERENCE COLLECTION by C.M. Gardner

Work commenced on the establishment of a specimen and thin section reference collection of igneous and metamorphic rocks, and rock-forming minerals. A classification system modified from Morgan (1964) was selected as the basis of the igneous part of the collection, whereas metamorphic rocks are being classified according to Miyashiro's (1961) facies series.

Thirty samples, mainly granites, granodiorites, rhyolites, rhyodacites, and tuffs have been assigned to the collection.

INSTRUMENT LABORATORIES AND SUPPORTING FACILITIES by K.R. Walker, R.N. England, and C.M. Gardner

The electron probe microanalyser laboratory (England, Ellis, and Johns) has been operated by England and Ellis on a part-time basis only, for, as mentioned above, both have been undertaking field work; England has been working on the petrology of Antarctic rocks, and Ellis on Mount Isa rocks.

Apart from the mineral analysis requirement of projects, an electron probe study (in collaboration with R.W. Johnson) of groundmass pyroxenes in tholeiitic lavas from the Bismarck Sea area was completed, and two distinct augite zonal trends have been noted. Some rocks show a typical tholeiitic trend; in others the augite compositional trend implies Ca-Fe substitution, but still with a consistent gap in the subcalcic augite region. The latter trend may be quite common in groundmass augite from tholeiitic lavas.

A short paper on the isochemical development of corona structures in a metamorphosed dolerite is nearing completion, and will be submitted to a mineralogical journal.

Ellis has analysed feldspars from the Antrim Plateau Volcanics for R.J. Bultitude, and has commenced analyses of xenotime and florencite from the Killi Killi uranium prospect in Western Australia.

In the X-ray diffraction laboratory (Gardner and Berryman) 1330 mineral identifications were made for Geological Branch field parties, and as part of various projects. These projects included the Estuary Study Project, J.O.I.D.E.S., and other marine sediment studies of the Phosphate Group. About 60 museum minerals were determined to check the identification of some, and obtain patterns for others to augment the ASTM index. After the resignation of G.H. Berryman at the end of May, ad hoc work continued intermittently.

Preliminary investigations are being made into the merits of a system of automatic conversion of chart patterns into numerical listings of diffraction peak angles and intensities.

In the thin section laboratory (Maenner) 1160 thin sections, 46 polished sections, and 6 polished thin sections were prepared. In addition, about 400 specimens received other forms of preparation - for chemical analyses, exhibition, and so on - through slabbing and, in some cases, polishing.

GEOCHEMISTRY

by

A.D. Haldane

Professional Staff: A.D. Haldane, S.E. Smith, B.I. Cruikshank, J.W. Sheraton (part time), D. Wyborn (part time), and A.G. Rossiter.

Technicians: T.I. Slezak, J.C.W. Weekes, G.C. Willcocks, G.H. Berryman (to May), and S.E. Heggie (to September).

The work in geochemistry has been mainly concerned with the continuation of the study of pollution in the Molonglo River arising from the Lake George Mine dumps and workings, the geochemical study of the Tennant Creek goldfield, and geochemical orientation surveys in the Georgetown, Westmoreland, and Mount Isa areas.

Two trainee Technical Officers have been associated with the analytical work throughout the year.

Progress with project work is as follows:

POLLUTION STUDIES IN THE MOLONGLO RIVER by A.D. Haldane

Arising out of departmental concern for the quality of the waters of the Molonglo River and Lake Burley Griffin in relation to the known pollution from mining operations at Captains Flat and the proposed construction of Googong Dam, a working group was established in August, 1972. The working group comprised representatives from the Australian Government's Department of Works, Department of the Capital Territory, Bureau of Mineral Resources, and

National Capital Development Commission, and the New South Wales Department of Mines. It is presently attached to the Water Quality Sub-committee of the Interdepartmental Committee on Environmental Quality pending final agreement on the status of the working group between the Australian and New South Wales Governments.

The working group was required to identify the sources of pollution, and to propose such remedial action as was thought necessary to prevent pollution. Specific conductance, pH, zinc, and iron were used to study the pollution pattern. After examination of the chemical results from systematic sampling begun in June, 1970, and the available hydrological data, a preliminary report was prepared. As a result, a number of additional observation stations were set up between the A.C.T. border at Burbong and the Lake George Mine in November, 1972.

The information from the revised sampling netowrk acquired during 1973 has clearly indicated that significant pollution load is entering the river channel over a distance of 5 to 6 km downstream from the Lake George Mine. Erosion of the tailings dumps north and south of the mine results in the deposition of pyrite along the river channel. Subsequent oxidation releases zinc and iron sulphates and sulphuric acid, resulting in an increase in zinc concentration and acidity in the river water, and the deposition of iron oxides on the river bed.

This year's work has high-lighted the need for a close examination of the control of erosion of the tailings dumps, a factor which had not been adequately assessed previously. Also from this year's observations it will be possible to make reasonable estimates of the zinc and salinity loads derived from the tailings dumps, and leakage of water from the mine. Relevant data are being computer-processed by the Department of Works to produce daily and cumulative load plots.

In March the National Capital Development Commission and the Department of Works began preparation of an Environmental Impact Statement on theproposed Googong Water Supply Project, which involved the BMR in the preparation of a detailed statement on the effect of reduced flow in the Queanbeyan River on the possible pollution of Lake Burley Griffin by the Molonglo River. The chemical and hydrological data, forming the basis of the statement, were taken from the work of the Bureau and Department of Works.

GEOCHEMISTRY OF THE TENNANT CREEK GOLDFIELD by A.D. Haldane and S.E. Smith

The Tennant Creek Geochemical Project is a joint venture involving Australian Development Ltd, Geopeko Ltd, the Mines Branch of the Department of the Northern Territory, and BMR. The project has been divided into two phases, Phase I being the study of the rock units in the area (mainly silicates) and Phase II the study of the ironstone bodies. The aims of the project are:

(1) to locate the source of the economic metals and to determine the genesis of the orebodies.

(2) to see if there are any geochemical criteria that would prove useful in exploration of the area.

(3) to provide basic geochemical data on the rock units in the area.

Phase 1 - Geochemistry of the silicate rocks: The preliminary assessment of the data obtained last year showed that some supplementary sampling was necessary to provide a better coverage of rocks in the area. Consequently another 120 samples were collected, mainly from localities drilled by the Mines Branch, making a total of 600 samples analysed for 29 elements in this phase of the project. The results are being treated statistically by computer. In addition, 220 thin sections have been described to help interpret the chemical data.

The results of chemical and petrographic examination of the supplementary samples re-inforced the results and conclusions presented in the Annual Summary for 1972. It is considered that the origin of the ironstone bodies is hydrothermal. A model system is being examined which proposes the separation of a magnesium and iron-rich aqueous phase from a basic magma contaminated by Warramunga sediments. It is considered that the melt phase differentiated into granitic rocks, lamprophyre, and diorite, whereas the aqueous phase caused replacement in certain units in the Warramunga sediments, where the main reaction is considered to be the conversion of muscovite/sericite to chlorite with associated formation of magnetite and talc. Residual solutions depleted in magnesium are emplaced at a higher level as the capping quartz-haematite bodies and quartz reefs. Evidence for potassium metasomatism is common in the granitic and porphyritic rocks.

Final assessment of the data will be made during 1974, when all the computing work should be completed.

Phase 2 - Geochemistry of the ironstones: During 1972,970 ironstone samples were collected; no further ironstone sampling was carried out in 1973.

A preliminary study was made of 100 ironstones for 33 elements to determine the general analytical program. The results indicated that the program should include Ag, Pb, Bi, Zn, Cd, Cu, Co, Ni, Cr, Mn, Be, V, Mo, Mg, Al, Ti, and Si as well as iron.

Analytical problems arising from the very high iron content of the samples have been solved, and analytical work is now in progress. So far, 200 samples have been analysed by atomic absorption. Some of the more interesting variations have been shown by Bi (0 to 1%), Cu (0 to 2%), Co (0 to 0.08%) Mn (0 to 13%), and Mo (0-0.5%).

On completion of the analytical work and evaluation of the data a Bulletin will be prepared.

GEORGETOWN GEOCHEMICAL SURVEY by A.G. Rossiter and A.D. Haldane

Most of the Georgetown geochemical work took the form of orientation studies in preparation for a program of regional stream sediment sampling to start in 1974.

Detailed soil, stream sediment (-85 mesh BSS), and heavy mineral concentrate sampling was carried out in areas of copper, lead-zinc-silver, tin, gold, uranium, molybdenum, tungsten, and fluorite mineralization to investigate the characteristics of the geochemical anomalies to be expected when the regional sampling commences.

Stream sediment samples were also collected in areas remote from mineralization to ascertain the geochemical background associated with the various rock types of the region. This work was largely confined to streams draining the Newcastle Range Volcanics, the Forsayth Granite, and the Robin Hood Granite; other rock units had been given sufficient attention during the 1972 program.

At a few selected localities (both mineralized and barren) a large number of stream sediment samples was taken to measure the variance of the metal content of the sediment at a sampling site. Often bank material was collected in addition to stream sediment in order to compare the amounts of minor elements present in each. A few large samples were collected to supplement the last year's study of metal distribution between different size fractions.

Some time was devoted to perfecting a rapid method of stream sediment sampling using a helicopter. A system has been developed whereby four men can collect 80 samples in a day, a substantial increase on the rate possible using ground crews with 4-wheel drive vehicles. It is intended to sample extensively by helicopter during the next field season.

Samples collected this year are being analysed by atomic absorption spectrophotometry for Ag, Be, Cd, Co, Cr, Ni, Pb, Cu, Zn, Li, and Mn. Preliminary results indicate strongly anomalous metal contents in many of the Georgetown stream sediment samples; the significance of the anomalies has yet to be evaluated. Sample preparation for X-ray flourescence analysis of about one-third of the samples is under way. The following elements have been selected for determination - Mo, U, Th, As, Se, Sn, Cl, Ba, V, P, S, and W. Microscopic examination of heavy mineral concentrates is in progress, and about 30 samples have been prepared as polished section grain mounts. A progress report on the geochemical work at Georgetown, and similar work described below in the Westmoreland and Mount Isa areas, has been programmed for 1974.

WESTMORELAND GEOCHEMICAL SURVEY by A.G. Rossiter

The Westmoreland work closely parallels that done at Georgetown in that it took the form of orientation studies. Much of the sample collection was done around areas of uranium mineralization but tin, copper, and lead-zinc deposits were also sampled. Background studies were carried out on the following units - Gold Creek Volcanics, Westmoreland Conglomerate, Lower Peters Creek Volcanics, and Fickling Beds. No analytical results are as yet available for this area.

MOUNT ISA GEOCHEMICAL STUDY by A.G. Rossiter

In co-operation with the Mount Isa Geological Mapping Party, a gossanous zone in the Corella Formation west of Mary Kathleen was sampled. Soils were collected from points on a rectilinear grid, and stream sediment and heavy mineral samples were taken. At each stream sediment site, three grainsizes (-16 mesh, -85 mesh, and -200 mesh BSS) were taken in order to determine the size fraction giving the highest anomaly. A small number of gossan samples was also collected.

A number of the gossan and soil samples was analysed by optical emission spectroscopy for Cu, Co, Ni, Mn, and Pb. The results indicate high Cu (to 2900 ppm), Co (to 1700 ppm), and Ni in the gossans, and a corresponding Cu (to 410 ppm) anomaly in the surrounding soils. A diamond drill hole to intersect mineralization below the gossan was completed towards the end of the year.

ANALYTICAL LABORATORIES AND SUPPORTING FACILITIES by S.E. Smith

Most of the analytical work carried out in the laboratory was associated with three geochemical projects:

(i) Granite Project,

(ii) Tennant Creek Project, and

(iii) Georgetown Project.

In addition, 500 water samples (mainly from the Molonglo River) were analysed. A summary of the work carried out is given below.

In the atomic absorption spectrophotometry laboratory (Cruikshank, Willcocks) 1550 samples (13 600 element determinations) were analysed. This included 630 samples for the Georgetown Project, and 320 for the Tennant Creek Project. Developmental work was concerned with finding a suitable method for analysing Tennant Creek ironstones, and with general revision of analytical techniques following the installation of a Techtron AA6DA atomic absorption unit.

In the optical emission laboratory (Smith, Slezak) 550 samples (8000 element determinations) were analysed, using the direct reader. This contributed to investigation of rocks from Tennant Creek, Georgetown, Mount Isa, Victoria River, and several areas in Papua New Guinea. In addition, 350 samples (10 000 element determinations) were analysed semiquantitatively. The semiquantitative work involved both the direct reader (170 samples) and the photographic spectrograph (180 samples). Experimental work was carried out to find a suitable method for analysing Tennant Creek ironstones. The problem of arcing iron-rich material was solved, but further work needs to be done to assess matrix effects, sensitivity, and reproducibility. This will be done early next year.

In the X-ray fluorescence laboratory (Sheraton, Weekes) 185 samples were analysed for major elements. Most of the samples belong to the Tennant Creek Project. Also 735 samples (5900 element determinations) were analysed for trace elements. This work was mainly for the Granite Project, but included some analyses of McArthur River samples and some international standards.

In the sample preparation laboratory (Heggie) 1600 samples were crushed, and 1800 were ground. In addition, 200 fusion discs, 640 powder pellets, and 670 mass absorption pellets were made.

GEOCHRONOLOGY

by

R.W. Page and L.P. Black

Professional Staff: R.W. Page, L.P. Black, Technical Officer: M.W. Mahon

This group has made good progress during the year; its work has been directed towards the establishment of a geochronological framework in six areas in Queensland, Northern Territory, and Western Australia. Minor project activities also continued in Papua New Guinea.

Work continued on the Mount Isa-Cloncurry and Georgetown projects, and considerable progress has also been achieved on three geochronological projects (Arunta, Alligator River, Granites-Tanami) which were started in 1972. In addition, one new project (in the Tennant Creek region) commenced this year.

As in the past, the BMR Geochronology Group continues to share isotope laboratory facilities at the Research School of Earth Sciences, ANU. Over 850 solid source and 30 gas source mass spectrometer runs, and 300 X-ray fluorescence analyses were carried out during the year. These included spike and standard calibrations of various kinds. The further increase in productivity from last year reflects, in large measure, the success of Dr P.A. Arriens' newly-developed time-share program used for on-line reduction of the mass spectrometer data. The co-operation, technical assistance, and stimulation received from A.N.U. staff (Dr. P.A. Arriens, Dr W. Compston, Dr I. McDougall, and Dr J.R. Richards) are gratefully acknowledged.

A summary of the work covered in geochronology during the year is given below.

ARUNTA COMPLEX, N.T. by L.P. Black

In contrast to last year, Rb analyses are now routinely performed by mass-spectrometry rather than by X-ray fluorescence procedures. In all, 174 separate isotopic analyses for Rb and for Sr were made on both whole-rock samples and mineral concentrates. Sampling continued again this year, and a procedure whereby a suite of rock samples is collected from a single blasting site was employed to overcome possible large variations in initial isotopic composition between widely-spaced localities.

During the 1973 field season samples were taken from a total of 25 sites in the Illogwa Creek, Alice Springs, Napperby, Alcoota, and Hermannsburg 1:250 000 Sheet areas.

Most mineral ages obtained to date have been affected, at least in part, by the Upper Palaeozoic Alice Springs Orogeny. Thus, heavy emphasis has been placed on total-rock analysis, but in some cases there was insufficient spread in Rb-Sr ratios to obtain a reliable isochron, and, consequently, determination of the original ages of rocks was impossible.

The overall results indicate at least three (and possibly more) distinct metamorphic events during the Precambrian history of the Arunta Block. Granulite-facies metamorphism took place between 1700 and 1800 m.y. ago. The final stage of this metamorphism appears to have been contemporaneous with a widespread metamorphic event of lower grade, which has affected much of the Arunta Block. To the north of the Ormiston Gorge area there is good evidence of migmatisation and granite formation at about 1080 m.y. This latter age sets an older limit for the time of deposition of the earliest member of the Amadeus Basin succession - the Heavitree Quartzite.

GEORGETOWN-HERBERTON-MT GARNET AREA by L.P. Black

Sixty-one mass-spectrometric analyses for Rb and Sr were made during the year. Many of these were on samples of Elizabeth Creek Granite from an extensive area to the east of the east of the Georgetown Inlier. The results show that most of this granite is older than the Herbert River Granite, not younger, as had previously been postulated from field observations.

Total-rock analyses on the Mareeba Granite indicate an age of about 290 m.y., a value slightly older than indicated by the previous K-Ar work.

Six total-rock samples originally analysed six years ago were reanalysed to test for possible contamination of the isotopic spikes during the intervening time, and thus allow a meaningful comparison of all Rb-Sr results. Excellent comparison was obtained.

During the 1973 field season, sample collection was virtually confined to the Georgetown Inlier itself. In all, eleven sites were chosen, to include representatives of the Mt Darcy microgranite, Robin Hood Granite, Forsayth Granite, Cobbold Dolerite, Robertson River Metamorphics, Dargalong Metamorphics, and Einasleigh Metamorphics.

TENNANT CREEK AREA, N.T. by L.P. Black

Specimens of porphyry, lamprophyre, intermediate to basic igneous rocks, the Warrego and Tennant Creek Granites, and sediments of the Warramunga Group were taken from drill core, made available by Mines Branch, Department of the Northern Territory. Isotopic work on these samples will commence in early 1974.

These results have recently been substantiated by further K-Ar mineral ages on schists and gneisses from the metamorphic complexes. These minimum K-Ar ages have been obtained on samples from within the immediate vicinity of the Ranger, Jabiluka, and Nabarlek deposits, and from mineralized areas elsewhere. This confirmation of the 1800 m.y. age as indicating the last major regional metamorphism in the area, appears to negate any hypothesis that would link the regional metamorphic event (1800 m.y.) and uranium deposition (tentative U-Pb pitchblende ages of 800-850 m.y. have been obtained - Hills & Richards, 1972; Cooper, 1973); however, additional U-Pb work has been carried out by Hills since these results were published. Rb-Sr total-rock work on the Nanambu and Nimbuwah Complexes is being done in an attempt to more fully understand the geological history.

Work is in progress on several large and small dolerite bodies which intrude the basement metamorphics east of Oenpelli. Conflicting K-Ar mineral ages, some around 2000 m.y., some around 1630 m.y., have been obtained so far. Recent preliminary Rb-Sr total-rock results on the same dolerite points to an emplacement age of about 1720 m.y.

Another aspect of the Alligator River work has been the continuing attempts to date the phonolite dykes in the area. A wide range of K-Ar ages (670 to 2200 m.y.) on biotite, aegirine, and whole-rock samples has been obtained. The reason for this large age spread is at present unknown. The most reliable K-Ar ages (on biotite separates) are around 1200-1300 m.y. Rb-Sr dating is being carried out on the phonolites in the hope of resolving the apparent discrepancies.

An age estimate for the Kombolgie Formation, which unconformably overlies all the other units, is being sought by K-Ar and Rb-Sr work on the interbedded Nungbalgarri Volcanic Member. No firm results are as yet available.

GRANITES-TANAMI AREA, W.A. AND N.T. by R.W. Page

This project was undertaken (sampling in 1972) to examine the age relationships between the basement granitic rocks, the volcanic pile they intrude, and glauconitic sandstones in the overlying Middle Proterozoic sediments. No previous isotopic ages had been determined in this area.

The Rb-Sr total-rock (and mineral) method has been successfully employed to yield several precise isochrons. Acid volcanics in the oldest rocks (Winnecke Formation) are placed at 1805 ± 24 m.y. Massive granophyric bodies intruding the Winnecke Formation have been dated at 1793 ± 23 m.y., and have a similar initial Sr^{87}/Sr^{86} ratio (0.706) to that of the volcanic rocks. Thus the ages of two of the volcanic and intrusive units are not experimentally distinguishable from each other, strongly pointing to the probability that these units are comagmatic.

Plutonic bodies in the vicinity of The Granites have been firmly dated at 1778 ± 24 m.y. Work on the Lewis Granite is not yet complete, but this granite appears to be distinctly younger than the others (between 1600 and 1700 m.y.).

MOUNT ISA/CLONCURRY AREA, QLD. by R.W. Page

This past year saw the completion of Rb-Sr total-rock analytical work on several granitic, volcanic, and metamorphic suites (sampled in September, 1971) in the basement complex, and in the eastern and western successions in the Mount Isa, Mary Kathleen, Marraba, and Cloncurry 1:100 000 Sheet areas.

Most of the total-rock work on the granites (including the Kalkadoon, Wonga, Burstall, Naraku, and Sybella Granites) has yielded quite precise and unambiguous ages in the range 1540 m.y. to 1740 m.y. Certain parts of the Burstall and Naraku Granites represent much younger phases intruded about 1400 m.y. ago. This finding accords with the field evidence for younger emplacement of these bodies, and is supported by similarly young (1400 m.y.) K-Ar mineral ages (Richards et al., 1963) which pointed to widespread metamorphism at this time.

Preliminary Rb-Sr ages on the Leichhardt Metamorphics and Argylla Formation in the basement succession are approximately 1700 m.y. and 1600 m.y., respectively. These are minimum ages, and at this stage these results remain somewhat equivocal. A major part of the detailed sampling in the Prospector Sheet area, undertaken in September this year, was directed at resolving these uncertainties. The mild, but ubiquitous, recrystallization in the Leichhardt Metamorphics and Argylla Formation acid volcanics renders it likely that a new approach, using U-Pb dating of zircon, will be necessary to adequately clarify the basement geochronology.

The isotopic make-up of the strontium present in each granite in the area at the time of its formation, has been obtained with the establishment of each Rb-Sr isochron. The composition of the initial strontium (Sr^{87}/Sr^{86} ratio) in a rock unit depends on the previous history of the Sr, and reflects particularly the Rb/Sr ratio of the systems in which the Sr had previously resided. The Mount Isa granites demonstrate a definite trend of increasing Sr^{87}/Sr^{86} with time (i.e. in younger units), strongly suggesting that they were formed by reconstitution of the pre-existing sialic rocks.

A start was made on determining a firm age for deposition of the Mount Isa Group (containing the Ag-Pb-Znorebodies). Several tuff marker beds and phlogopitic horizons in the Urquhart Shale were sampled on our behalf by Mount Isa Mines geologists for Rb-Sr dating. Provided that the rocks have remained a closed system, it would be expected (from stratigraphic extrapolation and new age data on the Sybella Granite) that the Mount Isa Group is less than 1570 m.y. old, and not, as has been recently postulated in the literature (Farquharson and Wilson, 1972), greater than 1930 m.y.

A progress Record on the results of these investigations is being prepared.

ALLIGATOR RIVER AREA, N.T. by R.W. Page

Last year (1972 Annual Summary) reconnaissance K-Ar and Rb-Sr mineral ages of around 1800 m.y. were reported for several gneisses and schists in the Nanambu Complex, Myra Falls Metamorphics, and the Lower Proterozoic sequence.

Glauconitic sandstone in the overlying Gardiner Formation was dated by the K-Ar method. The glauconite ages range from 1465 to 1630 m.y., suggesting moderate leakage of radiogenic argon from some samples. An interpreted minimum age of 1560 to 1630 m.y. for the Gardiner Formation is in good agreement with the field relationships and the ages determined on the underlying igneous rocks.

A Record on the results of this work is being prepared.

PAPUA NEW GUINEA by R.W. Page

Geochronological work in Papua New Guinea was confined to rocks from the West Sepik area and Manus Island. Further K-Ar work and some duplicate analyses on the mineralized porphyries near Tifalmin have confirmed Pliocene ages of between 2 and 5 m.y.

Several specimens of glaucophane schist from the Salumei Metamorphics in the West Sepik region were dated by both K-Ar and Rb-Sr techniques. Phengitic mica yields K-Ar ages of 25 to 30 m.y., whereas co-existing glaucophane shows evidence of excess radiogenic argon and "ages" between 40 and 150 m.y. To test the above interpretation deduced from the K-Ar data, Rb-Sr analyses were done on two total-rocks and their separated minerals. This resulted in two parallel Rb-Sr isochrons with a slope of 24 m.y., in good agreement with the muscovite K-Ar ages. This age, probably corresponding to the time of metamorphism (late Oligocene) suggests a probable correlation with the Ambunti (22-24 m.y.) and Gwin Metamorphics (21 m.y.) to the north.

Two K-Ar ages were determined on porphyry samples from the Checkel Porphyry Prospect from the southern part of Manus Island. A mineralized hornblende diorite yielded a mid-Oligocene age (30 m.y.), and an intrusive non-mineralized andesite gave an apparent whole-rock age of 11 m.y.

BAAS BECKING GEOBIOLOGICAL RESEARCH LABORATORY

BIOLOGICAL GROUP.

Staff: P.A. Trudinger (Executive Officer), B. Bubela, Miss L.A. Chambers, T.H. Donnelly, H.E. Jones, G.W. Skyring

Mr T.H. Donnelly joined the Baas Becking group from the Division of Mineralogy, CSIRO, in Febfuary.

RESEARCH PROJECTS

Research has proceeded on the major subjects listed in previous summaries. They are:

1. Physiology and biochemistry of sulphate-reducing bacteria.
2. Taxonomy and evolutionary status of sulphur metabolizing organisms.
3. Geobiological investigations of early diagenetic processes using simulated sedimentary systems.
4. Participation of algae in formation of metastable carbonates

Sulphur isotope fractionation by sulphate-reducing bacteria

(L.A. Chambers, P.A. Trudinger, with J. Smith, CSIRO Division of Mineralogy, North Ryde).

This project is aimed at evaluation of sulphur isotope data in discriminating between biogenic and non-biogenic sulphides. Cultures of a species of sulphate-reducing bacteria grown under controlled steady-state conditions have shown an inverse relationship between extent of fractionation and metabolic activity. The lower values of about -17‰ - ^{32}S enrichment - in sulphide - approximate the values recently shown as the average fractionation in sulphur of stratabound sulphide deposits relative to that of contemporaneous sea-water sulphates. Six other species, including a thermophilic organism, have given ^{32}S enrichments of about the same order. The effect of temperature and pH are currently under investigation.

Sulphur isotope studies (T.H. Donnelly)

(a) A sulphur isotope study of the copper sulphide deposits at Pernatty Lagoon was completed, and a paper submitted to Economic Geology.

(b) Sulphur isotope investigation (in co-operation with Dr J. McDonald, A.N.U.) confirms the hypothesis that sulphide mineralization in Devonian rocks in the West Kimberley region of W.A. is typical of Mississippi Valley type deposits. Further investigation of this region is in progress.

(c) Studies of the ore fluids (in conjunction with Dr R. Kemp, Melbourne University) which formed the magmatic Cu/Ni sulphides of the Wood's Point dyke is partly completed.

Sulphur isotope fractionation within a Simulated Sedimentary System
(L.A. Chambers, T.H. Donnelly, and B. Bubela).

(a) Isotope ratio determinations on sulphidic material formed within a Simulated Sedimentary System are in progress.

(b) An experiment has been designed, under simulated sedimentary conditions, to test an hypothesis based on sulphur isotope data, that pyrite formation in the McArthur River involved a secondary sulphur source.

Chemistry of sulphate-reducing bacteria (H.E. Jones, G.W. Skyring)

Studies have continued on the porphyrinic pigments from the sulphate reducing bacteria. The interest in these pigments stems from their possible relationship to similar organic molecules which are found in a variety of modern and ancient sediments. Some of these sulphate-reducing bacteria have been shown to contain a cytochrome of the d-type which hitherto had been thought to be associated only with aerobic respiration. The presence of this cytochrome in strictly anaerobic sulphate-reducing bacteria may be of considerable evolutionary significance. Studies are also in progress on a green porphyro-protein, desulfoviridin, which has been identified as the catalyst responsible for the reduction of sulphite in sulphate-reducing bacteria of the genus Desulfovibrio. The products of sulphite reduction were sulphide, thiosulphate, and trithionate; the amounts of these varied according to the method of assay.

Relationships amongst dissimilatory sulphate-reducing bacteria (G.W. Skyring)

These studies are aimed at determining the extent of the natural relationships between sulphate-reducing bacteria, and to obtain information on the evolution of bacterial sulphate reduction. Results of taxonomic, electrophoretic, and DNA studies have revealed a number of inter-species and intergeneric similarities. They suggest that the genetic machinery governing sulphate reduction may have been conserved for a long period of geological time. In respect of these results attention has been focused on a more detailed study of the enzymic reduction of sulphide in these organisms. The feasibility of evolutionary steps beginning with the reduction of sulphite are being examined.

Accumulation of elements in sulphate-reducing bacteria (H.E. Jones, P.A. Trudinger, and L.A. Chambers)

In addition to iron accumulation which has been previously reported, a species of sulphate-reducing bacterium has been shown to accumulate large amounts of a water insoluble, non-crystalline substance within the bacterial cell. This substance has so far been found to contain calcium, phosphorus, and magnesium; these elements were concentrated from the growth medium to a remarkable extent. Further identification of the composition and structure of the material and conditions affecting its formation are in progress.

Simulated Sedimentary System (B. Bubela, J. Ferguson)

An experimental tank filled with material simulating the McArthur River deposits was monitored, and a number of observations were made. Algal material participated in accumulation of metals from an environment low in such components. Two zones of encrustation and mineralization were formed. Formation and transformation of carbonates, resulting in dolomitization, took place. Biological activity resulting in H_2S production led to metal sulphide formation. In addition, the biological activity was responsible for the formation of H_2, CO_2, methane, and normal-, iso-, and cyclo-derivatives of butane and pentane. These gases were trapped by a "cap rock" of a thixotropic layer of dolomite. Isotopic studies of the sulphides from the tank are under way.

Carbonates (B. Bubela, P.J. Davies)

Metastable carbonates (nesquehonite, dypingite) were prepared, their stability studied,and a sequence for their transition was established. A new magnesium carbonate, tentatively named "protohydromagnesite" was identified and included in the sequence: nesquehonite, dypingite, protohydromagnesite,and hydromagnesite. Huntite was found to be another carbonate formed from the metastable carbonates described above. Formation of well ordered dolomite was confirmed at temperatures below 25°C in the presence of organic matter.

Analytical Methods (T.H. Donnelly)

A method for automatic background correction in a flameless Atomic Absorption Spectrophotometer was worked out and is being described in a publication submitted to J. Physics. E. An application of this method to Varian Techtron Model 63 carbon rod furnace is being completed (in co-operation with Dr J. Ferguson, B.M.R.) for submission to Anal. Chim. Acta.

MINERALOGICAL GROUP.

by

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

Staff: W.M.B. Roberts, J. Ferguson, K. Johnson (BMR); C.J. Downes, I.B. Lambert (CSIRO).

Rum Jungle Area, N.T. (Roberts, Johnson)

Mapping for the revised Rum Jungle Special Sheet continued from 1 May to 9 November.

A BMR drilling rig commenced work at Rum Jungle on 1 May. Sixteen holes were drilled for a total depth of 526 m. The drilling had three main objectives:

1. To help define the Coomalie Dolomite/Golden Dyke Formation boundary.

2. To obtain information in the Beestons Formation/Rum Jungle Complex contact.

3. To obtain fresh rock for geochemical and petrological investigation.

Results of drilling south of Gould airstrip showed that the Coomalie/Golden Dyke boundary should be placed about 2.4 km farther west (at least in some places) than on the existing map, and that the boundary between these formations in the Crater Lake area on the present map is substantially correct.

Difficulties were encountered in drilling at the Beestons/Complex contact, and although some core was obtained results were inconclusive. As a result a costean about 30 m long and 2 m deep was cut across the contact 2.4 km northeast of Batchelor township; this showed that the contact is steeply dipping and strongly sheared. Rocks at the contact were identified in thin section as mylonitized granite and sediment.

Outcrops examined around the Rum Jungle and Waterhouse Complexes, in both the Beestons Formation and the Complexes, showed evidence of intense shearing of both the granites and the sediments, indicating that a sheared contact probably exists around the entire margin of both complexes. This suggests a possible solution to the problem of the steep dips in the sediments surrounding the granites, which were at an earlier stage of the current investigation, thought to be possibly due to recumbent folding. Evidence obtained during this year's field work suggests that the steep dips of the sheared contact and of the sediments unconformably overlying the basement Archaean complexes are probably attributable to up-doming of the complexes. Part of what appears to be a post-Archaean granite intrusion is exposed in a new railway cutting near Mt Fitch; because of the influence any such granite may have had in the deposition of ore in the area, detailed isotopic dating of the complexes will be necessary to determine which part of them could consist of younger granite.

Much of the Coomalie and Celia Dolomites shown on the existing Rum Jungle Special map was depicted as such on the assumption that siliceous outcrops represent silicified dolomite magnesite. Petrological examination almost invariably did not support this assumption, because of destruction of possibly helpful diagnostic structures (e.g., stromatolites) by extensive recrystallization and shearing in the siliceous rocks. Furthermore, parts of what are now regarded as Beestons Formation, the Crater Formation, and the Golden Dyke Formation had previously been assigned to one or other of the two dolomite/magnesite formations because of the presence of siliceous bodies resembling those associated with the Celia and Coomalie Dolomites. Mapping of massive siliceous outcrops as unequivocally indicating underlying dolomite is therefore regarded as unreliable in this area. In a few places, however, the preservation of stromatolitic structures in the siliceous rocks clearly points to their derivation from carbonate rocks; outcrops containing such structures are invariably situated within a belt of carbonate rocks already fairly well delineated by outcrops of dolomite or magnesite.

The amphibolite study was continued from last year, and the amphibolites from the Brocks Creek (Burnside) area, which are regarded as being of igneous origin, were compared with specimens from Dolerite Ridge and other amphibolites from the Rum Jungle area. The results indicate that both sedimentary and igneous amphibolites are present in the Rum Jungle area.

An investigation of specimens from the Beestons and Crater Formations was carried out to assess whether these formations could be distinguished petrographically. Both formations have generally been strongly sheared, and also show evidence of recrystallization by the action of low-temperature solutions during shearing, and this, coupled with basically similar mineralogical composition, makes a petrographic distinction between the two formations impossible.

A preliminary examination of material from Brown's lead-zinc-copper deposit shows that the Golden Dyke rocks from this area have been more strongly metasomatized than those from other parts of the same formation, with the exception of rocks from White's Mine. The rocks are characterised by the presence of biotite, andalusite, chlorite, and actinolite, and are generally more schistose than elsewhere in the area. The principal sulphide minerals in the deposit are galena, sphalerite, chalcopyrite, and pyrite; a common assessory is the cobalt-nickel sulphide, siegenite.

A map based on detailed mapping by companies and by the Bureau of Mineral Resources, and on auger drilling results, has been produced. The map depicts boundaries of formations ranging from the Beestons up to the base of the Golden Dyke in an area from about Sargent's homestead, in the south, to Woodcutters prospect on the eastern side of the Rum Jungle Complex, and Mt Fitch near its western boundary. Part of the 1974 program will be directed towards delineating these boundaries more clearly, using geophysical methods and diamond drilling.

Ore transport and metal concentration by algae (Ferguson, Bubela)

One major project - an investigation of the role of algal materials in the concentration and transport of metals in sedimentary environments - was pursued during the year, and a second, involving field studies of the formation of iron sulphides in volcano-sedimentary environments was completed.

Measurements of the amounts of metal sorbed from solution by three species of green alga indicated that this process would be unlikely to contribute significantly to the formation of a sedimentary ore deposit unless 1) a weight of organic matter approximately equal to that of the inorganic sediments was available for metal complexing, and 2) the waters of the sedimentary basin had metal concentrations at least 1 to 2 orders of magnitude above those in average seawater.

Ferguson collaborated with B. Bubela and P.J. Davies on the design and establishment of a simulated sedimentary system (see report of Baas Becking Biological Group) and in determining the chemical changes which occurred in the system. Manuscripts on general aspects of the sedimentary system (Bubela, Ferguson, and Davies), the chemical composition and mineralogy of carbonate phases which precipitated in the course of the experiments (Davies, Bubela, and Ferguson), and the distribution of Pb, Zn, and Fe in the brine and carbonate sediments (Ferguson, Bubela, and Davies) are in preparation.

Metal Transport by Brines (Downes)

Fluid inclusion data and present-day geothermal solutions such as the Salton Sea brines offer substantial evidence that ore-transporting solutions are concentrated brines, and that the main constituents are sodium and calcium chlorides. It has been suggested that the solubility of base-metal sulphides is increased in these brines because of the formation of complexes by the base-metal ions and chloride ions. For these reasons the thermodynamics of base-metal ions in concentrated chloride brines was investigated experimentally.

The results show that for a given pH and sulphide concentration the effect of the concentrated brine is to increase the amount of zinc that can be transported in solution by a factor of 200, and that, in the case of lead, the factor is much larger - about 10,000. It should be noted that the effects need to be much greater for lead than zinc to transport similar amounts of the metals because the solubility product of galena is about 10^{-28}, and that of sphalerite is about 10^{-23}. The amount of copper (as Cu II) which can be transported would be slightly reduced by high concentrations of chloride ions.

To compare the behaviour of other elements, results have also been obtained for brines containing manganese, cobalt, and nickel. This comparison shows that chloride brines are effective in the extraction of lead and zinc (and also silver) from source rocks and result in the separation of these elements from other base-metals. Thus solutions containing high salt concentrations would appear to be essential for the mobilization of lead and zinc at low temperatures.

As there is evidence (mainly from oil-field brines) that some connate waters are sulphate/chloride mixtures, experiments have been carried out to determine the behaviour of copper and zinc in such brines. These results are being assessed at present.

In addition to the papers already published on the results of this investigation, six other manuscripts covering the following topics are in preparation:

1. Thermodynamics of Mixed Electrolyte Solutions: the Systems H_2O-$NaCl$-$NiCl_2$ and H_2O-$CaCl_2$-$NiCl_2$ at 25°C.

2. Osmotic and Activity Coefficients for mixtures of zinc chloride with sodium chloride and with calcium chloride at 298.15 K.

3. Osmotic and Activity Coefficients for Aqueous Solutions of $CuSO_4$ and $CoSO_4$ at 25°C.

4. Thermodynamics of Mixed Electrolyte Solutions: the Systems H_2O-$ZnSO_4$-$NaCl$ and H_2O-$ZnSO_4$-Na_2SO_4 at 25°C.

5. Thermodynamics of Mixed Electrolyte Solutions: the Systems H_2O-$CuSO_4$-$NaCl$ and H_2O-$CuSO_4$-Na_2SO_4 at 25°C.

6. Behaviour of Trace Amounts of Base Metal Ions in Chloride Brines.

Downes also collaborated with A.R. Jensen on the investigation at Lake Frome, S.A. (see report by A.R. Jensen, Sedimentary Section).

McArthur River Geochemistry and Experimental Metamorphism (Lambert)

At the end of February, Lambert returned from Japan where he had been studying the Kuroko-type Cu-Zn-Pb-Ag-Au deposits.

A publication on the geochemical investigation of sedimentary rocks from the McArthur Zn-Pb-Ag deposit was completed; the conclusion reached (paper in press) was that the deposit formed syngenetically from solutions introduced into a subsiding euxinic basin in the nearshore parts of a shallow sea. Pyritic shales associated with the deposit are strongly anomalous in Zn, Pb, As and Hg. The suggestion was put forward that such anomalous shales should be of fundamental importance in prospecting for this type of deposit. Several papers were prepared during the year, and investigation of McArthur River and Japanese Kuroko rocks continued.

GEOLOGICAL SERVICES SECTION

GEOLOGICAL SERVICES SECTION

GENERAL

During June and early July the Section Head (E.K. Carter) visited Europe. He attended the 'International Commission on Large Dams' XI Congress and a related study tour in Spain, the 5th World Conference on Earthquake Engineering in Rome and visited dams and hydro-electric projects in karstic limestone in Yugoslavia and Italy. He also discussed technical matters with various people in Paris and London. He visited the Ramu hydro-electric project, under construction in the Eastern Highlands of Papua New Guinea, where satisfactory progress is being made despite difficult shaft-sinking and tunnelling conditions.

In addition to normal management duties, including supervision and staffing of the Section and Branch finance control, Carter served on three inter-departmental committees, two departmental committees, two inter-service committees and four Bureau committees. Technical matters dealt with included stratigraphic nomenclature, the mineral deposits map of PNG and notes, the proposed 1:2 500 000 geological map of Australia, various engineering geological and environmental matters and foreign aid to Tanzania. He gave evidence before the Supreme Court of the Northern Territory relating to a dispute over leases in the Jervois Range area, N.T. and he acted for or carried out the office duties of the Assistant Director (Geology) for a total of seven weeks during that officer's absence from Canberra.

ENGINEERING GEOLOGY AND HYDROLOGY

by

D.C. Purcell, A.T. Laws and E.G. Wilson

ORGANIZATION

The Supervising Geologist for the Sub-Section, G.M. Burton died in November 1972; a tireless worker for the advancement of hydrogeology and engineering geology, he was particularly interested in the training of geologists and modern development in these fields and his loss was a blow to the Sub-Section; E.G. Wilson was subsequently promoted to fill his position.

Group A   Hydrogeological and Regional Development Group

Staff: A.T. Laws, Senior Geologist (Geologist, Class 3); P.D. Hohnen (Geologist Class 2); P.H. Vanden Broek (Geologist, Class 1); J.R. Kellett (Technical Officer Class 1); and Field hands A.D. McCormick, G.W. Barnes and C. Hodden.

This group provided services to the National Capital Development Commission (NCDC), Department of the Capital Territory (DCT), Australian Water Resources Council (AWRC), and rural landowners in the Australian Capital Territory. Most of the services were geotechnical investigations of areas set aside for major urban development in the A.C.T.; the investigations are generally concerned with engineering geology, hydrogeology and soil mechanics.

Group B   Major Construction and Special Projects Group

Staff: D.C. Purcell, Senior Geologist (Geologist, Class 3); G.A.M. Henderson (Geologist, Class 2); G.B. Simpson (Geologist, Class 1); P.A. Lang (Geologist, Class 1); A.W. Schuett (Technical Assistant, Grade 2); and Field hands V.P. Carberry and J. Ceplecha.

This group provided services to Department of Works (CDW), and other authorities. Services include feasibility, design, construction and maintenance investigations for major structures, such as dams and tunnels, and special smaller investigations.

GENERAL

The work completed in November and December 1972 is included as part of the general report for 1973; most of these projects continued into 1973. All field projects of the group, other than the Darwin Second Steam Power Station, were in the Canberra region. Geological work was closely supported as required, by the Engineering Geophysics Group.

Important aspects of the twelve-months' work were:

(a) Tunnelling: Construction of the Tuggeranong Tunnel, a six-mile sewerage tunnel continued throughout the year, and construction of the Molonglo Valley Interceptor Sewer, which includes two major tunnels, commenced in September. Geological mapping of the Tuggeranong Tunnel has confirmed the accuracy and value of seismic traverses as a means of ascertaining the extent and nature of weathered volcanic rock at depth; it has confirmed the reliability of projecting photo-lineations across to the tunnel line where they are evident as fractured and/or sheared zones; and considerable experience has been gained in the assessment of groundwater volume and movement within fractured volcanic rock.

(b) Dam site investigation: Geological investigations for the design of Googong Dam and appurtenant structures was completed in August. The recovery of oriented core from diamond-drill holes by the Craelius core orienter was of considerable value to the investigation.

(c) Urban geology: Investigations for urban development of the Tuggeranong area indicated that an area in excess of 3 square kilometres of Isabella Plains contained permanently saturated soils and constituted the largest drainage problem so far encountered in the Canberra area. A detailed investigation comprising soil augering, the setting of piezometers, permeability measurements and seismic traverses has enabled maps of the upper and lower surfaces of the aquifer, the potentiometric surface, and soil permeabilities to be compiled. A composite map was prepared to indicate the course that drainage channels should take to achieve effective drainage of the soils.

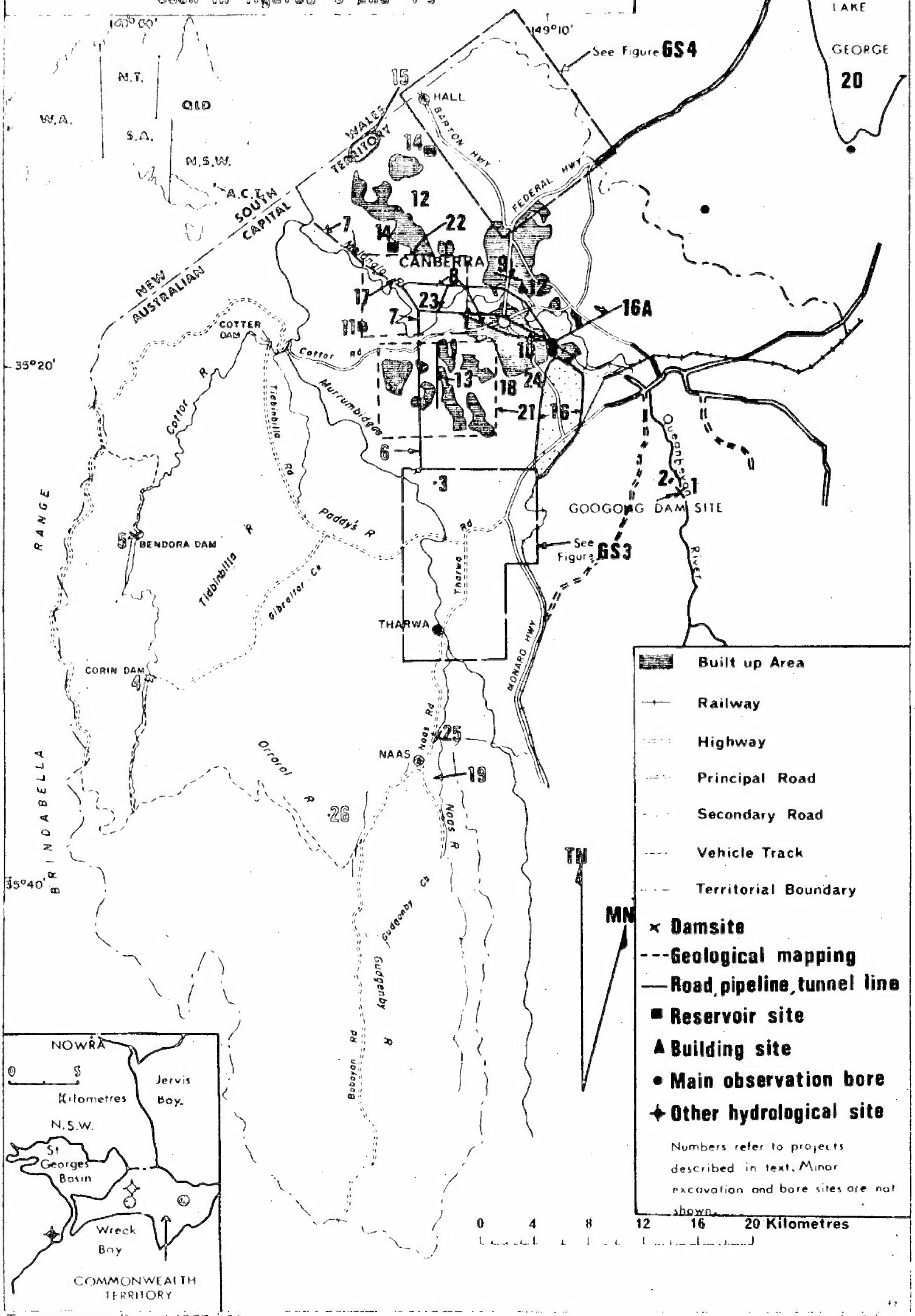
Program Amendments

A number of requests for services were received during the year that were not indicated at the time of programming. Most such requests originated with client departments and authorities who were consulted prior to planning of the 1973 program. This additional workload was mainly due to the increase in the tempo of Canberra's development and it affected all aspects of engineering geology work in the Sub-Section. Eight investigations were carried out during the year that were not written in to the original program; two were major investigations, and the others were lesser projects. Some items listed in the 1973 program have not yet been required by the client organization, so have not been commenced.

FIGURE GS1

A.C.T. ENGINEERING GEOLOGY AND HYDROLOGY INVESTIGATIONS 1973

(Investigations in Tuggeranong and Gungahlin can be seen in figures 3 and 4)



To accompany Record 1973/174

I55/A16/1085

Use of consultants

The referral of client departments and authorities to consultants for geotechnical services was recommended wherever it was known that consultants were able to carry out the project, and our staff were previously committed on other projects. Nevertheless, the Sub-Section was still called on by consultants to provide information from its records and from previous Bureau investigations. The Sub-Section was required by the client department or authority to exercise a direct supervisory role over augering and drilling contracts, and to carry out such mapping of excavations as is necessary to ensure that satisfactory records are available for subsequent contract payment discussions. The referral of work to consultants has not eased the call on our field services to any great extent, and the administrative and minor reporting role increased considerably during the year.

Staff Training

Staff training continued with attendance at the Australian Mineral Foundation courses by E.G. Wilson (Rock Fragmentation, Drilling and Blasting, and Underground Water School) and P.D. Hohnen (Site Investigation Course). P.H. Vanden Broek attended a Site Investigation Course at the A.N.U. conducted by Mr D. Stapledon; Mr D.C. Purcell attended the 13th annual ANCOLD (Australian National Committee on Large Dams) Conference and Study Tour at Bundaberg in September; and A.T. Laws and D.C. Purcell visited the Pike Head - Potts Hill pipeline tunnel in Sydney in May.

A.T. Laws delivered a lecture entitled 'Geology and Groundwater Occurrence' to 17 overseas delegates to the 1973 International Training Course in Public Health Engineering, held at the Australian National University.

P.H. Vanden Broek delivered two lectures, 'Waste Disposal and Geology' at the Canberra College of Advanced Education, and 'Engineering Geology and Road Construction' at BMR.

A.T. Laws, P.D. Hohnen and P.A. Lang attended a reading efficiency course run by the training section of the Department of Minerals and Energy.

DAMS AND APPURTENANT STRUCTURES

GOOGONG DAM SITE (G.B. Simpson, V.P. Carberry - Figure GS1, Locality 1)

The detailed geological design investigation for Googong Dam commenced in August 1972. Field investigations were completed in May 1973 and the design report was prepared as a Bureau Record, and for inclusion in the Commonwealth Department of Works (CDW) "information for tenderers" documents. The dimensions of the proposed structures are shown in Figure GS2.

A brief description of the geology of the Googong reservoir and an assessment of seismicity in the Googong area were prepared for the environmental impact statement for the Googong Water Supply Project. Construction of the dam is scheduled to commence in March 1974. The structures will be in generally sound dacite and granite.

The information from present and previous investigations has been used to assess the dam foundation conditions and necessary treatment; foundation permeabilities and grouting requirements; expected conditions along the diversion tunnel; stability of the spillway excavation and crest lining foundations; suitability and quantities of rock available from the spillway excavation for rockfill purposes; possible leakage paths from the reservoir; and the risk of seismicity in the area, both natural and induced by the filling of the reservoir.

<u>Mapping</u> Geological mapping of the dam site and spillway area was mainly concerned with the location and nature of the granite/dacite contact, sheared zones, lenses of metasediments and joint orientations. Six additional costeans were mapped and field data from the present and previous investigations were plotted on topographic plans at a scale of 1:500.

<u>Drilling</u> Sixteen diamond-drill holes, totalling 599 metres, were drilled; 3 holes along the proposed diversion tunnel route, 11 holes within the proposed spillway excavation and two groundwater observation holes on the abutments immediately downstream from the dam axis. A Craelius rock core orienter was used to obtain orientations of joints and fractures in the diamond-drill cores recovered along the diversion tunnel, spillway crest, and maximum-cut rock faces in the proposed spillway quarries.

<u>Hydrology</u> Holes drilled to test the proposed diversion tunnel, spillway crest and dam foundations were water pressure tested. Three groundwater observation bores were drilled by a BMR Mayhew rotary-percussion rig. The holes are situated in three saddles which present the shortest leakage paths from the proposed reservoir to the Queanbeyan River downstream of the dam.

<u>*GOOGONG WATER TREATMENT PLANT</u> (G.B. Simpson, P.A. Lang - Figure GS1, Locality 2)

The project requires surface excavations up to 15 m deep for clarifier tanks, filter beds, wash water and clear water storage tanks.

Seismic refraction traverses were carried out by CDW, and 10 diamond drill holes, totalling 104 m, were drilled. The treatment plant is founded on variably weathered granite, and the conditions to be expected during excavation have been assessed. A technical note is in preparation for inclusion in the "information for tenderers" documents. Construction is scheduled to commence in April 1975.

<u>TUGGERANONG TOWN CENTRE - WATER FEATURE</u> (D.C. Purcell, A.T. Laws - Figure GS1, Locality 3)

A study of the probability of leakage of water from the proposed Tuggeranong Town Centre Water Feature was carried out on

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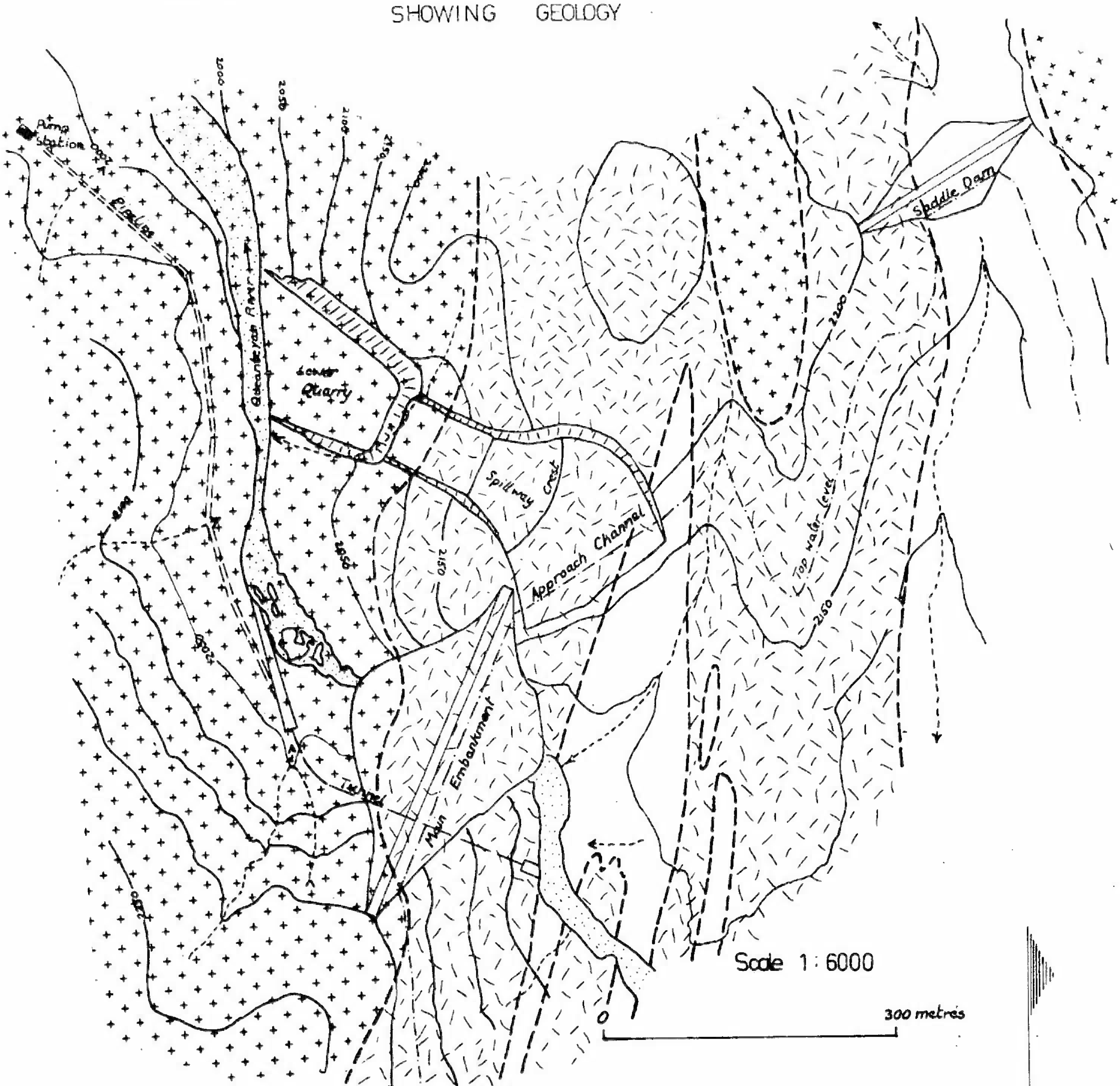
* Originally programmed for consultants, but carried out by BMR at the request of CDW.

Figure GS2

DESIGN LAYOUT OF GOOGONG DAM AND APPURTENANT STRUCTURES
SHOWING GEOLOGY



DESIGN DETAILS

Main embankment: Earth-rockfill, 60 m high, crest length 336m.

Saddle dam: Earth, 13·5m high, crest length 240 m.

Spillway: Curved free overflow crest. Crest length 124m. Max. discharge 152,000 cusecs.

Diversion tunnel: 5·0 m diameter, concrete-lined. Length 220 m.

Reservoir: Catchment area 875 km², volume of reservoir 118.6×10^6 m³

Granite | [illegible] | Metasediments

To accompany Record 1973/174

request from NCDC. Considering the known geology and hydrogeology of the area it was concluded that loss of water from the reservoir was unlikely to present any threat to either the safety of the project or to development of the western shores of the lake as a town centre.

CORIN DAM (G.A.M. Henderson, G.B. Simpson - Figure GS1, Locality 4)

The annual inspection of Corin Dam was carried out in March in company with officers from CDW, and included inspections of the spillway, valve tower and diversion tunnel. Scouring of the spillway discharge area was examined again in September and it was considered that erosion in this area would not be cause for concern in the short term future. No remedial measures were recommended, however periodic inspections will be made.

BENDORA DAM (G.A.M. Henderson, D.C. Purcell - Figure GS1, Locality 5)

An annual inspection of this dam was carried out in January and a brief report was prepared for CDW. Some leakage (estimated at about 2,500 gph) through both abutments was noted but is not considered significant.

TENNENT DAM (G.A.M. Henderson - Fig. GS1; Locality 25)

A report on the geological investigations previously carried out at Tennent Dam site was completed and issued as a Record.

SEWER LINES - TUNNELS AND PIPELINES

TUGGERANONG SEWER TUNNEL (D.C. Purcell, G.B. Simpson - Figure GS1, Locality 6)

Construction of the tunnel and appurtenant works continued throughout the year. A summary of progress appears in the table below:

DATE	PROGRESS (in feet) North heading*	South heading*	Total length excavated in year
At 31/10/72	29,170	2,250	
At 31/10/73 (estimated)	21,250	14,050	
Length excavated in year (estimated)	7,920	11,800	19,720

* Note: North portal chainage: 29,630
South portal chainage: 78

It is estimated that tunnel breakthrough will occur about March 1974.

Four pilot shafts have been sunk to tunnel invert (total length of shafts excavated is 200 metres), and work has commenced on the fifth and final shaft; its completed depth will be about 100 metres.

Full geological assistance has been given to CDW during the construction of the tunnel and its appurtenant structures. This service has included advice on the stability of all excavations and support requirements, forecasting conditions ahead of excavation faces and the recording of all significant rock defects and water inflows.

Excavation from the south (Tuggeranong) end has intersected several sheared and faulted zones requiring steel support; however most of the tunnel driven from the south portal has been through fresh, very hard and strong dacite requiring no support.

Excavation from the north (Weston Creek) end has been more difficult. The rock (dacite and rhyolite) has generally been highly weathered and in parts highly fractured and much of the heading has required steel set and extensive timber lagging support. Water inflows into this heading of up to 360,000 gallons per day have been recorded.

Special attention has been given to studies on the significance of air-photo lineations in the prediction of tunnelling conditions, and the observed correlation of rock conditions with the results of seismic refraction and magnetic surveys; in addition, the effect of tunnelling on groundwater in fractured rock aquifers is being monitored.

MOLONGLO VALLEY INTERCEPTOR SEWER (P.A. Lang - Figure GS1, Locality 7)

Construction of the Interceptor Sewer which involves the excavation of two tunnel sections, several kilometres of buried pipeline and six large bridges, began in August 1973. Full geological assistance is being provided to CDW during construction. By the end of October 1973 approximately 200 metres of tunnel in weathered dacite and about 800 metres of deep trench had been excavated; excavation for the Molonglo River bridge foundations were almost completed.

CANBERRA TRUNK SEWERS (G.A.M. Henderson, D.C. Purcell - Figure GS1, Locality 8)

On request from CDW, a preliminary geological assessment was made of three alternative sewer tunnel routes. All of the alternative routes would carry sewerage from the Fyshwick area westwards to the Molonglo Valley Interceptor Sewer.

The suitability of each route was assessed, and recommendations were made concerning the geological investigations required to fully investigate each alternative route. Two of the routes lie to the south of Lake Burley Griffin, and the third passes to the north of the lake.

CANBERRA CITY SEWERAGE SCHEME (D.C. Purcell, G.A.M. Henderson - Figure GS1, Locality 9)

On request from CDW, a geological assessment of the proposed sewer route for the augmentation of the Canberra City sewers was prepared. A report based on the geology of the area and on the results of drilling indicated the excavation problems likely to be encountered with deep trenching and tunnelling in the vicinity of roads and buildings.

FOUNDATIONS AND ROCK STABILITY

KINGSTON BUILDING SITE (G.A.M. Henderson - Figure GS1, Locality 10)

A note was prepared for NCDC on geological factors which could affect construction of multi-storied buildings on Section 28, Kingston.

STROMLO RESERVOIR (D.C. Purcell - Figure GS1, Locality 11)

Geological advice was sought by CDW during the excavation of foundations for a balancing storage reservoir on Mount Stromlo. Follow-up investigations during and after excavation enabled re-interpretation of the results of earlier geophysical and geological surveys. The difficulties of excavation encountered in this project were attributed partly to the failure to detect, by geophysical means large boulders of fresh volcanic rock in highly weathered material, and as a result, most of the rock could only be removed after extensive blasting.

CIVIC CENTRE BUILDING SITE (G.A.M. Henderson - Figure GS1, Locality 12)

A note was prepared for NCDC on geological factors affecting possible multi-storied building sites in south-east Civic area. Particular attention was given to the poor drainage and high water table in the area.

*TUGGERANONG PARKWAY (D.C. Purcell - Figure GS1, Locality 13)

On request from NCDC, a geological assessment of the stability of the deep sections of the eastern carriageway cutting was prepared. Several areas of the cutting appeared unstable and two fairly large slips had already occurred along bedding plane surfaces. Sections of the cutting that were considered unstable were outlined and remedial measures to stabilize the cutting were suggested; some recommendations were also supplied on request, concerning the stability problems likely to be encountered on the proposed western carriageway.

+DARWIN SECOND STEAM POWER STATION (A.T. Laws)

At the request of CDW, Melbourne, the Bureau provided engineering geological assistance with the site investigation for the second steam power station in Darwin. The advice included the siting of drillholes, the logging and interpretation of some of the drill core, recommendations for geophysics and other testing, and an overall assessment of the site.

The site is approximately 6 km south-east of the existing power station and is located at Quarantine Island. Near-horizontal beds of sandstone and conglomerate sandstone of the Mullaman Beds of Lower Cretaceous age unconformably overlie steeply dipping micaceous siltstone grading to phyllite of the Noltenius Formation of Lower Proterozoic age. Thin skeletal soils cover most of the area, and outcrops are few. The sandstone is moderately to highly weathered; the conglomeratic sandstone is generally moderately weathered; the siltstone/phyllite is highly to completely weathered. Major faulting has not been detected by the investigations to date.

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* Not on program: requested by NCDC for consultants

\+ Not on program: requested by CDW, Melbourne, on short notice

Recommendations were made for detailed mapping during excavation to base level, for mapping of costeans, for logging of drill cores, for laboratory and field tests, and for geophysical surveys.

An advance copy of a Record on this investigation was forwarded to CDW.

RESERVOIRS

<u>BELCONNEN 6B</u> (E.G. Wilson, Figure GS1, Locality 14) A discussion on site was held with officers of CDW on the difficulty of excavating to a fixed level in volcanic rock ranging from moderately weathered to fresh, at Belconnen reservoir 6B. The means of achieving a uniform bearing surface were also discussed.

<u>BELCONNEN 2</u> (E.G. Wilson, Figure GS1, Locality 14) At the request of CDW, and following seismic, and augering and drilling investigations, the foundation conditions likely to be encountered on excavation of a rectangular reservoir at Belconnen reservoir site 2 were compared with those likely to be met with in the construction of a group of circular reservoirs nearby.

URBAN GEOLOGY

Geology is applied to many problems associated with the planning of urban development such as the provision of engineering. Resources, water supply and drainage, severage and garbage disposal, flood control, excavations and foundations. NCDC have recognised the value of this work, and call upon the services of the Engineering Geology and Hydrology Sub-Section for general studies of the larger urban areas such as Tuggeranong, and for the more detailed localized investigations of areas with special problems such as drainage of Isabella Plains, or areas for special use such as Tuggeranong Town Centre. The following projects in urban geology were requested by NCDC for their own use or for use by their consultants.

<u>TUGGERANONG URBAN DEVELOPMENT</u> (Figure GS 3)

The study of the Tuggeranong Urban Development Area, which was commenced 1972 was completed this year. The investigation of the geology, soils and hydrology of the area laid down a framework of design constraints within which urban development could proceed, and ensured that more detailed work was carried out in several areas with special problems before development, or in some cases, planning could proceed. These areas were the proposed Tuggeranong Town Centre, Isabella Plains and the Lanyon area. A Record on the general feasibility report for the Tuggeranong area is in preparation; it contains 6 geological, hydrological and geotechnical maps of the Tuggeranong area.

*<u>Isabella Plains Drainage and Permeability Investigations</u> (A.T. Laws, J.R. Kellett, C. Madden - Figure GS3)

Following the initial investigation carried out by P. Vanden Broek in 1972, NCDC requested additional data on permeabilities and on the most effective locations for drainage channels on Isabella Plains; the investigation was planned to complement drainage design investigations by consultant engineers.

Fifty auger holes were drilled and twenty seven piezometers were established. Undisturbed soil sampling was attempted in all holes using a thin-wall sampling tube which was driven to refusal. The holes were continued to completely weathered bedrock by conventional augering.

Permeability tests were carried out on thirty four piezometers. In low permeability areas the method of analysis was the Ernst Auger Hole method; in areas of high permeability and larger water flows analysis by the Theis Recovery Method was applied. Results from the methods compared favourably when both were applied to the same hole. Permeabilities ranged from 13 metres/day to 0.01 metres/day, and constant flows of up to 81 m^3/day were obtained. Inflections in the linear-logarithmic plots of the results could be attributed to one or more of the following causes: delayed yield from storage, the existence of 'privileged' layers, and surface recharge. Mounds in the groundwater contours indicate that the stream is influent in parts of the channel.

From a composite data map it has been possible to delineate a zone in which the drainage channels should be set for optimium efficiency.

A Record is in preparation entitled "Isabella Plains ACT, permeability and drainage investigations 1973" by A.T. Laws and J.R. Kellett.

<u>Lanyon Planning Constraints</u> (A.T. Laws - Figure GS3)

Additional groundwater and drainage, and soil, investigations were carried out on Lanyon whenever access to the area could be arranged. Five rotary drilled observation bores were drilled on Lanyon; all bores intersecting water and the water levels recorded necessitated only minor alterations to the groundwater contour map prepared for the Tuggeranong feasibility report.

<u>Tuggeranong Town Centre</u> (P. Vanden Broek - Figure GS3)

A detailed geotechnical investigation of the area designated to be the Tuggeranong Town Centre is in progress to determine the geological constraints to planning, such as foundation and excavation characteristics, groundwater and drainage, and leakage from the proposed Tuggeranong lake.

Investigations for Stage 1 of the town centre were completed early in the year; the report setting out results of the geological outcrop mapping and soils augering was forwarded to NCDC and was subsequently issued as BMR Record 1973/100 'Engineering Geology of the Tuggeranong Town Centre ACT - Stage 1' by P. Vanden Broek.

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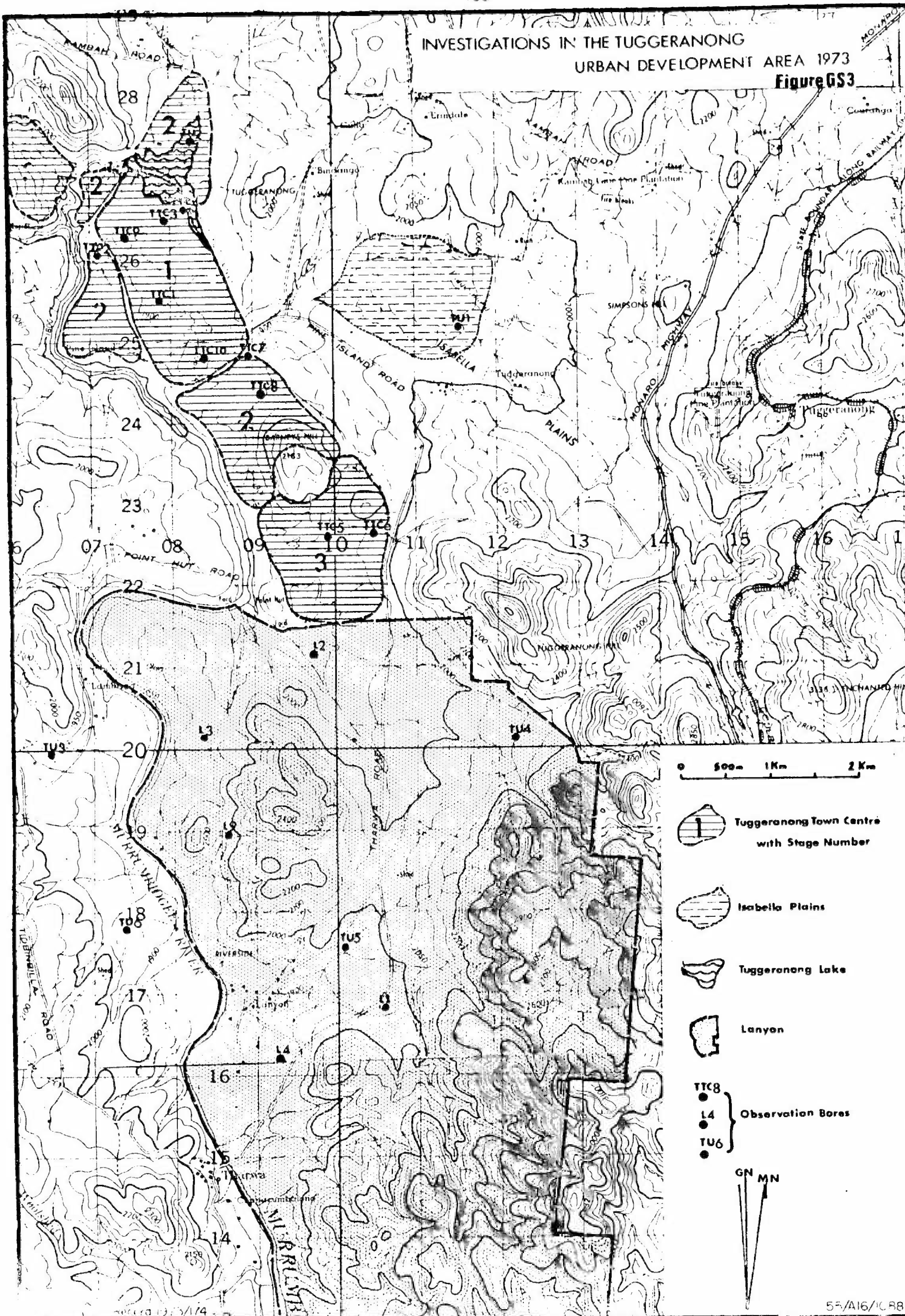
* Not on program: urgent request by NCDC following Tuggeranong progress report.


INVESTIGATIONS IN THE TUGGERANONG
URBAN DEVELOPMENT AREA 1973
Figure GS3
0 500m 1Km 2Km
Tuggeranong Town Centre with Stage Number
Isabella Plains
Tuggeranong Lake
Lanyon
TTC8
L4
TU6
Observation Bores
GN MN
KAMBAH ROAD
PINE ISLAND ROAD
ISABELLA PLAINS
MONARO HIGHWAY
POINT HUT ROAD
THARWA ROAD
TUGGERANONG HILL
SIMPSONS HILL
MURRUMBIDGEE RIVER
TIDBINBILLA ROAD
Tharwa
Lanyon
Tuggeranong
Erindale
Riverside

Ten bore holes have since been drilled in Tuggeranong Town Centre, as part of the rotary drilling contract, to assess groundwater conditions. They were completed as groundwater observation bores and the waterlevels are regularly recorded.

Outcrop mapping for Stage II of the investigation is continuing and soils augering should commence shortly.

GUNGAHLIN URBAN DEVELOPMENT (P.D. Hohnen, J.R. Kellett, G.W.R. Barnes - Figure GS4)

The general urban development study of Gungahlin was completed in March and maps at 1:25 000 scale showing geology, slope categories, hydrology, natural resources, soils and geological constraints upon design were delivered to NCDC.

The report indicated two main problem areas in the Halls Creek area and the northern region of Gungahlin. Detailed studies of these two areas were requested by NCDC. Advance copies of a Record to be titled "Engineering geology of the proposed urban development area at Halls Creek, Gungahlin District A.C.T." by P.D. Hohnen, were delivered to NCDC in September. This Record contains sections and maps at 1:9600 scale of soils and geological constraints upon design (poor drainage and low bearing strengths of slopewash) and a 1:5000 scale outcrop geological map showing degree of weathering of exposed rock and location of potential engineering resources.

A separate Record is being prepared for the north Gungahlin area and will be completed in November; the problems are shallow depths to moderately weathered rock and poorly drained humic gley soils of very low bearing strength.

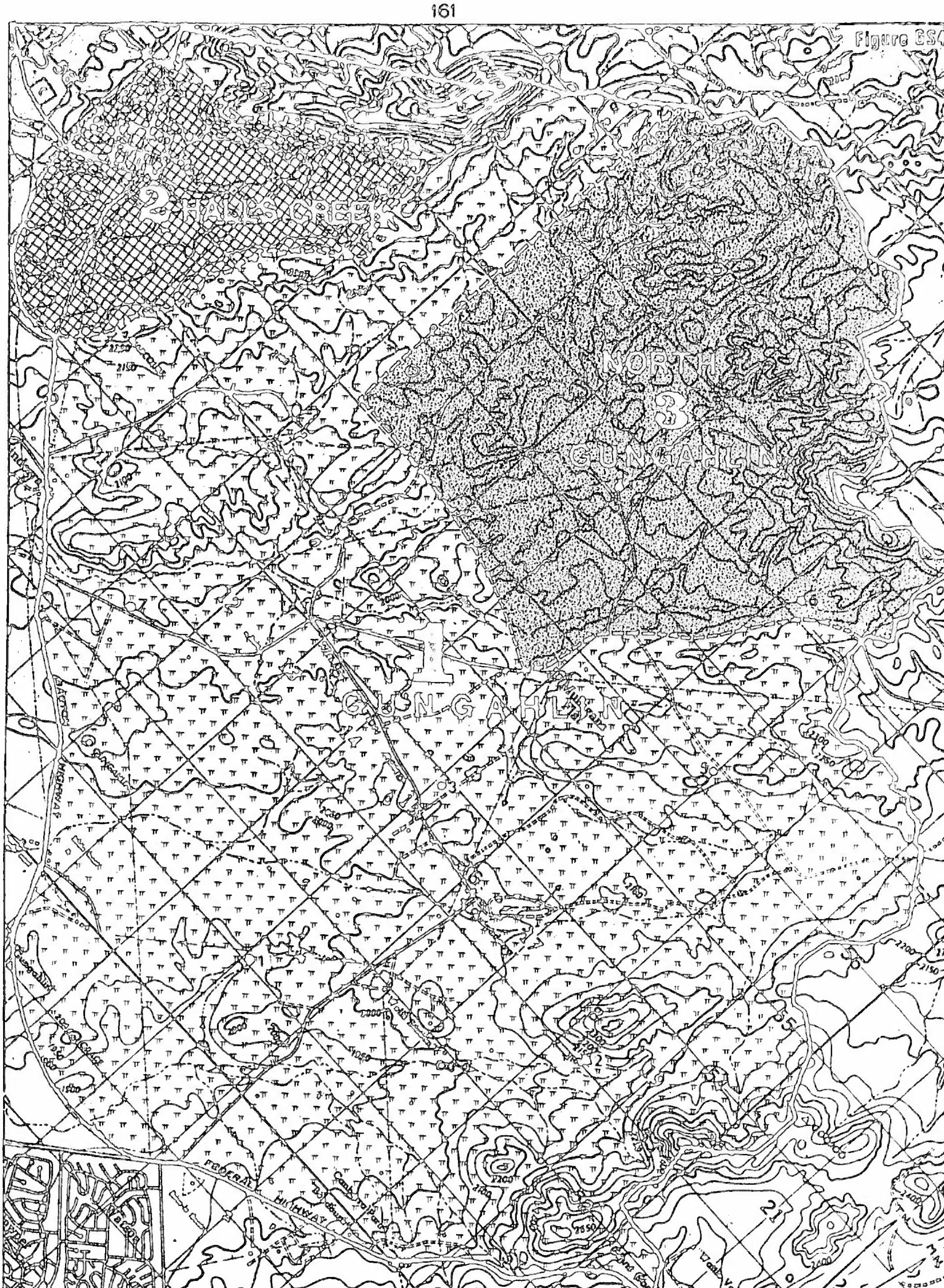
BELCONNEN WEST INDUSTRIAL ESTATE (P.H. Vanden Broek - Figure GS1, Locality 15)

The Bureau was asked to investigate subsurface conditions in the area designated to be the Belconnen West Industrial Estate, with particular emphasis to be placed on the foundation and excavation conditions, groundwater and drainage problems, and any other geological constraints to planning.

The area is underlain by weathered Silurian rhyodacites and rhyolites of the Deakin Volcanics, and a rhyodacite porphyry, and is traversed by two major faults, Gooromon and Deakin Faults.

Results of power augering over part of the area were used in conjunction with observable soil profiles and air-photo interpretation to assess foundation conditions, soil depths and drainage characteristics.

No major groundwater, foundation, or excavation problems are expected in the development of the area as an industrial estate. A Record, 73/165 "Geotechnical Investigations of the Proposed Belconnen West Industrial Estate", by P. Vanden Broek, has been issued.



ENGINEERING GEOLOGY STUDIES FOR URBAN DEVELOPMENT OF GUNGAHLIN A.C.T.

1-7 BMR observation bores drilled in 1973. 1 -Gungahlin general feasibility study. 2,3-Detailed studies.

To accompany Record 1973/174

I55/A16/1089

JERRABOMBERRA INDUSTRIAL ESTATE (P.D. Hohnen, J.R. Kellett - Figure GS1, Locality 16)

A "superficial deposits map" at a scale of 1:25 000 was prepared from colour air photography and undisturbed augering, for NCDC consultants, Scott and Furphy (Engineers) Pty Ltd. A potential drainage and foundation problem due to saturated organic clays was delineated.

JERRABOMBERRA RECLAMATION PROJECT (P.D. Hohnen, Student J. Coplecha - Figure GS1, Locality 16A)

A short technical note on the Jerrabomberra reclamation area indicated that permeable materials in the area could provide a means by which refuse leachate could enter Lake Burley Griffin if dumping were extended to that area.

°MOLONGLO VALLEY LAND USE STUDY (G.A.M. Henderson - Figure GS1, Locality 17)

A report was prepared outlining the constraints of a geological nature likely to affect land use in the lower Molonglo Valley area. A terrain evaluationmap and a resources map showing these geological features worth preserving were included in the report.

ISAACS DEVELOPMENT (G.A.M. Henderson - Figure GS1, Locality 18)

A geological appraisal of the site for the proposed suburb of Isaacs was carried out. The investigations included detailed mapping, a seismic survey and supervision of an augering contract. A detailed report on the investigations is in preparation.

+NAAS TOPSOIL INVESTIGATION (J.R. Kellett - Figure GS1, Locality 19)

The Department of Capital Territory (DCT) requested BMR to investigate "top soil" deposits on the former block H423, Booth District, A.C.T., which will be inundated if Tennent Dam is constructed. The deposits were located from airphotographs and were sampled by hand-augering. The sand forms depositional terraces and channel bar wedges of the Naas and Gudgenby Rivers. Indicated reserves are 170,000 cubic metres, of which 95,000 cubic metres were classified as "high grade" humic loam; the remainder was of lesser quality due to textural and structural variation. These deposits will replace the exhausted Tharwa workings as the principal source of topsoil for southern Tuggeranong. A BMR Record entitled "Topsoil Deposits on H423 Booth ACT", by J.R. Kellett, is in preparation.

TERRAIN EVALUATION STUDY - CANBERRA REGION (G.A.M. Henderson)

Fieldwork for the joint CSIRO-BMR terrain evaluation study of 1000 square miles of the Canberra region was completed by CSIRO early in 1973, and a map of the terrain regions was compiled by CSIRO for fair drawing by BMR. The geological province mapping which provides the basis for terrain evaluation was revised by BMR to place more value

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° Not on program: special request by NCDC

+ Not on program: special request by DCT on lithology rather than on formally named geological groups and formations, and CSIRO compiled a draft description of all terrain patterns and units. A joint draft on engineering properties of the various terrain patterns is almost complete, and the final draft of text and map is now being put together for publication early in 1974.

HYDROLOGY

OBSERVATION BORES (A.T. Laws, P.D. Hohnen, P. Vanden Broek, R. Abell, A.W. Schuett)

Monitoring of water levels in the network of observation bores in the ACT was carried out by technical staff. Water levels were generally higher than those for the corresponding period last year (1972), and were caused by the wet winter and early spring in the ACT this year.

Observation bore B5 was 'lost' this year during land servicing of one of the Belconnen suburbs but the network was increased considerably by observation bores drilled for special projects. Approximately 100 observation bores and piezometers are currently being monitored within the ACT. Special observation bores were drilled this year at Lanyon (5) Gungahlin (7) Tuggeranong Town Centre (11) Isabella Plains (50 augerholes), Lake Ginninderra (4) and Googong Damsite (3). The bores drilled at Lanyon, Gungahlin and Tuggeranong Town Centre were part of a rotary drilling contract supervised by BMR for NCDC.

The observations from these bores provide the basic information for constructing ground water contours for areas under investigation for urban development.

The following report was issued as BMR Record 1967/93
BURTON, G.M.: Recharge conditions and siting of bores in fractured-rock aquifers of the A.C.T.

BORE SITING FOR LANDHOLDERS AND GOVERNMENT AUTHORITIES

Numerous requests were received for advice and assistance in the selection of waterbore sites for landholders, prospective landholders and government authorities. Some of the requests were for sites within the ACT, others for sites in New South Wales.

By agreement with the Water Conservation and Irrigation Commission of New South Wales, the Bureau has been siting bores in areas of NSW adjacent to the A.C.T.; however, the requests are increasing and the services of R.S. Abell of the Sedimentary Basins Section were made available for the siting of some bores. Delays of up to three months in the siting of bores have occurred during the year. Twelve requests for assistance by siting bores resulted in the selection of 27 sites, of which only one was drilled and it was successful. Advice on general groundwater problems was given to nine landholders and developers, and advice was given to an officer of the Department of the Northern Territory on the availability of groundwater in the Katherine and Alice Springs areas.

LAKE GEORGE (A.U. Schuett, A.T. Laws and E.G. Wilson - Figure GS1, Locality 20)

The establishment of bench marks by the Survey Branch of the Department of Property and Services at the three lowest points on the watershed of the Lake George inland drainage basin has proved that Geary's Gap is the lowest point, 708.04 m above sea level, with Milbank Gap to the north at 746.28 m and Halfway Gap to the south at 755.51 m. The highest level of Brooks Creek gravels was also fixed at 764.69 m.

The Survey Branch also completed a number of traverses across the lake bed, taking advantage of the water levels of less than one metre, and compared them with the recomputed survey of N.S.W. Department of Works of 1902. Little change in lake bed levels were found, but changes in beach features ranging to more than 0.3 m were found in some places. A new bench mark for measurement of lake waterlevels was set at Rocky Point at 677.66 m.

Measurements of water level, water temperature and conductivity were taken at monthly intervals, and chemical analyses of water samples were made every six months. The water level fell to its lowest point since the lake was filled in 1949, 0.591 m on 2 July covering about 4290 hectares with a salt content of about 30 000 parts per million (ppm). Since 1 July, winter and spring rains have contributed 1208 points, and the water level on 30 October was 0.866 m. Water in the lake has been unfit for consumption by sheep or cattle, or for agricultural purposes throughout the whole year, except around the margin of the lake when fresh water is draining into the lake following heavy rain.

The following reports on Lake George were issued as BMR Records:
BURTON, G.M.: Lake George, N.S.W. - Notes for sedimentologists excursion, November 1970 - BMR Record 1972/79.
BURTON, G.M., and WILSON, E.G.: Lake George, N.S.W.: Its relevance to salinity problems in agriculture - BMR Record 1973/166.

DRILLING CONTRACTS (A.T. Laws)

Laws prepared specifications on behalf of NCDC for rotary drilling in the Tuggeranong and Gungahlin areas, and for auger drilling in the Isabella Plains region. The contracts were let and financed by NCDC and supervised by BMR.

The rotary drilling contract called for 3000 feet of drilling to be completed within a period of 10 weeks; this was successfully completed within the time period and at less than the estimated cost. The auger contract called for up to 800 feet of coring and the establishment of piezometers; it was also successfully completed within the time period but exceeded the estimated cost by 1%.

Details of and results from the rotary drilling contract will appear in the Record 'Contract rotary drilling program A.C.T. 1973' by A.T. Laws, P. Hohnen, P. Vanden Broek, and G. Barnes (in preparation). Those from the augering contract will appear in the Record "Isabella Plains ACT, permeability and drainage investigations 1973' by A.T. Laws and J.R. Kellett.

GEOLOGICAL MAPPING

CANBERRA 1:50 000 SHEET (G.A.M. Henderson)

Notes written before publication of the Canberra 1:50 000 sheet were revised and brought out as a Record; they form a supplement to the published explanatory notes.

CAPITAL HILL AREA (G.A.M. Henderson)

A Record was produced on the geology of the Capital Hill area presenting data from the excavations for the Capital Hill ring roads, and a revised interpretation of the stratigraphy of the area was outlined.

WODEN-WESTON CREEK (G.A.M. Henderson - Figure GS1, Locality 21)

Notes were written for a report on the geology of the Woden-Weston Creek area. Maps which had been prepared previously were revised to include more recent outcrop and excavation mapping.

ENGINEERING GEOLOGICAL SHEETS (G.A.M. Henderson)

Preliminary 1:10 000 scale topographic maps were used as base maps for compiling engineering geological data in the Coppins Crossing (Locality 22) and Woden-Weston Creek (Locality 21) areas. Information shown includes auger holes, diamond-drill holes, seismic traverses and localities of samples gathered for thin section examination as well as other geological data. The geological information was derived from detailed outcrop mapping at a scale of 1 inch:200 feet (1:2400) carried out by the engineering geology sub-section with the assistance of vacation students. Some field checking was done during compilation to resolve inconsistencies on the field sheets, and to gather information in critical areas.

CITY AND BELCONNEN AREAS (G.A.M. Henderson)

The 1:9600 geological map of Belconnen compiled in previous years was amended to conform with new data from excavations and with revised interpretation of rock relationships. Maps at scale 1 inch: ¼ mile (1:15 840) covering other parts of Belconnen were also revised for preparation as Records. Major excavations for roads in Southwell's Ridge and south of the College of Advanced Education were mapped.

The 1:4800 scale geological map of the Civic Centre area was brought up to date with new information from excavations for the Canberra School of Music building and the extensions to the Canberra Club. Information from augering for a proposed pipeline along Rudd and Bunda Streets was also added.

An excavation at the Department of Overseas Trade building site was mapped. Limestone with cavities had been found in one corner of the site when it was drilled, and a limestone boulder was found in the same area in the excavation, but no cavities were seen.

MISCELLANEOUS

CANBERRA CITY EXCURSION NOTES (G.A.M. Henderson)

The text of a pamphlet on interesting geological outcrops in the Canberra City area, originally published for the Open Day in 1971 was revised for a second edition.

*MOLONGLO FREEWAY - QUARRY SITES (D.C. Purcell - Figure GS1, Locality 23)

On request from NCDC four quarry sites were evaluated for rock material suitable for lake fill for the proposed Molonglo Freeway along the southern part of Black Mountain. Recommendations as to the most suitable site were made.

POSSIBLE QUARRY SITES WITHIN THE MUGGA MUGGA PORPHYRY (G.A.M. Henderson - Figure GS1, Locality 24)

Following a request from NCDC a geological assessment of areas suitable for future quarrying within the Mugga Mugga Porphyry was carried out. Several potential sites within the porphyry were outlined; another, but less favourable site in the Deakin Volcanics was also discussed.

RURAL ROADS GRAVEL INVESTIGATIONS (P. Hohnen, P. Lang)

Reports on gravel investigations in the Pierces Creek - Paddys River area, the Mt McDonald area and the Uriarra Crossing area were ready for final edit by Record editors by the end of the year.

FOREIGN STUDENT TRAINING

In co-operation with the Department of Foreign Affairs, specialist training in engineering geology and hydrogeology was arranged at the Bureau and other Australian geological organizations for Mr J. Elifas of the Indonesian Geological Survey for a period of eight months.

A student from Austria, Franz Klemm worked with the Sub-section for a month as a field hand under the scheme for overseas students on working vacations in Australia.

ORRORAL VALLEY - LUNAR LASER RANGER SITE (A. Laws, G. Barnes - Fig. GS1; Locality 26)

At the request of the Division of National Mapping, three possible sites for the location of a lunar laser ranger were investigated in the Orroral Valley. Two sites are in the valley near the Tracking Station and the third is on the crest of the ridge to the southwest of the valley and alongside the collimation tower.

Four shallow holes were drilled to test foundation conditions. Only one hole intersected fresh rock (at 7 m), the others remained in completely weathered granodiorite. Groundwater was struck in three of the four holes.

It is considered that the sites in the Valley would be generally unsuitable for the lunar laser ranger, owing to the completely weathered rock and excessive groundwater in the valley.

* Not on program: request by NCDC on behalf of consultants.

No drilling was undertaken at the Collimation tower site because of lack of access for the drilling rig.

Geophysical testing indicated this site to be the most suitable.

ENGINEERING GEOLOGY COMPUTING (A.W. Schuett)

Metric Conversion

The following programs have been converted to metric, and conversion of the other five programs currently in use is in hand.

1. Observation bore records
2. Yarralumla meteorology records
3. Lake George records

Additional conversions to metric will be required as other metric changes come into use e.g. change in rainfall measurement from points to mm comes into use 1st January 1974.

3600 Conversion to Cyber 76

The conversion to Cyber 76 is complete for the 3 programs mentioned above and for Observation Bores Jervis Bay; conversion to Cyber 76 is in progress for the Chemical Analysis records, and Googong waterlevels. Conversion has not yet commenced on the Lake Burley Griffin and Lake Bores programs.

MINOR REPORTS AND TECHNICAL NOTES

The following minor reports and technical notes were prepared during the year.

1. Chemical waste disposal: Wells Station quarry
2. Brief note on brick shale deposit, Queanbeyan, N.S.W.
3. Brief note on brick shale deposits, Gungahlin, A.C.T.
4. Assessment of rocks for aggregate, Williamsdale, A.C.T.
5. Outline of method of investigation for East Basin sand deposit.
6. Geological brief on Tanzania for Australian aid to Tanzania's rural water program.
7. Report on the location of weir on the Queanbeyan River, downstream from Googong Dam site.
8. Report on drainage problem, Ainslie, A.C.T.

MAP EDITING AND COMPILATION

by

G.W. D'Addario

STAFF: G.W. D'Addario, W.D. Palfreyman, D.J. Grainger (resigned in December, 1972), J.M. Fetherston (to 4th June), Miss J.W. Wedgbrow.

GENERAL

A Map Committee meeting was held in February 1973; another will be convened in November. G.W. D'Addario attended a meeting of the Automated Cartography Study Group in September and an Efficient Reading course, conducted by the Training Section of the Department of Minerals and Energy in February. W.D. Palfreyman attended in May the Tasman Geosyncline Symposium in Brisbane. Field geologists were given training in map editing to improve the preparation of maps. Advice was given to authors on various aspects of map compilation during preparation of preliminary editions of the 1:250 000 geological series and special maps.

EDITING

Nine special maps (two at 1:50 000 scale, six at 1:1 000 000 and one at 1:2 500 000) and twelve final edition maps of the 1:250 000 Geological Series were edited and checked against the draft Explanatory Notes during the year and editing for four 1:250 000 maps and notes is in progress.

COMPILATION

Geology of the Northern Territory Scale 1:2 500 000 (G.W. D'Addario)

1972 field data were incorporated in the map. Drawing of the pre-Cainozoic map and final colour guide was completed. The map was edited, assembled and negatives sent to the printer in September for printing of the preliminary edition: it was issued at the end of October. Drawing of the Cainozoic screen plate for the coloured editions was completed and a colour guide made. The plate was also edited. Notes to accompany the map are being written.

Papua New Guinea Mineral Deposits Map. Scale 1:2 500 000 (D.J. Grainger, R.L. Grainger, authors, W. Palfreyman)

Comments on the map and notes were received from the Geological Survey of PNG and corrections were made to both. The map is now with the printer and the notes, which are to appear as a Bulletin, have been edited.

Geological Map of Australia. Scale 1:2 500 000 (W.D. Palfreyman, E.K. Carter)

Compilation of the draft reference was commenced. Publication of the map in time for the 1976 International Geological Congress is planned.

Geological Map of Papua New Guinea. Scale 1:2 500 000 (G.W. D'Addario, D.B. Dow (BMR); S.K. Skwarko (GSPNG))

Preparation of compilation material was commenced. Preliminary discussion on the draft reference was held.

Review of Standard and Geomorphological Symbols (G.W. D'Addario, W.D. Palfreyman)

W.D. Palfreyman reviewed and compiled a list of the suggested changes from some of the State Geological Surveys.

Author's Corrections

1:250 000 Geological Series (J.M. Wedgbrow)

Drafting of corrections was completed on nine maps and new colour guides were made for three of them.

INDEXES, TECHNICAL FILES AND MINERAL REPORTS

by

B. Hall & J.A. Ingram

STAFF

J.A. Ingram, B. Hall, R. Towner (until March), K. Summers part-time (March to October) M. Shackleton part-time (from April), K. Modrak part-time (from July), N. Knight (from October). Administrative supervision of the group was provided by W.D. Palfreyman.

STRATIGRAPHIC INDEX

Literature received in the Bureau library was checked for stratigraphic names. New names were added to the Central Register of Stratigraphic Names and all references to previously published names were noted in the stratigraphic index held in Room 301.

Bimonthly variation lists, giving additions to the Central Register, were compiled and sent to State Geological Surveys, Universities and interested companies.

Proposed new names, generally submitted by authors, were checked against the Register and, where appropriate, were reserved for the enquirer's use.

Publications were indexed by author, 1:250 000 sheet areas, Basin names and by broad subject headings. Copies of the index cards were sent to the Library. Duplicates were also sent to State Geological Suveys and the Basin Study Group.

A meeting of the Stratigraphic Nomenclature Committee was held on 22 August 1973. The group assisted Dr Carter, Convener, in preparing the agenda and minutes for this meeting and in writing reports for the Geological Society of Australia.

The manuscript of Volume 5h - Australia, General - of the International Stratigraphic Lexicon was sent to Paris in March 1973 for printing by the International Stratigraphic Commission; it is now with the printer.

Papers to be published by the Australasian Institute of Mining and Metallurgy in the four-volume "Economic Geology of Australia and Papua New Guinea" were, and are still being, submitted to the Stratigraphic Indexers by the Institute's editor-in-chief for checking of stratigraphic names used in the papers. Part of this work is being done under contract by Mrs L.E. Walraven.

TECHNICAL FILES

Filing of unpublished data and newspaper clippings by 1:250 000 Sheet area continued. Many registry files were searched for technical information.

Enquiries from Bureau officers and visitors were answered from the information contained in the various indexes and filing systems.

MINERAL INDEX

As time allowed, officers of the group edited and checked the typing of the old pre-1950 mineral index arranged by commodity and locality. When typing is completed this index will be published. About one-third of the cards have been typed during the year.

A bibliographic index to current literature on mineral deposits (arranged by commodity and State) has been maintained throughout the year. In addition a card index of major mineral deposits is kept, showing grades and sizes of orebodies.

MINERAL REPORTS (J.A. Ingram)

Mineral resources reports on bauxite, nickel and phosphate deposits were revised for publication. A report on uranium deposits is nearly complete and one on tin deposits is being prepared. These reports are compiled with the co-operation of State Mines Departments and mining companies.

During the year field visits were made to some nickel deposits in Western Australia and tin deposits in the Northern Territory, in order to gain first-hand knowledge of their geological environments.

Visits were also made to the State Mines Departments to find out the nature and scope of mineral indexing with a view to further co-ordination and co-operation in this field between the State and Federal organisations, to make any system we might introduce compatible with existing State indexes.

MUSEUM AND TRANSIT ROOM

by

D.H. McColl

MUSEUM

Staff: D.H. McColl, G.C. Young (part-time), A. Haupt (transferred to Palaeontology section in January), L. Aldridge (temp. until March), J. Falla (temp. since June), M. Tighe (temp. June, July), J. Reid (since October).

Museum Collections and Displays

The museum staff has continued the policy of emphasizing the national character of our specimen collections while developing readily available extensive reference groups of those materials in most common demand. Space limitations necessitate that the bulk of the collections be kept at the Fyshwick rock store.

Reorganization of the mineral collections was commenced during this year with the object of computerising the catalogue and indexing into a single reference system. Over 3,000 specimens have been added to the register during the year, and about half of these coded for computer processing.

Descriptive mineralogical investigations of stored and collected specimens have been undertaken in conjunction with other Bureau personnel as opportunity permitted, and some brief papers are being prepared. A paper on the occurrence of raspite from the Cordillera mine, N.S.W. was issued as Record 1973/152 and submitted for publication in the Mineralogical Record.

Collections of Australian metallic and non-metallic ores were prepared for display by the Australian High Commission in New Delhi, India. A similar set and a fluorescent mineral display were sent for a trade fair in Vientianne, Laos.

Amongst the considerable new material added to our collections was a representative set of the oxidised ores and primary and supergene sulphide ores from the Woodlawn deposit near Tarago, N.S.W. Another exceptional specimen purchased for the collections was a large well-crystallized group of the mineral scholzite from Reaphook Hill in South Australia. This is the only locality from which this material is available in the world today.

Rock Storage and Registration

Two units of compactus shelving have been constructed at the Fyshwick rock store and a third is proposed for the coming year. This has entailed much moving of the boxed survey collections and a degree of consequent temporary disorganization. During this period the opportunity was taken to revise and cull the reference samples which have been retained from isotopic age determinations, with a very considerable saving of storage space. Newly registered field samples and other collections contributed by Bureau parties total approximately 8,000 specimens which are stored in 210 new boxes.

Commonwealth Palaeontological Collection

All the available type specimens have been systematically collated and stored in the strongroom security storage. Both macro- and micro-fossil types are therefore now readily accessible for reference.

Exchange and Loan of Specimens

Loans of museum rocks, fossils and thin sections were arranged for museums, universities or geological surveys in Washington, Warsaw, Brisbane, Sydney, Melbourne and Canberra.

Mineral and rock exchanges have been carried out with other Australian institutions and specimen dealers to obtain material not previously represented in our collections. This has been made possible by the collection or sorting of a small collection of duplicates.

Educational and School Collections

The sets of rocks and ores used in the geology training course for BMR technical staff have been expanded and improved, to be available for any public relations work inside or outside the Bureau; they are constantly being used in various arrangements.

Displays of various kinds have been staged in the Museum for eleven visiting classes from Canberra Schools and two from Sydney. Where teachers indicated a particular interest or project on which their students were engaged, special displays were arranged.

As well as the schools, we assisted the Canberra Gem Society, the College of Advanced Education, Queanbeyan Rotary International, Reid Presbyterian Fellowship, the Women's International Club and the Embassies of Indonesia and the United States.

Field Work

D. McColl visited Rum Jungle, Mount Isa, Broken Hill and Kimba for a few days each, collecting suites and duplicates of several mineral assemblages of unique character and considerable value. New displays utilizing these materials are on show in the corridors and foyer of the Bureau. Visits in connection with museum interests were also made to Sydney, Melbourne, Adelaide and Port Lincoln.

G. Young was engaged for six weeks in May-June collecting Devonian fish fossils in the Amadeus Basin. The formations investigated were the Ordovician Stairways Sandstone and the Mereenie Sandstone and the Pertnjara Group of Siluro-Devonian age, from which abundant well-preserved material was collected.

Visitors to the Museum

This has been a record year for public visitors to the museum. Three hundred and fifty seven adults and a similar number of children attended, the latter mainly in school groups. Many brought specimens to be identified or came seeking information, particularly about the local geology. Gemmological enquiries were common; differentiation of natural and synthetic facetted stones was often sought.

In addition, there were many enquiries from Bureau personnel or official visitors, most of which were concerned with sample storage and the related data retrieval system.

TRANSIT ROOM

Samples requiring petrological, petrographic, chemical, or radio-isotopic age investigations are forwarded to contractors by the officer in charge (C. Modrak). The total number of samples processed this year was 8,775, which is made up as follows,

Thin section preparations	-	4,655
Polished section preparations	-	32
Polished thin section preparations	-	111
Radio-isotope age determinations	-	275
Various chemical analyses	-	3,702

Systematic storage and cataloguing of petrological thin sections has also been continued so that 10,000 slides are now in the collection, from which loans are made intermittently to interested institutions.

Liaison continues between the transit room and museum by way of the standardised computer-compatible sample submission system and indexing. Full benefit of this system will only become apparent when the data are computerised.

GEOLOGICAL DRAWING OFFICE

by

H.F. Boltz and P.A. Boekenstein

H.F. Boltz, representing the Bureau, attended two meetings of the Cartography Advisory Committee which is concerned with setting up a degree course in Cartography at the Canberra College of Advanced Education.

H.F. Boltz and P.A. Boekenstein attended four meetings of the Division of National Mapping-BMR Committee during the last year. This Committee was formed in 1971 and quarterly meetings are held to plan and co-ordinate programs to ensure that air photographs, ortho photomaps, compilations and fair drawn topographic bases are available when needed.

Highlight of map production was the publication of the geological map of Papua and New Guinea at 1:1 000 000 scale in four sheets. In addition to geological formations the map shows volcanic centres, mineral occurrences, oil and gas wells and basement contours. Compilation commenced in February 1971, and final colour copies were received in May 1973.

Four draftsmen worked in the field as members of geological parties: Miss D.M. Pillinger, Georgetown Party; M. Little, Mount Isa-Cloncurry Party; D. Walton, N.E. Canning Basin party; J. Mifsud, Tantangara and Westmoreland parties. P. Fuchs (based at Darwin) continued work on the compilation of data from the Alligator River party.

M. Nancarrow, Supervising Draftsman, visited BMR geological field parties (N.E. Canning; Mount Isa-Cloncurry; Westmoreland) in a supervisory and liaison capacity, to assess drafting progress, contribution of draftsmen to field geological program, and facilities available for draftsmen in geological camps. He also visited the Darwin office to check and edit compilation data, and investigate the backlog in compilation of 1972 field data.

In May, E. Feeken, Senior Draftsman, visited R. Collie & Co. Pty Ltd, Melbourne, and discussed and resolved printing ink problems connected with the revised BMR Standard Colour Scheme. Preparations are now being made for the production of a new colour chart. In June he prepared, and had approved by the Chief Geologist, a new layout for the published 1:100 000 series geological maps. Typography is presently being considered.

H. Hennig, Supervising Draftsman, undertook a private overseas visit early this year to the following cartographic firms and institutes to study current European map reproduction techniques:

Bertelsmann Publishing Co.
Geological Survey of the Federal Republic of Germany
Dr F. Hölzel, specialising in design of block diagrams
Cartographic Institute Schaffmann & Kluge, Berlin
Institute of Applied Geodesy, Frankfurt
Geological Commission, Basle, Switzerland

Details of the visits are reported in BMR Record 73/155.

J.E. Zawartko, Photographer-in-Charge, visited geological parties in the Alligator River, Cape York and Weipa areas during August to photograph field activities.

Joaf Buloiloi and Peter Eno, Drafting Assistants with the Geological Survey of Papua New Guinea, were awarded Commonwealth Practical Training Scheme fellowships of four months duration to study geological drafting with the Geological Drawing office. They arrived in Canberra on 4 December 1972 and returned to Papua New Guinea on 31 March, 1973.

The seventh BMR "in house" course in basic geology was conducted between March and August by M. Nancarrow. Technical, drafting and clerical staff attended.

Production (M. Nancarrow, K. Matveev, H. Hennig, R. Molloy)

1) Preliminary Edition Maps	1:100 000	1:250 000	Other scales
Printed:	1	36	4
Drafting in progress:	1	10	1

2) Field compilation bases (various scales); 85

3) 1st or 2nd Edition Maps	1:250 000	Other scales
Printed:	14	3
Printing in progress:	15	6
Fairdrawn	13	8
Fair drawing in progress:	8	4
Compilation completed:	-	3
Compilation in progress:	-	4
Reprinted:	6	1
Reprinting in progress:	4	-
	Total	89

4) Text figures or diagrams	Completed	In progress
1) Records and miscellaneous	963	76
2) Reports	52	13
3) Explanatory Notes	46	-
4) Bulletins	282	21

5) Photo centre transfer 4250

6) Completion of Pictorial Index

PUBLICATIONS AND RECORDS

PUBLICATIONS AND RECORDS

INTRODUCTION

Set out below are lists of publications and unpublished Records prepared in the Geological Branch during the year. They are divided into the following categories:

Bulletins: Published or in Press
" : In Preparation (i.e. text is complete and is being edited)
Reports : Published or in Press
" : In Preparation (i.e. text is complete and is being edited)
Outside Publications: Published or in Press
" " : Submitted or in Preparation (papers classified as submitted have been produced for internal use as Records)
Standard Series Explanatory Notes and Maps: Published or in Press
" " " " " " : With editor
Special maps: Published or in Press
" " : With editor
Records: Issued or with Publication and Information Section
" : In Preparation (i.e. text is complete and is being edited)

Numbers against authors' names indicate that the author:

1. was formerly a Bureau Officer
2. is, or was, an officer of a State Geological Survey
3. is a member of the staff of the Baas Becking Geo-biological Research Laboratory and is not a Bureau officer.
4. is a member of a University or other educational institution
5. is not a Bureau officer and does not fall into categories 1 to 4.

BULLETINS

PUBLISHED OR IN PRESS*

124	BLAKE, D.H.	Regional and economic geology of the Herberton/Mount Garnet area - Herberton Tinfield, north Queensland.
126	KEMP, ELIZABETH M.	Permian flora from the Beaver Lake area, Prince Charles Mountains i. Palynological Examination of samples.
	[5]WHITE, MARY E.	ii. Plant Fossils
	SHERGOLD, J.H.	A new conocoryphid trilobite from the Middle Cambrian of western Queensland.
	SKWARKO, S.K.	Middle and Upper Triassic mollusca from Yuat River, eastern New Guinea.
	SKWARKO, S.K.	On the discovery of Halodiidae (Bivalvia, Triassic) in New Guinea.
	SKWARKO, S.K.	A correlation chart for the Cretaceous system in Australia.
	GILBERT-TOMLINSON, Joyce	The Lower Ordovician gastropod Teiichispra in northern Australia.
130	DICKINS, J.M. [1]MALONE, E.J.	Geology of the Bowen Basin, Queensland
133	DOW, D.B. [1]SMIT, J.A.J. BAIN, J.H.C. RYBURN, R.J.	Geology of the south Sepik Region PNG.
134	[4]LINK, A.G. DRUCE, E.C.	1972 - Ludlovian and Gedinnian Conodont Stratigraphy of the Yass Basin, New South Wales.
135	[1]WILLMOTT, W.F. [2]WHITAKER, W.G. PALFREYMAN, W.D. [1]TRAIL, D.S.	The igneous and metamorphic rocks of Cape York Peninsula and Torres Strait.
*136	JONES, H.A.	Marine geology of the northwest Australian continental shelf.
*139	BAIN, J.H.C. [1]BINNEKAMP, J.G.	The Foraminifera and stratigraphy of the Chimbu Limestone, New Guinea.
	[1]de KEYSER, F.	A review of the Middle Cambrian stratigraphy in the Queensland portion of the Georgina Basin.
	[1]ROBERTS, J. [1]VEEVERS, J.J.	Summary of BMR studies of the onshore Bonaparte Gulf Basin, 1963-71.

*139	[1]SMITH, I.E.	An uplifted wave-cut terrace on Sudest Island, southeastern Papua.
	[1]SMITH, I.E. PIETERS, P.E.	The geology of the Deboyne Island Group, southeastern Papua.
	[1]SMITH, I.E. PIETERS, P.E. SIMPSON, C.J.	Notes to accompany a geological map of Rossell Island, southeastern Papua.
	[1]VEEVERS, J.J.	Stratigraphy and structure of the continental margin between North-West Cape and Seringapatam Reef, northwest Australia.
	[1]PLUMB, K.A. BROWN, M.C.	Revised correlations and stratigraphic nomenclature in the Proterozoic carbonate complex of the McArthur Group, Northern Territory.
140	BURGER, D.	Palynological observations in the Carpentaria Basin, Queensland.
	NORVICK, M.	The microplankton genus Disphaeria Cookson & Eisenack Emend.
	[1]BINNEKAMP, J.G.	Tertiary larger Foraminifera from New Britain, P.N.G.
	SKWARKO, S.K.	First report of Domerian (Lower Jurassic) marine Mollusca from New Guinea.
	SKWARKO, S.K.	Cretaceous stratigraphy of part of the Wiso Basin, N.T.
	OWEN, M.	Upper Cretaceous planktonic Foraminifera from Papua-New Guinea.
	SHERGOLD, J.H.	Bibliography and index of Australian Cambrian trilobites.
144	FORMAN, D.J. SHAW, R.D.	Deformation of the crust and mantle in central Australia.
145	WARREN, R.G.	A commentary on the metallogenic map of Australia and Papua New Guinea.
*146	[4]JOPLIN, Germaine A.	Chemical analyses of Australian Rocks, Igneous and Metamorphic - Supplement 1961-1969.
*150	BELFORD, D.J.	Foraminifera from the Nassau Range, Iloga Valley, West Irian.

*150	BURGER, D.	Palynology of Subsurface Lower Cretaceous strata in the Surat Basin, Queensland.
*151	NORVICK, M.S. BURGER, D.	Stratigraphic Palynology of the Cenomanian of Bathurst Island, Northern Territory.
*151	BUFGER, D.	Cenomanian spores and pollen grains from Bathurst Island, Northern Territory, Australia.
*151	NORVICK, M.	Mid-Cretaceous microplankton from Bathurst Island, Northern Territory, Australia.
*153	SHERGOLD, J.H.	Late Cambrian and early Ordovician Trilobites from the Burke River structural belt, Western Queensland.
154	JENSEN, A.R.	Permo-Triassic stratigraphy and sedimentation in the Bowen Basin, Queensland.
155	BAIN, J.H.C. MACKENZIE, D.E. RYBURN, R.J.	Geology of the Kubor Anticline, PNG.
*156	JONES, P.J. 4 CAMPBELL, K.S.W. 1 ROBERTS, J.,	Correlation chart for the Carboniferous System of Australia.
*157	JONGSMA, D.	Marine geology of the Arafura Sea.
*158	DRUCE, E.C.	Conodont biostratigraphy of the Upper Devonian Reef Complexes of the Canning Basin, Western Australia.

BULLETINS

IN PREPARATION

MARSHALL, J.E.	Marine geology of the Capricorn Channel area.
PAGE, R.W.	The geochronology of igneous and metamorphic rocks in the New Guinea Highlands.
[1]SMITH, I.E. DAVIES, H.L. BELFORD, D.J.	Geology of southeast Papuan mainland.
SWEET, I.P.	The Precambrian Geology of the Victoria River Region.
YOUNG, G.C.	Devonian fishes from Billiluna, northwest Australia.

REPORTS

PUBLISHED OR IN PRESS *

* 140	EXON, N.F., REISER, R.F.[2] CASEY, D.J.,[2] BRUNKER R.L.[2]	The post-Palaeozoic rocks on the Warwick Sheet area.
150	ROBERTS, H.G.[1] GEMUTS, I.[2] HALLIGAN, R.[2]	Adelaidean and Cambrian stratigraphy of the Mount Ramsay 1:250 000 Sheet area, W.A.
* 152	GELLATLY, D.C.[1] DERRICK, G.M. PLUMB, K.A.	Geology of the Lansdowne 1:250 000 Sheet area, W.A.
* 154	GELLATLY, D.C.[1] DERRICK, G.M. SOFOULIS, J.[2] HALLIGAN, R.A.[2]	Geology of the Charnley 1:250 000 Sheet area, W.A.
* 153	GELLATLY, D.C.[1] SOFOULIS, J.[2] DERRICK, G.M. MORGAN, C.M.[1]	The older Precambrian geology of the Lennard River 1:250 000 Sheet area W.A.
* 161	SWEET, I.P. PONTIFEX, I.R.[1] MORGAN, C.M.[1]	The Geology of the Auvergne 1:250 000 Sheet area, Northern Territory (excluding Bonaparte Gulf Basin).
* 162	BENNETT, R.[1] PAGE, R.W. BLADON, G.	1973 - Catalogue of isotopic age determinations on Australian Rocks, 1966- 1970.
* 166	SWEET, I.P. MENDUM, J.R.[1] MORGAN, C.M.[1] PONTIFEX, I.R.[1]	The Geology of the Northern Victoria River Region, Northern Territory.
* 167	SWEET, I.P. MENDUM, J.R.[1] BULTITUDE, R.J. MORGAN, C.M.[1]	The Geology of the Southern Victoria River Region, Northern Territory.
* 174	BLAKE, D.H. HODGSON, I.M. SMITH, P.A.	Geology of the Birrindudu and Tanami Sheet areas, Northern Territory.

MINERAL RESOURCES REPORTS

1	INGRAM, J.A.	Bauxite Deposits Second Edition.
2	INGRAM, J.A.	Nickel Deposits Second Edition
3	INGRAM, J.A.	Phosphate Deposits Second Edition

REPORTS

IN PREPARATION

BURGIS, W.A.[1]	Palaeogeography and sedimentology of the Bulimba Formation in the Torwood/Bulimba area, Queensland.
GLIKSON, A.Y.	Geology of the Cloncurry 1:100 000 Sheet area, Queensland.
HOHNEN, P.D.	Geology of New Ireland, PNG.
WELLS, A.T. STEWART, A.J. KENNEWELL, P.J.	Petrographic and Geochemical studies of evaporite deposits in the Amadeus Basin, N.T. - Ringwood, Gardiner Range, Lake Amadeus and Goyder Pass.

OUTSIDE PUBLICATIONS

PUBLISHED OR IN PRESS*

2 ABELE, C. PAGE, R.W.	Stratigraphic and isotopic age of Tertiary basalts at Maude and Airey's Inlet, Victoria, Australia.	Proc. Roy. Soc. Vict.*
ADAMS, C.G. BELFORD, D.J.	Foraminiferal biostratigraphy of the Oligocene/Miocene Limestones of Christmas Island; (Indian Ocean).	Palaeontology.*
BAIN, J.H.C.	A summary of the main structural elements of Papua New Guinea.	in Western Pacific: Island Arcs, Marginal Seas, Geochemistry, pp. 147-161, 1973 Ed. P.J. Coleman UWA Press.
BAIN, J.H.C.	Reference lines, fault classification, transform systems and ocean floor spreading: Discussion.	Tectonophysics;*
1 BLACK, L.P. 5 MORGAN, W.R. WHITE, M.E.	Age of a mixed Cardiopteris-Glossopteris flora from Rb-Sr measurements on the Nychum Volcanics, North Queensland.	J. geol. Soc. Aust., 19, pp. 189-196.
4 BLACK, L.P. 4 MOORBATH, S. 4 PANKHURST, R.J. WINDLEY, B.F.	$^{207}Pb/^{206}Pb$ whole rock age of the Archaean granulite facies metamorphic event in West Greenland.	Nature: Physical Science 244, No. 134, pp. 50-53.
4 BLACK, L.P. RICHARDS, J.R.	Isotopic compositions and possible genesis of ore leads in northeastern Queensland, Australia.	Econ. Geol., 67, pp. 1168-1179.
4 BLACK, L.P. RICHARDS, J.R.	Rock lead isotopes in northwest Queensland.	J. geol. Soc. Aust., 19, pp. 321-330.
BLAKE, D.H.	Geology of eastern Papua.	CSIRO Land Res. Ser. No 32, 1973.
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4 BLAKE, D.H. MCDOUGALL, I.	Ages of the Cape Hoskins volcanoes, New Britain, Papua New Guinea.	J. geol. Soc. Aust., 20, 199-204, 1973.
5 BLAKE, D.H. PAIJMANS, K.	Reconnaissance mapping of land resources in Papua New Guinea.	Australian Geographic Studies. Oct; 1973.
5 BLAKE, D.H. 5 PAIJMANS, K. 5 MCALPINE, J.R. SAUNDERS, J.C.	Land-form types and vegetation of eastern Papua.	CSIRO Land Research Ser. No 32, 1973.
5 BREWER, R. HALDANE, A.D.	Some Aspects of the Genesis of an Alpine Humus Soil.	Aust. J. Soil Res. 1973 Vol 11 pp. 1-11.

[3]BUBELA, B.	Effect of copper on the growth of B. stearothermophilus.	Zentralblatt für Bakteriologie.*
[3]BUBELA, B. FERGUSON, J.	Apparatus for studies of artificial sediments.	J. Sed. Petrol.* (Rec. 1973/19).
[3]BUBELA, B. POWELL, T.G.	Effect of copper on the composition of bacterial cell wall peptides.	Zentralblatt für Bakteriologie.*
BURGER, D.	Palynological zonation and sedimentary history of the Neocomian in the Great Artesian Basin, Queensland.	J. Geol. Soc. Aust., Spec. Paper 4.
[5]CHILDS, C.W. [3]DOWNES, C.J. [5]PLATFORD, R.F.	Thermodynamics of Aqueous Sodium and Potassium Dihydrogen Orthophosphate Solutions at 25°C.	Australian Journal of Chemistry, <u>26</u> 863 (1973).
[5]CHILDS, C.W. [3]DOWNES, C.J. [5]PLATFORD, R.F.	Thermodynamics of Multicomponent Electrolyte Solutions: Excess Free Energies of Mixing for Aqueous Two Salt Solutions of Sodium and Potassium Chlorides and Dihydrogen Orthophosphates.	Journal of Solution Chemistry.*
[4]CLEMENS, W.A. PLANE, M.	Mid-Tertiary Thylacoleonidae (Marsupialia, Mammalia).	Jour. Paleontology.*
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D'ADDARIO, G.W.	Northern Territory	<u>in</u> Encyclopedia of earth Sciences. Volume VIIIA - World Regional Geology - Western Hemisphere.*
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DAVIES, P.J.	Subsurface solution unconformities at Heron Island, Great Barrier Reef.	Proc. Int. Symp. Coral Reefs, Australia.*
DAVIES, P.J. [3]BUBELA, B.	The transformation of nesquehonite to hydromagnesite.	Chemical Geology*
DAVIES, P.J. KINSEY, D.W.	Organic and inorganic factors in recent beach rock formation, Heron Island, Great Barrier Reef.	J. Sedim. Petrol. V 43, No. 1 59-81.
DODSON, R.G.	'Some environments of formation of uranium deposits'	<u>in</u> Uranium Prospecting Handbook, Edited by S.H.U. Bowie et al The Institute of Mining and Metallurgy, London 1973.
[3]DONNELLY, T.H. [3]LAMBERT, I.B. [4]DALE, D.H.	Sulphur isotope studies of the Mount Gunson copper deposits, Pernatty Lagoon, South Australia.	Mineral Deposita 7, 314-322, 1972
DOW, D.B.	Geological evolution of Papua New Guinea.	Aust. Nat. Hist.*
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DAVIES, P.J. BUBELA, B, FERGUSON, J.	Biological and abiological processes in a simulated sedimentary system.	*
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SC56/9	Samarai	[1]SMITH, I.E.* DAVIES, H.L.
SD52/7	Cape Scott	[1]MENDUM, J.R.
SD52/11	Port Keats	[1]MORGAN, C.M.
SD52/12	Fergusson River	[1]PONTIFEX, I.R. [1]MENDUM, J.R.
SD52/15	Auvergne	[1]PONTIFEX, I.R. SWEET, I.P.
SD52/16	Delamere	SWEET, I.P.
SD54/15	Rutland Plains	NEEDHAM, R.S.* DOUTCH, H.F.
SE51/3	Yampi	[1]GELLATLY, D.C.* [2]SOFOULIS, J.
SE51/4	Charnley	[1]GELLATLY, D.C. [2]HALLIGAN, R.A.
SE51/8	Lennard River	DERRICK, G.M. [2]PLAYFORD, P.E.
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WITH EDITORS

SE54/7	Blucher Range	DAVIES, H.L. NORVICK, M.S.
SB55/5	Ramu	BAIN, J.H.C. MACKENZIE, D.E.
SB55/8	Cape Raoult - Arawe	RYBURN, R.J.
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SPECIAL MAPS

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1:1 000 000	Geology of Papua New Guinea	
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WITH EDITOR

1:250 000	Geology of New Ireland (PNG)	HOHNEN, P.D.
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