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GEOLOGICAL BRANCH
SUMMARY OF ACTIVITIES
1974

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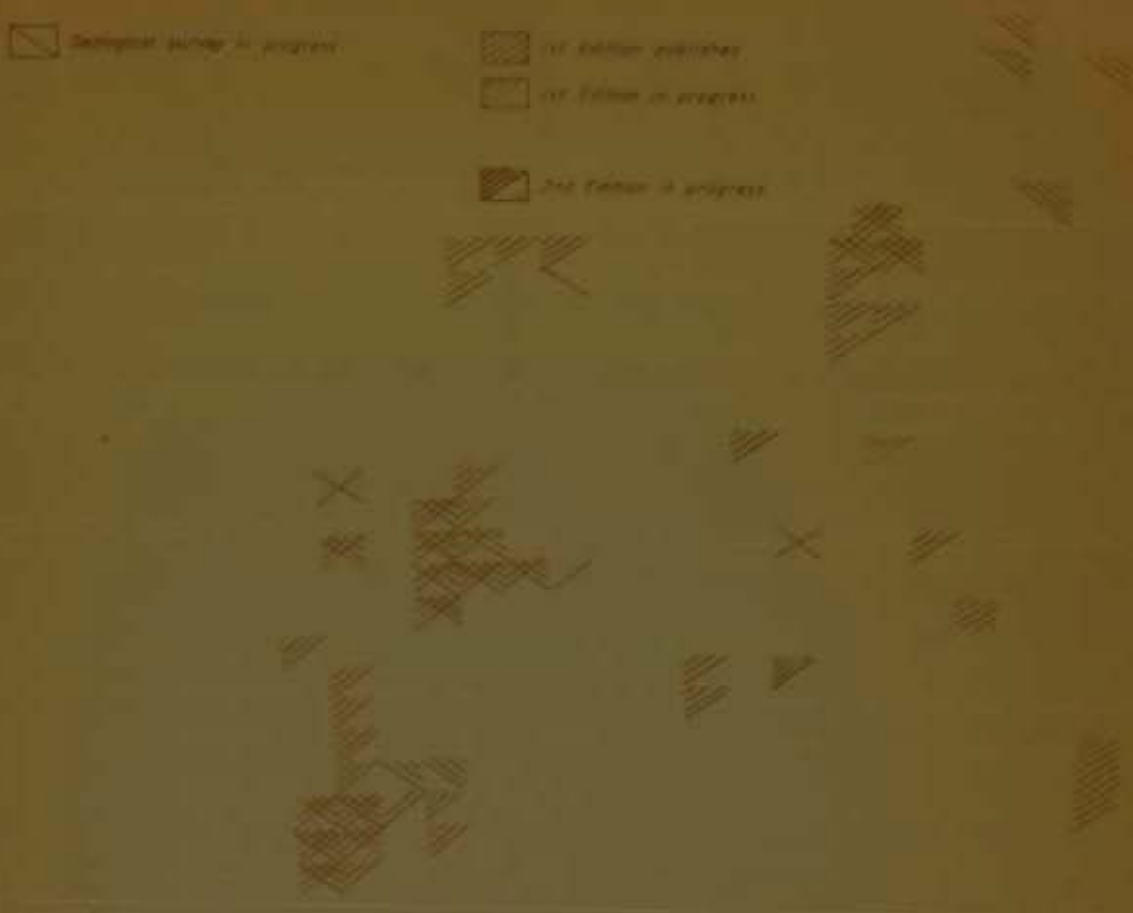


Progress in geological field mapping and series map production in the year ended 31 Oct 1974

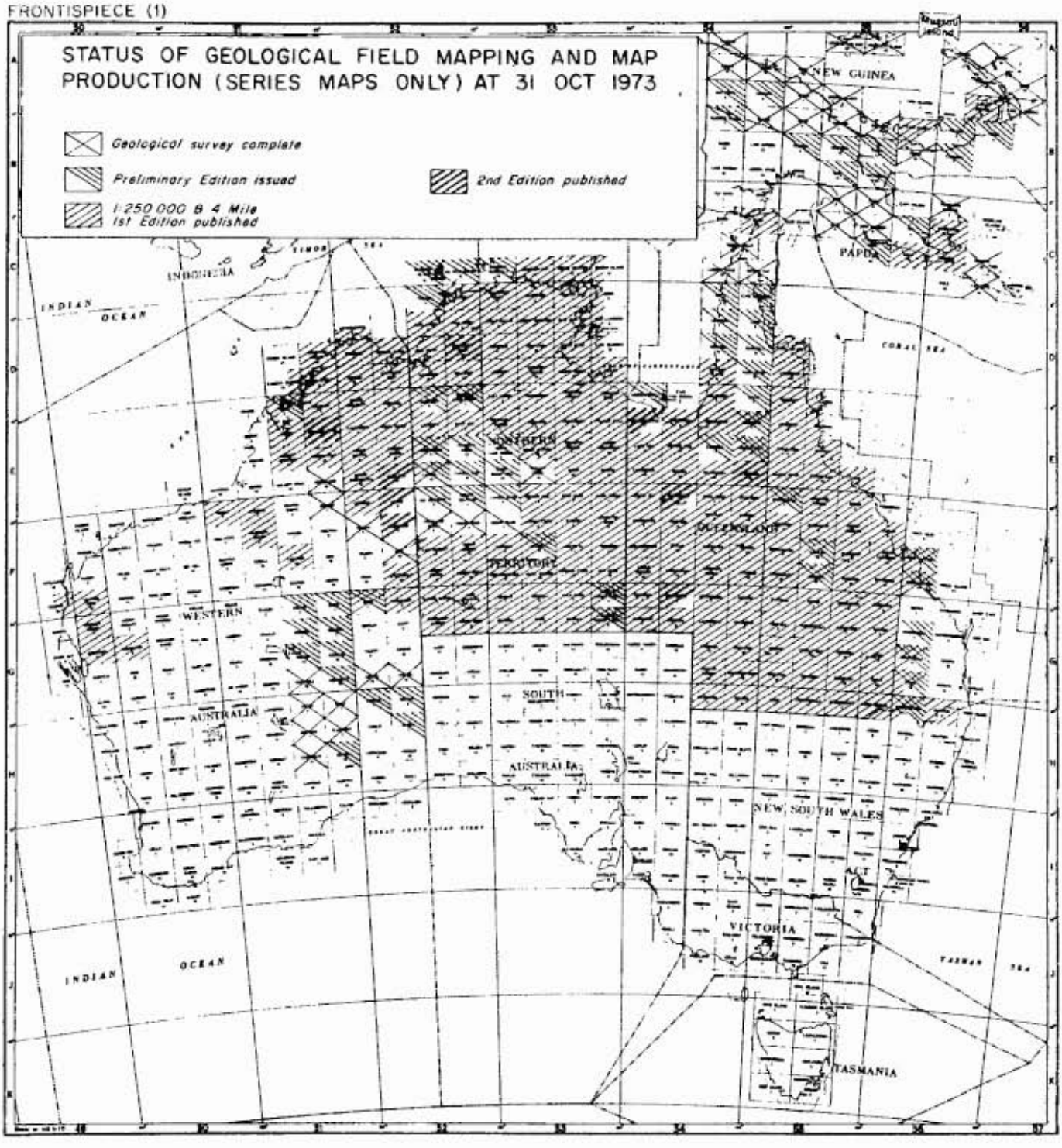
DUMBLTON MASSIF	MAWSON ESCARPMENT NORTH	MOUNT MENZIES	WILSON BLUFF
GOODSPEED NUNATAKS	MAWSON ESCARPMENT SOUTH	MOUNT TWIGG	CHURCH MOUNTAIN
GROVE MOUNTAINS	MOUNT CRESSWELL	SSAR - 42.75	SULLIVAN MONOLITH

PRELIMINARY EDITION ISSUED

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

OVERLEAF
USB 2/840

FRONTISPIECE (1)



1:250000 B56-8 BOUGAINVILLE - BUKA, PNG, ALSO PUBLISHED

PUBLISHED 1 MILE SERIES MAPS

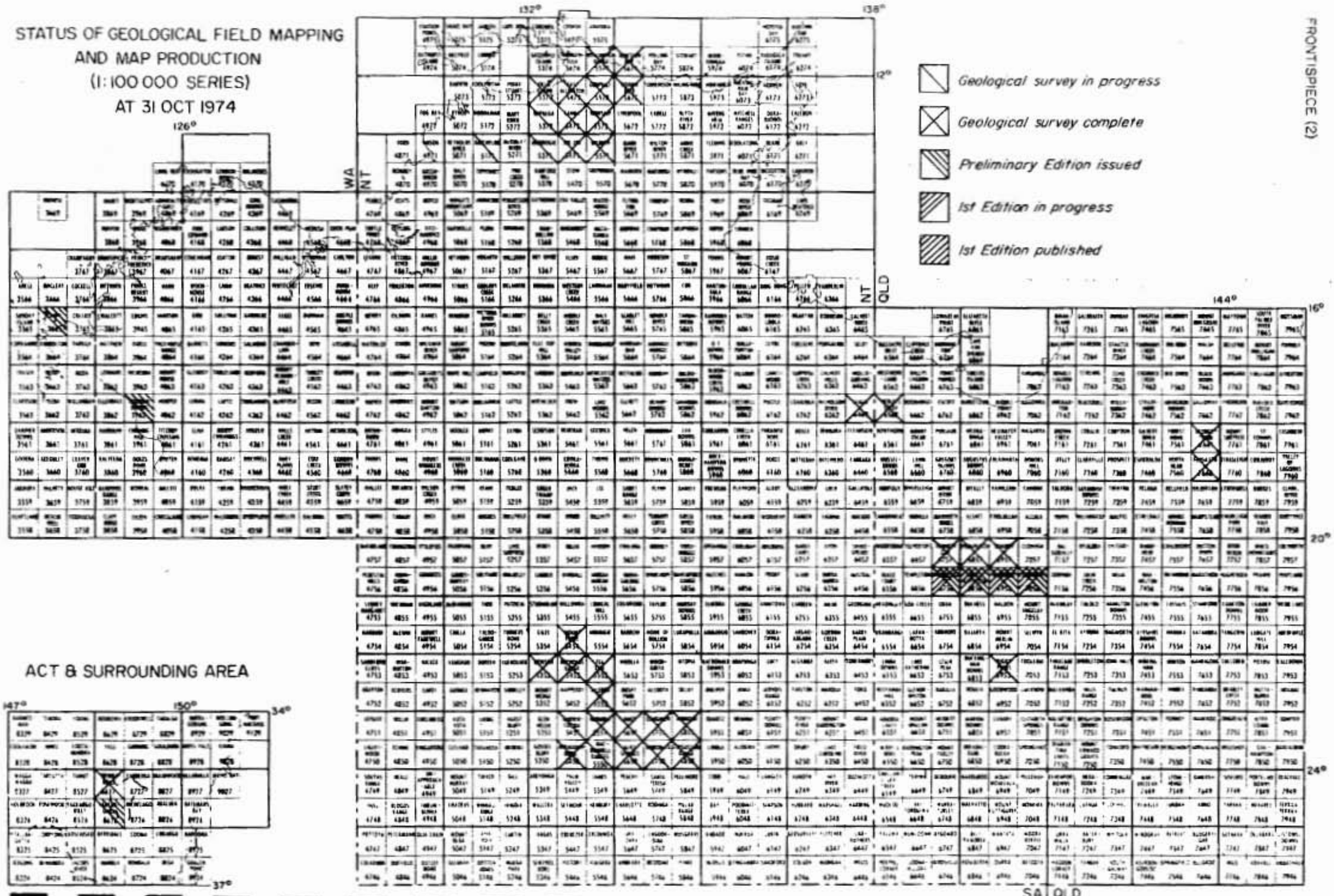
ALMADEN	CHILLAGOE	HUMPTY DOO	MOUNT HAYWARD	MUNGANA	TENNANT CREEK
BAN BAN	DALY RIVER	KATHERINE	MOUNT STOW	RANFORD HILL	TIPPERARY
BATCHELOR	DILGIN HILL	LEWIN SPRINGS	MOUNT TODD	RAVENSWOOD	TUMBLING WATERS
BLACK CAP	GOODPARLA NORTH	MARRAKAI	MOUNT TOLMER	REYNOLDS RIVER	WATERHOUSE
BURNSIDE	GOODPARLA SOUTH	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 COMPLETED

STATUS OF GEOLOGICAL FIELD MAPPING AND MAP PRODUCTION (1:100 000 SERIES) AT 31 OCT 1974



FRONTISPIECE (2)

ACT & SURROUNDING AREA

GEOLOGICAL BRANCH

ANNUAL SUMMARY OF ACTIVITIES

1974

RECORD 1974/127

CONTENTS

SUMMARY

Page

Sedimentary Section i

Metalliferous Section v

Geological Services Section viii

SEDIMENTARY SECTION

REGIONAL MAPPING PROJECTS 1
- Carpentaria Basin Project 1
- Eromanga Basin Project 3
- Surat Basin Project 4
- Ngalia Basin Project 5
- Wiso Basin Project 6
- Bathurst Island, Melville Island, Coburg Peninsula and Fog Bay Project 6
- Northeast Canning Basin Project 7
- Officer Basin Project 11

DETAILED MAPPING PROJECTS 13
- Southwest Queensland Geomorphology Project 13
- West Canning Basin Project 17
- Georgina Basin Project 20
- Tantangara-Brindabella Project 22

HYDROGEOLOGICAL STUDIES 26
- Great Artesian Basin Project 26
- Wire-line logging of water bores in the Great Artesian Basin 30
- Hydrogeology of Norfolk Island 32

SEDIMENTOLOGICAL STUDIES 36
- Lake Frome Project 36
- Laurel-Fairfield Project, Canning Basin 38
- Heavy mineral sand Study 41

PHOTOGEOLOGY AND REMOTE SENSING 43
- Photo-interpretation 43
- Remote sensing 43
- Miscellaneous activities 45
- Australian Committee for ERTS (ACERTS) 46

Page

MARINE GEOLOGY 46
Coastal Studies 48
Broad Sound 48
Mallacoota Inlet 48
SE South Australia 48
Deep Sea Drilling 50
East Australian Continental Shelf 50
Continental Shelf Morphology 50
Shallow Seismic Structure 51
Origin of the Shelf Break 51
Arsenic in Surface Sediments 53

GEOLOGY OF SEDIMENTARY MINERAL DEPOSITS 55
Phosphate deposits 55
Quaternary coastal and heavy mineral deposits 55
Evaporite Study Projects 59

PALAEONTOLOGICAL STUDIES 61
Introduction 61
Activities 61

OTHER SEDIMENTARY SECTION ACTIVITIES 73
Computing Group 73
New Programming 73
Conversion to the Cyber 76 73
Program documentation 74
Storage Retrieval 74
Uranium series dating 75
International Geological Congress 75

METALLIFEROUS SECTION

GEOLOGICAL INVESTIGATIONS IN NORTHERN TERRITORY, WESTERN AUSTRALIA, AND ANTARCTICA 77
Arunta Project 77
Isotopic dating 77
Investigation of mineral deposits 79
Hermannsburg 1:250 000 Sheet area 82
Alice Springs 1:250 000 Sheet area 84
Alcoota 1:250 000 Sheet area 85
Napperby 1:250 000 Sheet area 85
Mount Peake 1:250 000 Sheet area 86
Mount Theo 1:250 000 Sheet area 87
The Granites-Tanami Project 87
Introduction 87
Summary of geology 89
Victoria River Basin Project 90
The Antrim Plateau Volcanics and Correlatives, northern Australia 91
Pine Creek Geosyncline 93
Darwin Uranium Group 93
Alligator River Party 93
Rum Jungle and western Pine Creek Geosyncline 101
McArthur Basin 109
Carpentarian age determination project 109
Tennant Creek 109
Antarctica 110
Introduction 110
Geology 111

Page

GEOLOGICAL INVESTIGATIONS IN QUEENSLAND AND PAPUA NEW GUINEA 113
Northwest Queensland Province 113
Mount Isa-Cloncurry Project 113
Westmoreland Project 119
Georgetown Inlier 119
Georgetown Project 119
Cape York Peninsula 124
Papua New Guinea 125
North Sepik Project 125
West Sepik Project 125
Volcanology and Ore Genesis 126

PETROLOGICAL, GEOCHEMICAL, AND GEOCHRONOLOGICAL LABORATORIES 128
Introduction 128
Petrology and Mineralogy 131
Geochemistry 138
Geochronology 144

ORE GENESIS INVESTIGATIONS 148
Rum Jungle Special Sheet Mapping 148
Mineralization, Rum Jungle Area 149
Experimental Investigations 150

MISCELLANEOUS 151
Oversea Visits 151
Training Courses 152

BAAS BECKING GEOBIOLOGICAL RESEARCH LABORATORY 153

GEOLOGICAL SERVICES SECTION

GENERAL 159

ENVIRONMENTAL AND ENGINEERING GEOLOGY 159
Functions and General Activities 159
Engineering Geology 161
Sewer Lines 161
Googong Water Supply Project 164
Tuggeranong Lake Dam 164
Foundation and Slope Stability Investigations 165
Construction Materials 166
Environmental Geology 167
Hydrology and Drainage Investigations 167
Urban Geology: A.C.T. and Environs 168
Other Urban Geology Studies 171
Miscellaneous 173

MAP EDITING AND COMPILATION 174
General 174
Editing 174
Compilation 174

Page

INDEXES, TECHNICAL AND MINERAL REPORTS 176
Stratigraphic Index 176
Technical Files 176
Mineral Index 176
Mineral Reports 177

MUSEUM AND TRANSIT ROOM 178
Museum 178
Transit Room 180

PUBLICATIONS AND RECORDS

INTRODUCTION 183

BULLETINS 184
Published or In Press 184
In Preparation 186

REPORTS 187
Published or In Press 187
In Preparation 188

OUTSIDE PUBLICATIONS 189
Published or In Press 189
Submitted or In Preparation 198

STANDARD SERIES EXPLANATORY NOTES AND MAPS 200
Published or In Press 200
With Editor 201

SPECIAL MAPS 202
Published or In Press 202
With Editor 202

RECORDS 203
Issued or With Publications and Information Section 203
In Preparation 207

TABLES

S1 Great Artesian Basin hydrogeological prototype 29
S2 Heavy mineral sand production, Eastern Australia 58
M1 Current mining and exploration ventures in the Arunta Complex 81
M2 Preliminary subdivisions and correlations of units in the Kennedy Gap Sheet area 115
M3 Preliminary subdivisions of the 'eastern succession' in the Quamby Sheet area 117
M4 Results of replicate stream sediment sampling at three localities 140
GS1 Summary of tunnelling conditions 162

FIGURES

		Page
S1	Sedimentary Section field activities	ii
S2	1974 auger drilling, Carpentaria Basin Party	2
S3	Tectonic map northeast Canning Basin	8
S4	Relationships of weathered rock units, Southwest Queensland	14
S5	Precious opal structures, Queensland	15
S6	Lennard Shelf, Canning Basin	18
S7	Stratigraphic relationships, Fairfield Group	18
S8	Geochemistry of Fairfield Group	19
S9	Burke River Structural Belt, Georgina Basin	21
S10	Tectonic setting Tantangara-Brindabella Sheet areas	24
S11	Hydrogeological units in the Great Artesian Basin	27
S12	Potentiometric surfaces of confined aquifers in the Great Artesian Basin	28
S13	Norfolk Island geomorphology	33
S14	Range histograms for minor elements in Lake Frome sediments	37
S15	Facies distribution and depositional environments, Fairfield Group	40
S16	Drilling program, southeast South Australia	49
S17	Diagramatic seismic sections, N.S.W. Shelf	52
S18	Arsenic distribution, southeast Australian continental shelf	54
S19	Heavy mineral sand distribution	56
S20	Current Palaeontological projects	60
S21	Correlation of Cretaceous units	68
M1	Field activities, Metalliferous Section	iv
M2	Arunta project: coverage of mapping and colour photographs	78
M3	Distribution of mineral deposits in Arunta Block, N.T.	80
M4	Geological sketch map of The Granites-Tanami region	88
M5	Distribution of Lower Cambrian volcanics in northern Australia	92
M6	Alligator River Party, progress of mapping	94
M7	Geological history of the Alligator Rivers area, N.T.	96
M8	Area of Alligator River Party operations during 1974 field season	98
M9	Goodparla Group	104
M10	Finniss River Group	106
M11	Correlation within the Goodparla Group	108
M12	Metamorphic map of southern Prince Charles Mountains, Antarctica	112
M13	Progress of mapping, Cloncurry-Mount Isa project	114
M14	Geological mapping, Georgetown project	118
M15	Geographical distribution, sequence of intrusion, and main metallogenic associations of the granites, Georgetown and Sorsayth 1:100 000 Sheet areas	118
M16	Generalised geology of the Georgetown 1:100 000 Sheet area A - Reference B - Map	120-121
GS1	Canberra sewerage, Tuggeranong tunnel and Molonglo Valley Interceptor Sewer	160
GS2	Geological studies for urban development planning, 1974, A.C.T. and environs	169
GS3	Darwin East urban development study	172

SUMMARY

SEDIMENTARY SECTION

Substantial progress was again made with completing the reconnaissance geological mapping of sedimentary basin areas, emphasis being given to reporting. Sixteen First Edition 1:250 000 maps and accompanying Explanatory Notes were prepared for parts of the Carpentaria, Officer and Canning Basins in co-operation with the Queensland and Western Australian State Geological Surveys, and for the Bathurst/Melville Island area of the Northern Territory. Seventeen Preliminary Edition maps at 1:250 000 scale were issued. Bulletins on the Surat Basin and the central and northern parts of the Eromanga Basin, accompanied by 1:1 000 000 scale geological and isopach maps, were completed with assistance from Geophysical Branch. The results of shallow stratigraphic drilling in the Ngalia Basin were reported prior to the preparation of a Bulletin in the area in 1975. Regional mapping field investigations included auger drilling in the Carpentaria Basin, shallow stratigraphic drilling in the Wiso Basin, and re-mapping the Noonkanbah 1:250 000 Sheet area in the Canning Basin.

The study of chemical weathering processes, superficial geology, landform development and Cainozoic tectonics in SW Queensland, commenced in 1973, was continued in 1974 and a start made in evaluating the use of a proton magnetometer in locating opal-bearing ironstone concretions in some weathered profiles. Palaeontological, petrographic and geochemical work continued on the Late Devonian to Early Carboniferous Fairfield Group on the Lennard Shelf of Western Australia that was investigated in the field in 1972; reporting on this project is scheduled to be completed in 1975. The knowledge of the detailed geological history of the area arising from the study has a bearing on the possible formation of base metal deposits and the entrapment of hydrocarbons. A long-term study of the Georgina Basin was started and will include petrographic, geochemical and palaeontological investigation of all the units with the aim of making palaeogeographic reconstructions. The results will aid exploration for hydrocarbons, phosphate and base metals. In 1974 colour air photographs proved invaluable in mapping carbonate units in the area south of Mt Isa. Detailed mapping of the Brindabella 1:100 000 Sheet area near Canberra was completed and a Preliminary Edition of the neighbouring Tantangara 1:100 000 Sheet was issued. Isotopic age determinations and a geochemical study of the many igneous rock suites in the area have enabled a detailed geological history of this complex area to be worked out.

Hydrogeological studies continued and substantial progress was made with the Great Artesian Basin project. Data gathering, with the assistance of the State water authorities, was completed, the basic reservoir structure was re-assessed resulting in a two-layer, rather than the previously assumed three-layer system and, towards the end of the period, work was proceeding on calibrating the mathematical model of the basin. Water-bore logging in the Queensland part of the Surat Basin was completed. The logs from the 54 wells were used in the preparation of the synthesis of the geology of the Basin and the Great Artesian Basin study.

A preliminary hydrogeological survey of Norfolk Island was made to evaluate the groundwater potential.

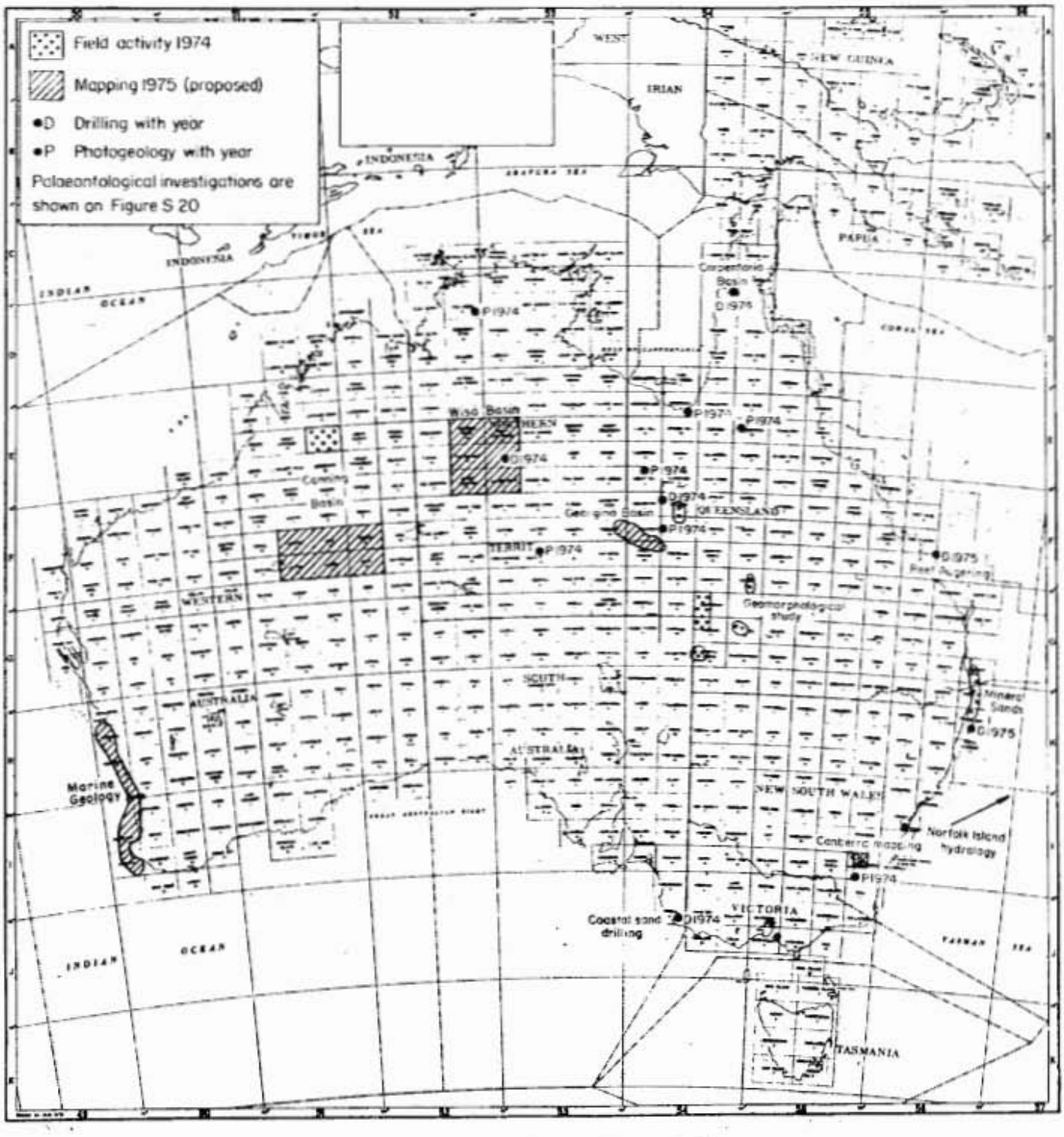


Figure SI Sedimentary Section field activities

Sedimentological studies included geochemical and isotopic dating studies on surface and near-surface sediment in Lake Frome, SA, a continuation of the examination of heavy mineral-bearing sands from offshore NSW and Qld, and a continuation of laboratory and writing-up work on the estuary studies at Broad Sound, Qld and Mallacoota Inlet, Vic.

The photogeological and remote sensing group was mostly involved in administrative matters connected with the Australian Committee for Earth Resources Technology Satellites (ACERTS), in evaluating and interpreting satellite and Side-Looking Airborne Radar (SLAR) imagery, and in giving assistance to field parties in photo-interpretation.

The interpretation of sedimentological, seismic and bathymetric data from the east Australian continental shelf continued. Bathymetric data obtained by the Division of National Mapping revealed fossil shorelines at depths of about 105, 84, and 28 m off the central part of the NSW coast. Geochemical studies showed that the arsenic content of the sea floor sediment is higher off the industrial areas of Port Kembla, Sydney, and Newcastle than elsewhere along the coast. Further sedimentological studies were made on core from Deep Sea Drilling Project Site 262 in the Timor Trough. A project to date selected marine carbonate by the uranium-series technique was started.

Work on mineral deposits included the preparation of a review of phosphorite deposits and an investigation into their source rock potential, a bibliographic study of Quaternary coastal deposits containing heavy mineral sands and the preparation of maps showing their distribution and factors fundamental to their accumulation, and an up-dating of a review on Australian evaporite deposits.

The palaeontological group continued the systematic description of faunas and floras from Australia, Papua New Guinea and Antarctica. Much of the work is integrated with field mapping projects, particularly those in Papua New Guinea, and in the Canning, Georgina, Carpentaria, Eromanga, and Officer Basins.

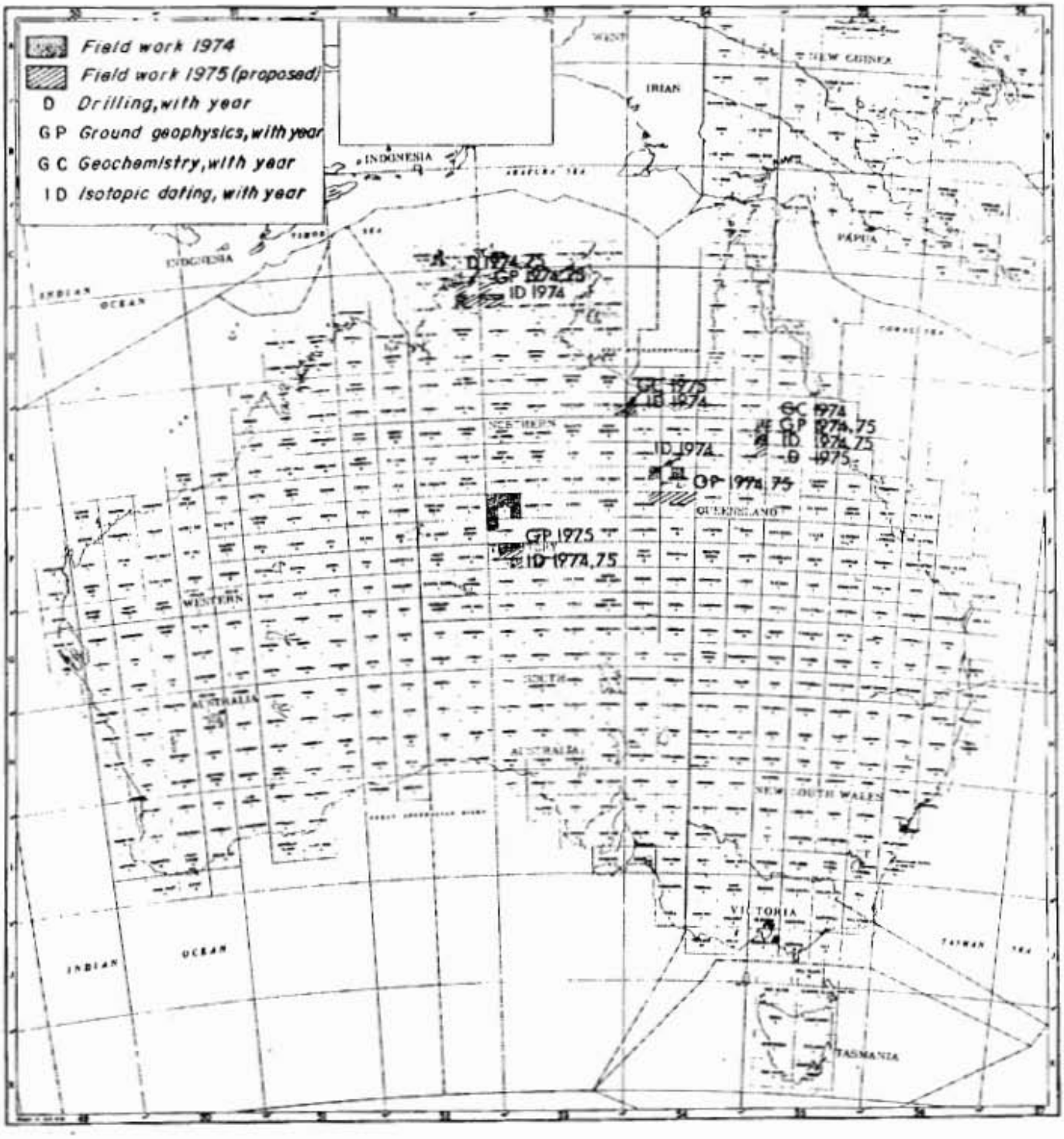


Fig.MI-Field activities, Metalliferous Section

METALLIFEROUS SECTION

Figure M 1 shows the areas where geological mapping and related field activities were carried out by the Metalliferous Section in 1974, and where similar operations are planned for 1975.

Report writing and/or map preparation continued for twenty or more projects or parts of projects for which mapping, field collecting, and laboratory work have been completed or largely completed.

The Northern Territory has now been completely mapped at 1:250 000 scale, and only the Tennant Creek and Mount Peake 1:250 000 Preliminary Maps remain to be issued. However, some areas in the Territory, mainly the uranium province in the Top End, and parts of the Arunta Complex, are being mapped at 1:100 000 scale, and second-edition 1:250 000 Sheets for such areas will be produced as the work progresses.

Revised editions of 1:250 000 maps for the Mount Isa-Westmoreland area and parts of the Georgetown Inlier will also be prepared as 1:100 000 mapping proceeds in those areas.

Regional mapping was carried out in the Arunta Complex (Mount Peake) and in Antarctica, and semi-detailed mapping (coupled with geophysical surveys, geochemical sampling, and drilling in some areas) in the Arunta Complex, and the Rum Jungle, Batchelor, Alligator Rivers, Mount Isa, and Georgetown areas. The Denison 1:100 000 Sheet area was mapped; mapping of the Anburla and Harvietooma Sheet areas is almost complete, and staff and students from Monash University started mapping the MacDonell Ranges Sheet area. Mapping of the Kennedy Gap, Quamby, and Georgetown 1:100 000 Sheet areas was completed, and geochemical sampling of the Forsayth Sheet area was carried out, mainly by helicopter.

In the Alligator Rivers uranium area geophysical surveys and shallow stratigraphic drilling were carried out to check the relationship between the Koolpin Formation-host-rock to ore in the South Alligator River valley - and its postulated metamorphic equivalent to the north. Isotopic dating of the Nanambu Complex pointed to the existence of Archaean (2,500 m.y.) rocks in its core; a close parallel with the Rum Jungle situation is thus suggested, the difference being that part of the basement and part of the Lower Proterozoic succession has been migmatized in the Alligator River Sheet area. No rocks of Archaean age have so far been identified in the Nimbuwah Complex, but additional material for dating both from this complex and from other areas was collected this year.

Field work for a revised edition of the Rum Jungle Special Sheet was completed during the year. The mapping was supported by geophysical work and shallow stratigraphic drilling over and around parts of both the Rum Jungle and the Waterhouse Complexes. It was established that there are considerable differences between the types and proportions of sediments around the two complexes, that the Waterhouse Complex contains at least as great a variety of granitic and metamorphic rocks as does the Rum Jungle Complex, and that an ironstone bed in the Golden Dyke Formation provides a good marker for making correlations over a considerable area. Widespread metasomatism around parts of both complexes points to the probability of late granite intrusion which may have been responsible for up-doming of both complexes and concomitant shearing of the sediments surrounding them, and may also have played a part in mobilization of ore fluids contained in sediments.

Mapping in the Kennedy Gap Sheet area, north of Mount Isa, strengthened the possibility that stratigraphic subdivisions and nomenclature will be simplified as work proceeds, thus making it easier to correlate and trace potentially mineralized beds over a wide area.

Considerable changes in interpretation and emphasis resulted from mapping in Georgetown and Forsayth areas. Ten granitic complexes and a number of smaller separate plutons have been distinguished. The Robertson River Metamorphics and the higher-grade Einasleigh Metamorphics are probably equivalents of the Etheridge Formation. The Newcastle Range Volcanics appear to have been deposited in two partly fault-bounded depressions; six volcanic units have been recognized in the main range, and five in the eastern range; in both areas these units are underlain by sandstone, siltstone, and conglomerate.

Analysis of orientation stream sediment samples collected in the Georgetown area in 1973 showed that both minus 85 mesh and heavy mineral fractions provided useful information; the Forsayth 1:100 000 Sheet area was systematically sampled, mainly by helicopter, in 1974. In both the Georgetown and Westmoreland areas stream sediment samples were found to be useful in prospecting for uranium: dispersion trains persisted for between 3 and 5 km downstream from mineralisation.

A draft report on the petrology and major-element geochemistry of volcanoes in the south Bismarck Sea area was prepared, and additional samples were collected from a petrographically unusual suite of lavas from volcanoes off-shore from New Ireland.

Major new pieces of analytical equipment have been installed in the Laboratory, other equipment has been updated, and on-line outputs to computer facilities have been arranged.

Various projects were continued by petrologists and geochemists from the Laboratory in the Arunta Complex, in north-west Queensland, and in the Westmoreland, Georgetown, Tennant Creek, Tantangara, and Brindabella areas, as well as in Antarctica. Analcite, leucite, haüyne, pyroxene, and plagioclase in rocks from volcanic islands off New Ireland were analysed with the electron probe, and marked compositional zoning was found in the last three of these minerals. Observations on a sharp transition from basic amphibolite to basic granulite were made on rocks from the Mawson Escarpment, Antarctica.

Pollution studies in the Molonglo River by BHR and the Department of Housing and Construction have led to a recommendation by a joint Australian and NSW Government Technical Committee to seal mine dumps at Captains Flat to minimize further leaching and erosion.

The Geochronological Laboratory had a successful year: over 900 mass spectrometer determinations of Rb and Sr were carried out on samples from ten areas in NT, WA, Qld, PNG, and Irian Jaya.

Experimental work on the behaviour of lead and zinc in a sulphide-deficient brine showed that these metals could be incorporated into carbonates and iron oxides. Work continued on the part played by organic matter in complexing copper.

The Bass Becking Laboratory pursued a number of lines of investigation directly or indirectly related to the formation of sulphide, and the fixation and transport of heavy metals in the sedimentary environment. These included

studies on the physiological and biochemical behaviour of sulphate-reducing bacteria, and the use of isotopic measurements to assess the part played by them in the precipitation of metallic sulphides; studies (including carbon isotope determinations) of Precambrian life in relation to the part played by biological processes in the fixation of metals; the usefulness of Precambrian fossils for biostratigraphy, and for understanding ancient basin environments; the evaluation of the role of organic matter, brines, and carbonates in the transport, accumulation, and fixation of metals in sediments; an investigation of abiological sulphate reduction by petroleum; the contamination of ancient kerogens by younger organic compounds; the behaviour of brines as transporting agents for heavy-metal ions and reduced sulphur species; and the geochemical and mineralogical investigation of host-rocks to the Woodlawn (NSW) orebody.

GEOLOGICAL SERVICES SECTION

The accelerated growth of Canberra during the year increased the demand for engineering geological services. The systematic evaluation of the Gungahlin urban development area was completed, and in the Tuggeranong area, follow up work was continued in the assessment of groundwater conditions at Isabella Plains and Lanyon, and of foundation and excavation conditions for engineering projects. New studies were initiated to determine the geological constraints on development in the Gooromon Ponds area, and in the Canberra-Queanbeyan interaction study. The number of major foundation investigations increased, and included investigation of the complex conditions encountered on the proposed site of the Department of Capital Territory building in Civic Centre. Studies of several smaller areas for urban development in the A.C.T. were also undertaken, or completed from the preceding year.

Co-ordination of an environmental geology study of Albury-Wodonga by the N.S.W. and Victorian Geological Surveys required a number of field visits to the area, and a major investigation of the geological constraints on urban development at Darwin East was undertaken. Liaison with Cities Commission has been maintained on projects outside the Canberra area.

Excavation of the Tuggeranong and Pine Ridge Sewer Tunnels was completed, and excavation of the Ryan Sewer Tunnel commenced; good correlation with earlier geological and geophysical investigations was found during the provision of geological services throughout the year. Construction of the buried pipeline and bridges of the Molonglo Valley Interceptor Sewer continued and a full geological service was provided throughout the year. A geological feasibility route study for the Belconnen Sewer tunnel was commenced, and a number of studies related to major engineering projects, such as Googong Dam were carried out for DHC.

Preparation of geological maps of Canberra urban areas and accompanying notes continued, and compilation of the first map of an engineering geological series for Canberra at 1:10 000 is nearing completing. Hydrological work in and around the A.C.T. continued.

The Map Editing and Compilation Group completed the editing of 21 maps, and the editing of 9 maps is in progress. The 1:2 500 000 scale PNG mineral deposits map was printed and the notes are in press; the preliminary edition of the 1:2 500 000 NT geological map was printed, and editing of the first edition has been completed. The map of the Cainozoic of NT at 1:2 500 000 and the geological map of PNG 1:2 500 000 have been compiled. The new geological map of Australia, 1:2 500 000 (4 sheets) has been compiled and the layout and references are being finalised.

The work of the Indexing group was increased by the indexing of 600 articles in the 4-volume AIMM "Economic geology of Australia and Papua New Guinea", and proofs of the manuscript of Fascicule 5H-Australia, General - of the International Stratigraphic Lexicon were corrected and

returned to the printers in Paris. Mineral resources reports on uranium and tin were revised for new editions, and reports on molybdenum and tungsten are being prepared. An assessment of base metals in Australia was commenced as a joint project with the Mineral Resources Branch. The pre-1950 Mineral Index is ready for publication, and the general mineral index is being maintained.

Many new rock, fossil and mineral collections, including the mineral collection made by Reverend A.E. Gardner, were acquired for the Museum. A number of field collecting visits and exchanges of specimens added to the Museums holdings, and the Commonwealth Palaeontological Collection now comprises 14,669 specimens. Numerous displays were organised for exhibitions, and visits by the general public and school groups to the Museum continued throughout the year. The Transit Room handled 10,003 samples on which specimen preparation or determinations were required.

A high level of production was maintained by the Geological Drawing Office, but there is still a backlog of work in most sections of the Drawing Office.

Twenty-four Records, including two with co-authors from the Geophysical Branch, were issued from the Section during the year and 11 others were written and are being processed. Five publications were submitted to editors or sent to press.

SEDIMENTARY SECTION

REGIONAL MAPPING PROJECTS

CARPENTARIA BASIN PROJECT

by

H.F. Doutch and J. Smart

STAFF: H.F. Doutch, J. Smart, D.L. Gibson, B.S. Powell (BMR); K.G. Grimes (GSQ).

INTRODUCTION

The main objectives of the Carpentaria Basin project are to understand the Mesozoic and Cainozoic geology of the onshore part of the Carpentaria Basin area and to publish the results in the form of: 1:250 000 geological maps and explanatory notes, a bulletin synthesizing the geology of the whole area accompanied by 1:1 000 000 geological maps, an assessment of geophysical data by the Geophysical Branch, and papers on specific aspects of the geology. Geological mapping started in 1969 and finished in 1973; reporting is planned to be completed in 1975.

FIELD WORK 1974

Normanton District Floodwaters Inspection

Doutch and C.J. Simpson (photo-geology) flew over the floods in the area between Croydon, Galbraith, Normanton, Burketown and Canobie on 13–14–15 Jan 1974, photographing various features in black and white, colour, and false infra-red. The objective was to study sedimentation and erosion in progress in the Gulf Country, and provide 'ground truth' for ERTS studies.

The floods were the biggest since 1951. Normanton was evacuated, Burketown partly inundated, and Karumba moderately damaged.

Streams flowed bankful in headwater areas in ranges; all flood overflow channels and anabranches were active, but floodplains - some of them may have been terraces - were not inundated. Rivers were coloured by sediment and were cutting into their banks. The 10 m high Leichhardt Falls were completely submerged.

Shallow water completely covered the plains, clear where the result of local rainfall, muddy where streams were overflowing. On the plains, sheet flow concentrated suddenly into stream flow, commonly at the upstream end of a stream incision, or fell laterally into valleys, forming scalloped erosion breakaways in the process. Sediment was presumably being deposited only from muddy water; ephemeral lakes, clear or muddy, on the plains probably account for soil variations and gilgai distribution. The lake on Alexandra River was the biggest and probably longest lasting.

Overall, erosion seems dominant in the Gulf Country, with only minor sedimentation close to major rivers.

Nearly all coastal flats were flooded, to as far as 30 km inland, mostly by muddy fresh water. The sea was discoloured as far as 10 km offshore. Tides had not been abnormally high and apparently little salt water had gone inland.

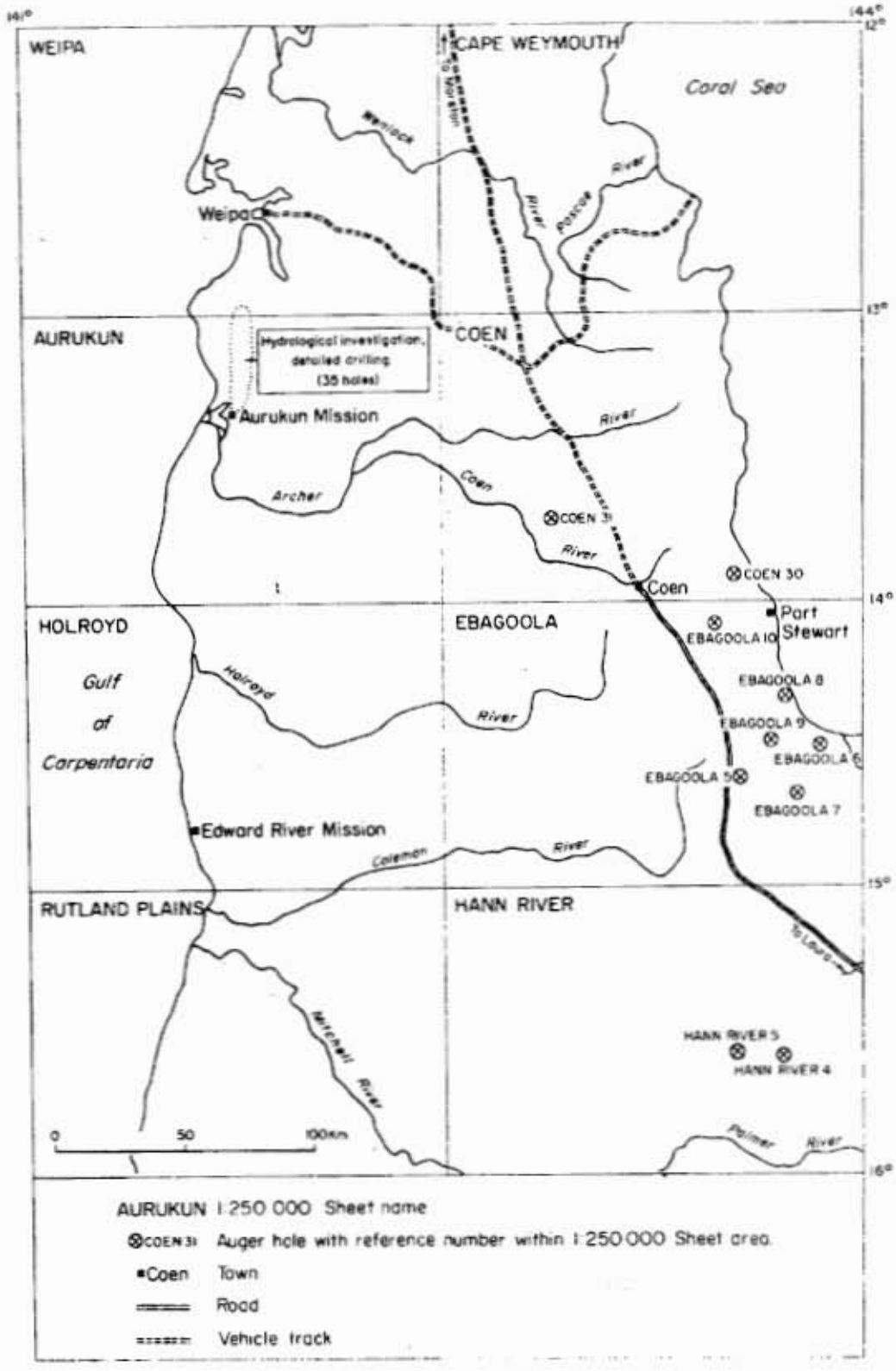


Fig.S 2 Locality map. Auger drilling 1974, Carpentaria Basin Party.

Auger Drilling (Figure S2)

Auger drilling was carried out in Cape York Peninsula during August and September 1974, using a Gemco 210B drill. The first month was spent on HANN RIVER, EBAGOOLA and COEN 1:250 000 Sheet areas, checking photo-interpretation and solving mapping problems. The late Cainozoic Lilyvale Beds were found to be less extensive in NE EBAGOOLA and SE COEN than previously thought. A beach ridge of the younger series on the east coast, about 6 km inland, was shown to rest on coastal alluvium, which itself rests on Lilyvale Beds. The presence was established in SW COEN of continental facies sandstone and conglomerate which does not crop out. Drilling in eastern EBAGOOLA confirmed the presence, suggested by photo-interpretation, of sandstone of probable Mesozoic age below residual sand.

The party spent September providing geological support for the Geophysical Branch group investigating the application of resistivity methods to the hydrological problems of the Bulimba Formation in the Weipa-Aurukun area. Overall permeability of the formation is relatively low and successful extraction of groundwater in quantity depends on the finding of bodies of higher permeability in which bores can be developed. Results so far indicate that permeable bodies are more widespread than previously believed and appear to trend E-W, with a width in the order of several tens of metres.

Construction of a detailed geological model for understanding the origins of the aquifers is hampered by the effects of lateritic weathering; much of the clay in the formation appears to have formed by the degradation of feldspar clasts, so that original grain size is not apparent.

Auger drilling proved to be more economic than resistivity sounding methods for the detailed examination of prospective areas. Subsequent work has concentrated on resistivity traversing methods to locate prospective areas for testing by drilling. Results have been encouraging and a simple technique has been developed which combined with drilling forms an economical method for hydrological investigation in this situation.

EROMANGA BASIN PROJECT

by

A. Mond & B.R. Senior

STAFF: B.R. Senior, A. Mond, P.L. Harrison (Geophysical Branch)

The Eromanga Basin is the largest of a group of basins that form the Trans-Australian Platform Cover. Covering an area of about one million km^2, the basin extends from $20^{\circ}S$ to $32^{\circ}S$ latitude and from 132° to $147^{\circ}E$ longitude.

The object of recent work in the basin has been to produce a synthesis of the geology of that part of the basin lying in Queensland and the Northern Territory as well as three geological maps at 1:1 000 000 scale covering the central, northern, and northwestern parts.

Fieldwork for the project was completed in 1973, and during 1974 the work has involved the preparation of maps and reports.

The first report, which deals with the geology of the central part of the basin, was written by Senior in 1973 and revised during 1974. The second, on the northern part was written during 1974. The remaining report is being written by Mond and is expected to be completed early in 1975. P.L. Harrison from the Geophysical Branch has synthesized geophysical data for the work.

The three reports, which will constitute a three-part Bulletin, take the form of notes on the geology together with isopach maps at 1:1 000 000 scale of the Wallumbilla, Mackunda and Winton Formations, and a structure contour map at the same scale of the base of the Rolling Downs Group.

SURAT BASIN PROJECT

by

N.F. Exon

The Surat Basin project was completed during the year and Exon was seconded to the Marine Geophysics section in mid-September. Several publications have been written, but the general picture of Surat Basin geology remains unaltered from that presented in the 1973 Summary of Activities.

In early 1974, a paper entitled "The geological evolution of the southern Taroom Trough and the overlying Surat Basin" was prepared for presentation at the Perth APEA Conference. The paper suggests that much of the petroleum produced from Lower Jurassic sandstones was derived from the Permian sequence, rather than from within the Lower Jurassic sequence itself.

Bulletin 166, entitled "The geology of the Surat Basin in Queensland" has been edited and the accompanying 1:1 000 000 scale geological map is being edited. Both should go to the printers in early 1975.

Report 188, a summary of the program of wireline logging of water-bores in the Surat Basin from 1960 to 1974 was written by Exon and Mrs J. Morrissey. This presents tables covering the 263 water bores and 20 petroleum exploration wells logged for BMR in the Surat Basin in the last 15 years, and discusses the methods used and the results obtained. Gamma-ray logs are available for all the bores listed, and neutron, temperature, differential temperature, flowmeter, and casing collar location logs are available for many.

These logs, in conjunction with logs from other petroleum exploration wells, have allowed reliable stratigraphic correlations to be made throughout the basin. A preliminary analysis of water data, making use of the logs, has enabled the characteristics of the major aquifers of the eastern and western sides of the basin to be ascertained. Flow rates are higher (as much as 5000 m^3/day), and water quality is generally better, in the west than in the east, although the Jurassic Pilliga Sandstone in the southeast yields excellent water, and is probably the most productive of all the aquifers. The shallowest major aquifer is 900 m deep in the centre of the basin, and in this area most of the production is consequently from shallow subartesian wells which provide saline water.

A paper for outside publication entitled "The Cretaceous sequence of the Eromanga and Surat Basins, Queensland" was written by Exon and B.R. Senior. This outlines the stratigraphy, structure and geological history of the Neocomian to early Cenomanian clastic sediments preserved over more than 1 000 000 km^2 of Queensland. These average 700 m in thickness, and two major transgressions and two regressions are documented. The Neocomian and Aptian sediments are quartz-rich, and were derived from basement rises surrounding the basin; the Albian and Cenomanian sediments are quartz-poor, and were probably derived from Late Jurassic or Early Cretaceous volcanics forming a mountain range to the northeast, which probably paralleled the present coast of Queensland.

A further paper for outside publication, dealing with the nomenclature and distribution of several Eromanga Basin sedimentary units, is presently being prepared.

NGALIA BASIN PROJECT

by

A.T. Wells

The objectives of the Ngalia Basin program are to complete compilation of outstanding data, and synthesize all available information into a form suitable for publication in the Bulletin Series.

In 1974 the results of the last phase of stratigraphic drilling in the Basin were compiled as Record 1974/153. The ten holes were drilled to depths of between 37 m and 246 m (total 1066 m) in the central and eastern parts of the Basin in 1970, and provided data on the continental Cainozoic cover rocks and on the pre-Cainozoic bedrock.

The Cainozoic deposits vary considerably in composition but the predominantly coarse-grained, feldspathic and arenaceous sands show strong evidence of derivation from a granitic provenance. Data on the relationship, depth, thickness and distribution of laterite and calcrete within the Cainozoic sequence was obtained. Information on the extent and nature of bedrock units provided additional control for a palaeo-geographic reconstruction of the Basin.

WISO BASIN PROJECT

by

P.J. Kennewell

The main objectives of the Wiso Basin Project are to up-grade the preliminary edition 1:250 000 geological maps of the area to First Edition status and to write accompanying explanatory notes.

Reconnaissance mapping of the Basin was carried out in 1965 and six preliminary edition maps issued in 1966. The earlier fieldwork indicated the presence of a relatively thin Lower Palaeozoic mainly carbonate sequence overlain in the south by Devonian sandstone. Geophysical surveys subsequently indicated the probable presence of thick, relatively non-magnetic rocks, in the south of the Basin in a zone known as the Lander Trough. Shallow stratigraphic drilling was started on 19 August 1974 to investigate the sequence on the northern flank of the trough, as the few outcrops there are deeply weathered. By late October 10 holes to depths of 65 to 105 metres had been drilled along a 40 km line extending north from a point 27 km north of Numagalong Homestead (Bonney Well 1:250 000 Sheet area). The rocks penetrated are poorly sorted sandstone, siltstone and claystone grading upwards into well-sorted sandstone. A few carbonate beds are present and the rocks are weathered to depths of 60 m. They lie stratigraphically between the Middle Cambrian Merrina Beds and the Devonian Dulcie Sandstone and could be equivalents of the Ordovician Hanson River Beds.

Further drilling and fieldwork are planned for 1975 prior to the preparation of the First Edition maps and explanatory notes.

BATHURST ISLAND, MELVILLE ISLAND, COBOURG PENINSULA AND FOG BAY PROJECT

by

R.J. Hughes

The objectives of this survey are to understand the Mesozoic and Cainozoic geology of the four 1:250 000 Sheet areas and to investigate the mineral potential. Reconnaissance geological mapping was done in 1972 and follow-up fieldwork and drilling in 1973. Shallow stratigraphic drilling on Melville Island and detailed investigations of heavy mineral sands on Melville and Bathurst Islands, planned for 1974, were cancelled for reasons beyond the control of the Bureau.

During 1974 explanatory notes to accompany the first edition geological maps of the Bathurst Island, Melville Island, Cobourg Peninsula and Fog Bay 1:250 000 Sheet areas were completed and passed to the editors. A draft Report on "The geology and mineral occurrences of Bathurst Island, Melville Island and Cobourg Peninsula, Northern Territory" was written and a start made on a 1:500 000 geological map to accompany the report.

An orientation program on the techniques and equipment used by the BMR for mineral sand evaluation was held for Mines Branch geologists in Darwin between 21 and 30 August. A reconnaissance evaluation was then made of the large volume of sand to the north of the Finniss River, Fog Bay and on the beaches close to Darwin. This showed a general absence of heavy minerals with the exception of one thin layer of heavy mineral concentration (0.2 m) in a hole augered at the base of a large backdune in the Fog Bay area. The samples are being analysed by AMDL. Previous work by the Mines Branch at Chambers Bay, to the east of Darwin, also suggests an absence of mineral sands. The dunes are low, narrow and composed mainly of fragmentary shell material. They are built on tidal flat and mangrove swamp deposits and form chenier structures. Radiocarbon dates of 5000 y B.P. have been obtained from shells collected in the cheniers (Roarty, pers. comm.).

NORTHEAST CANNING BASIN PROJECT

by

A.N. Yeates and R.R. Towner

STAFF: A.N. Yeates, R.R. Towner, Lesley A.I. Wyborn (until 20/9/74), BMR; R.W.A. Crowe, GSWA

INTRODUCTION

The objectives of the project are to remap the Canning Basin in sufficient detail to enable the preparation of all the outstanding 1:250 000 First Edition geological maps and explanatory notes. Second Edition maps and notes of some Sheet areas will be prepared where warranted by the existence of substantial new information from palaeontological, geophysical and drilling activities. The project is a joint one with the Geological Survey of Western Australia and the Basin Studies Group, BMR. Field investigations started in 1972. In 1974, the party compiled maps and reported results of the 1972 and 1973 field surveys in BILLILUNA, LUCAS, STANSMORE, WEBB, MOUNT BANNERMAN, CORNISH, HELENA, CROSSLAND and DUMMER 1:250 000 Sheet areas. Towner and Crowe (May to September) mapped the post-Lower Carboniferous strata in NOONKANBAH and MOUNT RAMSAY and did field checking in CROSSLAND.

The Precambrian geology of MOUNT BANNERMAN was mapped by GSWA in 1974; the Preliminary edition of this Sheet area will be prepared in 1975.

PROGRESS RESULTS

Preliminary geological editions of BILLILUNA, LUCAS, STANSMORE, WEBB and DUMMER were released during the year. Preliminary editions of CORNISH, HELENA and CROSSLAND were awaiting drafting at the end of October.

Explanatory Notes to accompany STANSMORE and DUMMER Geological sheets were written and Towner made a contribution to the Record "Geology of the Webb 1:250 000 Sheet area, Western Australia".

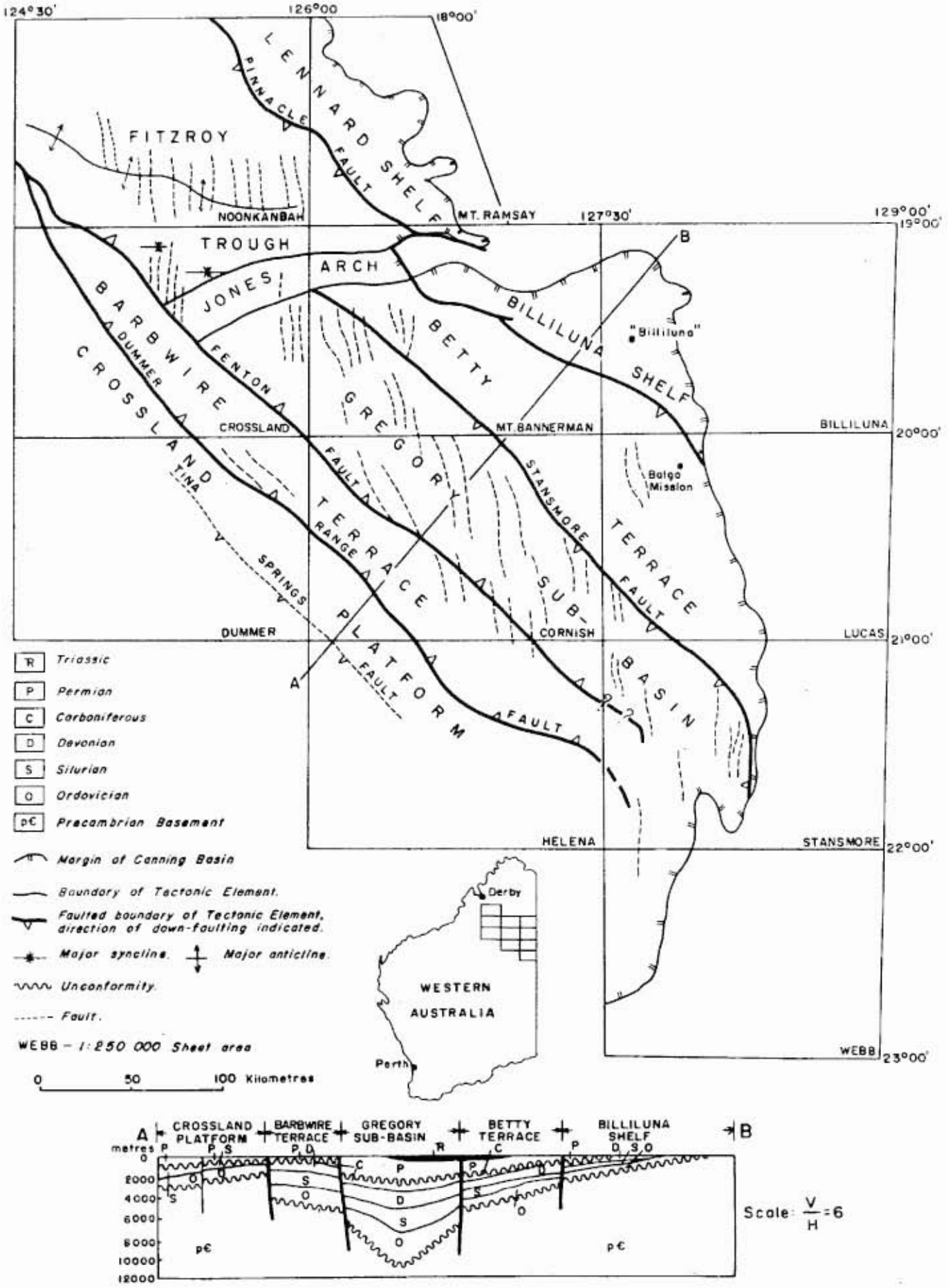


Fig. S3 Provisional Tectonic map and cross-section of the northeastern part of the Canning Basin showing position and relationship of main Tectonic Elements

The draft Record "Notes on the Geology of the Gregory Sub-basin and adjacent areas of the Canning Basin, Western Australia" contains, in addition to the 1972 and 1973 drilling and fieldwork results, a review of the results of all subsurface work undertaken in the area. A provisional tectonic map of the area has been compiled (Fig. S3). The main tectonic elements, most of which began to develop in Middle Devonian and later times are:

Billiluna Shelf - an area in the far northeastern margin of the Canning Basin on which relatively little sedimentary rock is preserved on Precambrian basement.

Betty Terrace - an area in which basement is down-faulted but is intermediate in depth between the Billiluna Shelf and the Gregory Sub-basin and which is separated from these elements by unnamed subsurface faults and the Stansmore Fault respectively. To the southeast, it is bound by basement and to the northwest by the Jones Arch.

Gregory Sub-basin - an elongate trough - shaped feature between the Stansmore Fault and the Fenton Fault System in which a relatively thick sedimentary section is preserved. To the southeast, it is bounded by basement and to the northwest by the Jones Arch.

Jones Arch - an area of elevated basement (and consequent thinner overlying sedimentary section) which trends east-northeast from the Fenton Fault to Proterozoic outcrops of similar trend forming part of the Halls Creek Mobile Belt. The Jones Arch separates the Gregory Sub-basin and Betty Terrace from the Fitzroy Trough.

Fitzroy Trough - a fault-bound trough trending northwest from Jones Arch to beyond the present coastline. In it, a substantial thickness of sedimentary rock is preserved and at the surface, Permian sedimentary rocks crop out along major east-west trending folds. This type of folding does not continue over the Jones Arch nor into the Gregory Sub-basin.

Barbwire Terrace - a narrow, down-faulted block adjacent to the southern flank of the Fitzroy Trough and the Gregory Sub-basin; basement along the Terrace is intermediate in depth between the Crossland Platform to the southwest and the Gregory Sub-basin and Fitzroy Trough to the northeast.

Crossland Platform - an area of relatively shallow basement on which the sedimentary section has a southwesterly regional dip towards the Kidson Sub-basin. It is separated from the Barbwire Terrace by the Dummer Range Fault System and from the Kidson Sub-basin possibly by the Tobin Hingeline, outside the area.

Results of palynologic work by Mines Administration Ltd, identifications of floras by Mary E. White, and faunas by J.M. Dickins and P.A. Jell (Record 1974/77) have assisted in the confirmation of the surface formations identified. Palynologic and plant fossil identification have clarified the relationships of the Triassic units to each other. The revised Triassic stratigraphy is the conformable sequence:

Culvida Sandstone - early Middle Triassic
Erskine Sandstone - Lower Triassic
Blina Shale - Lower Triassic
Chilpada Sandstone - Lower Triassic

The Chilpada Sandstone is the name proposed for a new unit lithologically similar to the Culvida Sandstone but older based on floras and stratigraphic position. Mary White's report on floras will be issued in the Record Series. Of particular interest is the occurrence of Glossopteris in Triassic rocks, the extended range of Lycopodiopsis pedroanus into the Lower Triassic and a new species of Equisetalean from the Erskine Sandstone described as Equisetites erskinii.

FIELDWORK

The 1974 fieldwork consisted of remapping NOONKANBAH 1:250 000 Sheet area. A first Edition geological map of the area was published in 1958.

The mapping was done on air-photographs at 1:80 000 scale in conjunction with the First Edition map. The position of fences, tracks and bores were marked on 1:100 000 topographical maps issued by National Mapping, 1970. The main geological results are:

(1) A tillite member within the Grant Formation was traced from the margins of the Sheet area through the Pool Range to the western end of the St Georges Range and Fitzroy Crossing. The member becomes sandier and contains fewer dropstones in the west. Marine fossils were collected from it in the Carolyn Valley. Varves were recognized at the base of the member in the St Georges Range.

(2) The units overlying the tillite member consist of a cross-bedded feldspathic sandstone (50-75m) and strongly slumped fine-grained sandstone and siltstone. At Mt Thorlan and in the Millajiddee Valley in St Georges Range, the slumped unit unconformably overlies the tillite member indicating that both these areas were possibly topographic highs before Poole Sandstone times.

(3) The Nura Nura Member of the Poole Sandstone was deposited in several environments. In the Poole Range it is fluviatile, at Mt Hutton it is continental and contains fossil soils, and in the St Georges Range it is near shore shallow-marine.

(4) The Poole Sandstone thickens at the southern and western ends of the St Georges Range. It appears to have been laid down under mainly paralic conditions although the upper 10 m in the Poole Range is fluviatile.

(5) The subdivisions of the Hardman Formation which were mapped on CROSSLAND have been confirmed at Mt Hardman and in the McLarty Syncline area.

(6) The Jurassic James and Barbwire Sandstones are lithologically similar; they form a thin veneer across the Fenton Fault in the southwest corner of NOONKANBAH. This indicates that the reverse moment along the Fenton Fault was pre-deposition of these units.

(7) Fourteen detailed sections were measured, nine in the Grant Formation and Poole Sandstone.

(8) Water salinity measurements were made in 120 of the 210 bores visited in the Sheet area.

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)

INTRODUCTION

The main objectives of the Officer Basin Project are to understand the geology of the Western Australian part of the Officer Basin and to publish the results in the form of: twenty 1:250,000 geological maps and explanatory notes, a bulletin synthesizing the geology of the whole area accompanied by a 1:1 000 000 geological map, and papers on specific aspects of the geology. Geological mapping was done in 1970 and 1971, and shallow stratigraphic drilling and geophysical work in 1972. Reporting of results started in 1973 and continued throughout 1974.

PRELIMINARY MAPS

Twelve out of a total of twenty map sheets involved in the project had been printed in 1973 (see frontispiece (1)). Of the remaining eight sheets, seven (Cundeelee, Lennis, Minigwal, Neale, Plumridge, Rason and Waigen) were printed during 1974 and the remaining sheet (Throssell) has been compiled and will probably be printed in late 1974.

EXPLANATORY NOTES AND FIRST EDITION MAPS

The main effort of the group during the year has been directed towards writing of Explanatory Notes and processing of maps from Preliminary to First Edition. Explanatory Notes have been written for sixteen of the twenty Sheet areas. Five (Cobb, Herbert, Mason, Neale and Warri) are in press; four (Browne, Madley, Vernon and Wanna) are with the editors; and seven (Cundeelee, Minigwal, Plumridge, Rason, Seemore, Westwood and Yowalga) are in advanced stages of preparation. Compilation of Lennis, Robert, Throssell and Waigen has not yet started.

BULLETIN

Van de Graaff has written a first draft of his contribution towards the Bulletin and hand-drafted 24 illustrations. Generalization and reduction of the twenty three 1:250 000 Sheet areas comprising the area to be covered on the 1:1 million geological map accompanying the Bulletin has been completed. Coloured working drafts of the map have been compiled in Perth and Canberra for office use until the actual map is drafted.

DRILLING RECORD

A detailed re-examination of all cores and cuttings collected during the 1972 drilling project was made necessitating extensive revision of field lithological descriptions and consequent substantial rewriting of the drilling record. Over 200 samples were submitted for various detailed analyses, and the results incorporated in the record.

Palynology. E. Kemp (Palaeontological Section) examined material from nine of the drillholes. Late Asselian to Sakmarian (early Permian) spores and pollen were recovered from the Paterson Formation. A well-preserved assemblage of spores, pollen and microplankton of late Aptian age were recovered from the Samuel Formation in Browne 1. This new palynological information allowed refinements to be made on both the age and depositional environment of the two formations. The details of the palynological study are being published by E. Kemp in BMR Bulletin 160.

Geochemistry. Chemical analyses of laterite and silcrete cuttings were made to allow comparison of Officer Basin material with other areas. A noteworthy feature was the discovery of the mineral alunite, a potassium aluminium sulphate hydroxide, in the lower part of the Bejah Claystone in Browne 1. Although this mineral is most commonly associated with alteration of acid volcanic rocks it here appears to be associated with chemical changes taking place in the development of a siliceous duricrust.

The clay fraction of diamictites in the Paterson Formation from Rason 2 and Neale 2 was analysed for 12 trace elements to assist in the interpretation of depositional environments. The values for iron and manganese content were compatible with recent data for glacial rocks deposited under marine conditions. However, the other 10 elements favour an interpretation of a non-marine environment of deposition. Although the results of the geochemistry are not totally conclusive a non-marine origin is also strongly suggested by the palynological results.

Twenty nine samples of basalt from the Lower Cambrian Table Hill Volcanics in Westwood 1 were thin sectioned and chemically analysed. The results represent the first systematic chemical and petrological information available on this widespread formation. Chemically the basalts are similar to the Lower Cambrian Antrim Plateau Volcanics of the Northern Territory. The analytical results will be incorporated in the drilling record.

DETAILED MAPPING PROJECTS

SOUTHWEST QUEENSLAND GEOMORPHOLOGY PROJECT

by

B.R. Senior

This project, started in 1973, is a study of chemical weathering processes, landform development and neotectonics of the southwest Queensland region. The main study area encompasses the western portion of the Canterbury and Barrolka 1:250 000 Sheet areas, between latitude 25° and 26°30'S and longitude 141° and 142°E. This area was chosen because it contains an extensive cover of weathered rocks which are flat-lying or folded along zones adjacent to fold axes. Fieldwork was undertaken between July and the end of September.

A geological map at 1:250 000 scale and network of sections depicting the three-dimensional distribution of weathering, profiles is being prepared. The geological map will give detailed litho-stratigraphic and physiographic division of the component weathering profiles and associated Mesozoic and Cainozoic rock successions.

Three groups of weathered rocks have been delineated; the trizonal chemically altered Winton Formation profile, silcrete beds and silcrete profiles in the Glendower Formation, and fossil soils which form crusts on the older Winton Formation profile. The relationships between these three groups of weathered rocks are shown in Figure S4.

The chemically weathered Winton Formation is the most widespread profile and is of Late Cretaceous age. It is up to 100 m thick and the most complete sections have an upper siliceous zone, a central varicoloured zone and a basal ferruginous zone. Concretions, lenses and bedding surfaces enriched in iron oxides in the basal zone contain concentric cracks and syneresis voids which under special circumstances contain precious opal (see Precious opal in Queensland).

The three zones are gradational and chemical analysis shows a gradual decrease of iron oxides accompanied by increasing silica upwards. Montmorillonite is the dominant clay in the parent rock but gives way to kaolinite and subdominant illite in the profile.

Silcrete which has developed in quartzose sedimentary parent rock (Glendower Formation) has several forms which relate to the thickness, porosity and permeability characteristics of the host rock in the landscape in relation to growing fold structures. Two broad groups of silcretes were mapped: those with subjacent profiles and those without profiles.

(1) Silcretes without profiles.

In this category are massive silcretes which have formed by silica-bearing groundwater moving laterally through permeable sediments. The receptive zones of silicification appear to be mainly controlled by the bedding geometry of the host rocks. Several subvariants, within this group are:-

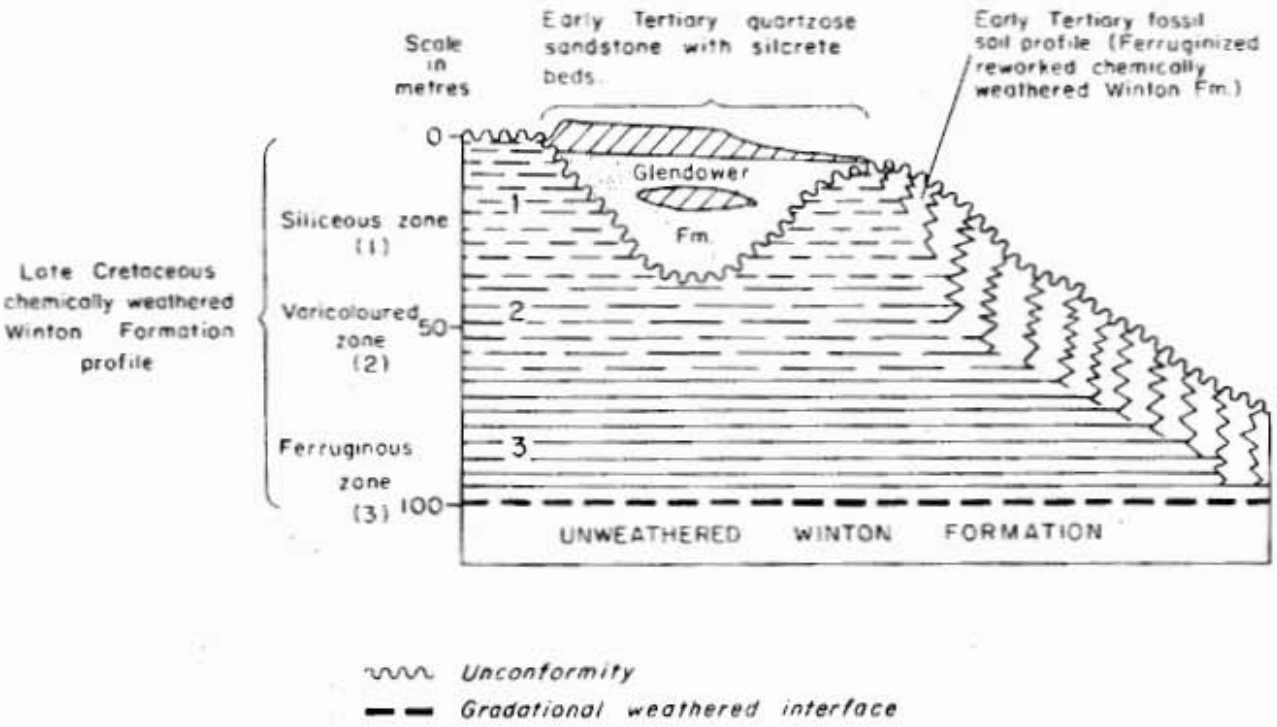
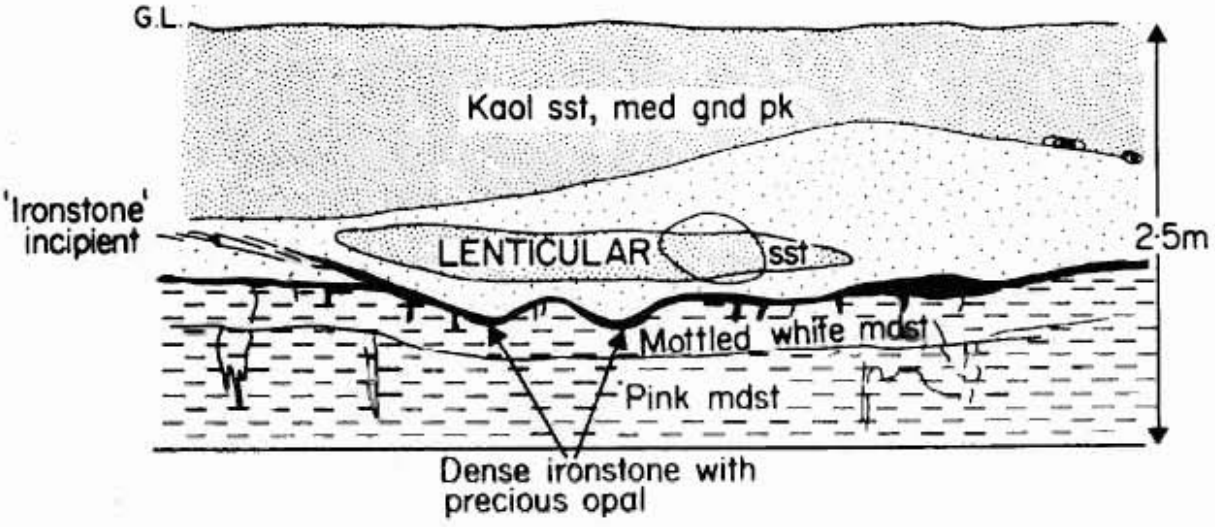
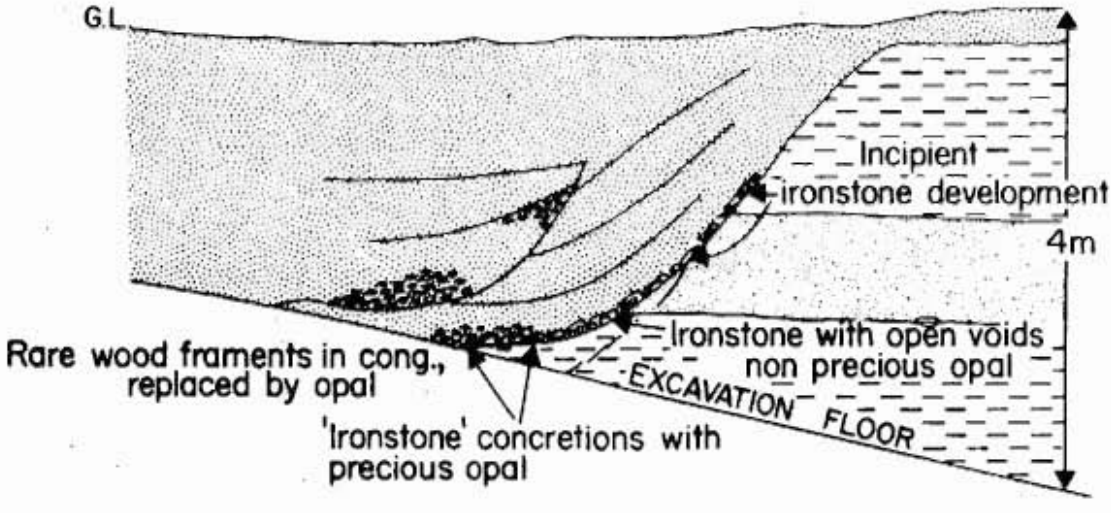


Fig. S4 Diagrammatic relationship of weathered rock units

SECTION 1 IRREGULAR BEDDING INTERFACE WITH SEAM OPAL



SECTION 2 CHANNEL FILL WITH BOULDER OPAL



SECTION 3 COMPACTION FAULT WITH SEAM OPAL

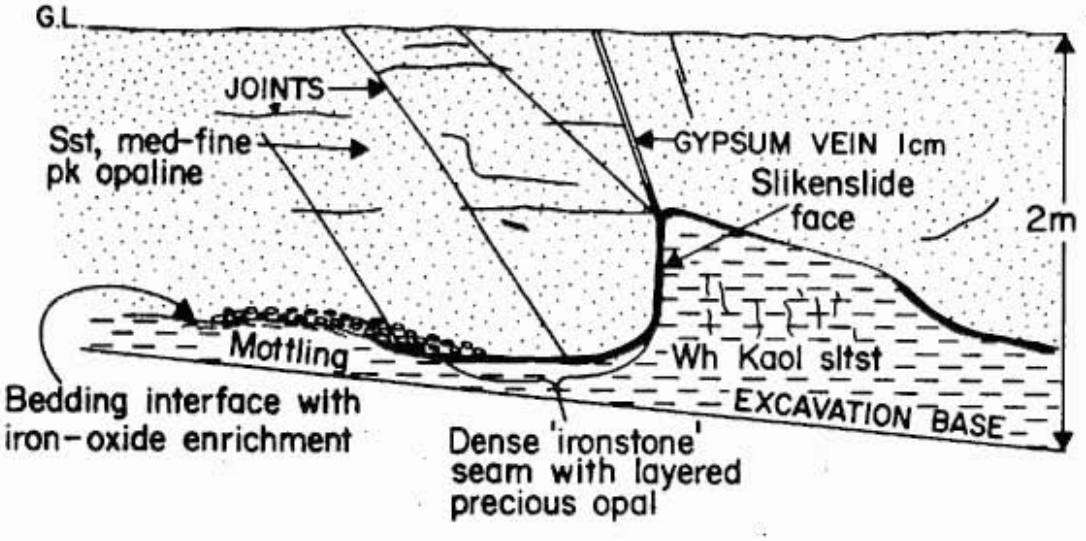


FIG. S5 PRECIOUS OPAL STRUCTURES

(a) Multiple beds of silcrete associated with thick sequences of quartzose sandstone which contained several zones receptive to silicification.

(b) Massive silcretes associated with thin well sorted sandstone on dip slopes. These grade downdip to zones of broad, less intense silicification where there is an intertonguing relationship with increasing thickness of unaltered parent rock. This group of silcretes appears to have formed by radial migration of siliceous groundwater from the axial zones of anticlines and domes towards adjacent downwarps.

(2) Silcretes with subjacent profiles.

In this category are blocky nodular and stumpy columnar silcretes which grade down into less siliceous cleaved and strongly brecciated sediments. Two types of silcrete are present, one developed in argillaceous quartzose sandstone of the Glendower Formation, and the other in the quartz-poor chemically weathered Winton Formation profile. The latter is not common and forms thin iron oxide-stained silcrete-cappings of local extent.

Indurated, iron oxide-rich, fossil soils up to 15 m thick are present in those parts of the landsurface which were not covered by fluviatile sedimentary rocks of the Glendower Formation. In these areas pedogenic processes reworked the exposed and truncated Winton Formation profile, and by a process of intense brecciation and iron-oxide cementation, formed hard crusts which grade down through a mottled zone into the older Winton Formation profile. A feature of this type of profile is its well developed macrocolumnar structure which is clearly seen in indurated cappings of plateaux and mesas.

Precious opal in Queensland

Precious opal deposits in Queensland are present in the chemically weathered profile of the Winton Formation. Opal is only present in areas where the chemically weathered Winton Formation profile has been truncated by erosion and the ferruginous zone has been brought closer to the ground surface and hence into the zone of fluctuating groundwater. Common opal was precipitated extensively in such situations. Precious opal was only precipitated under very special circumstances in situations controlled by the structure and bedding geometry of the host rocks. The several types of precious opal-bearing structures are illustrated in Fig. 35. A proton magnetometer was used in conjunction with detailed geological mapping to trace the extent of the host "ironstone". This technique has promise as a useful exploration tool in delineating "ironstone" concretions and lenses in flay-lying areas of poor outcrop.

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 (Figs S6, S7). 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 information obtained during the 1972 field survey was collated during 1973, and palaeontological, petrographic and geochemical analyses (Fig. S8) of samples were undertaken. First drafts of manuscripts on the sedimentary geochemistry, sedimentology (see under sedimentology, p. 38) and general geology of the Fairfield Group (Late Devonian-Early Carboniferous) were completed in 1974. A manuscript on the conodont faunas is in preparation.

The major conclusions of the geochemical survey are: (i) subtle but statistically significant differences in major and minor element geochemistry can be used to differentiate lithologically similar carbonate beds in the Gumhole (Late Devonian) and Laurel (Early Carboniferous) Formations (Fig. S8), (ii) these differences are probably due to environmental factors, particularly temperature and relative humidity, (iii) within the Gumhole Formation statistically significant differences in element concentrations are due to palaeogeographic and provenance factors, and (iv) the values for Pb, Zn, & Cu suggest that the units could have been used as conduits by mineralising fluids.

During the Late Devonian and Early Carboniferous there was a subtle change at the basin margin from an environment in which fenestrate carbonates were deposited to an environment in which marine bioclastic limestones with associated clastics were deposited. In the central part of the Fitzroy Trough deposition of shale was continuous. In the northwest part of the trough there was a long peninsula with associated islands jutting southward into the basin. "Reef" deposition may have continued longer around the islands than elsewhere in the basin.

Subsidence appears to have been continuous and, apart from downward movement, the basement blocks have tilted to the north so that maximum sedimentation has taken place in as many as three linear zones parallel to the basin axis. Relatively rapid subsidence occurred in do V-V1 time (latest Devonian) and culb time (early Carboniferous) separated by a period of slow subsidence. Slow subsidence also occurred towards the end of the deposition of the Fairfield Group. Both these slow subsidence periods were marked by the basinward spread of clastic sediments. The resulting overlap of porous and non-porous clastic sediments could have produced stratigraphic conditions suitable for the entrapment of hydrocarbons and base metals.

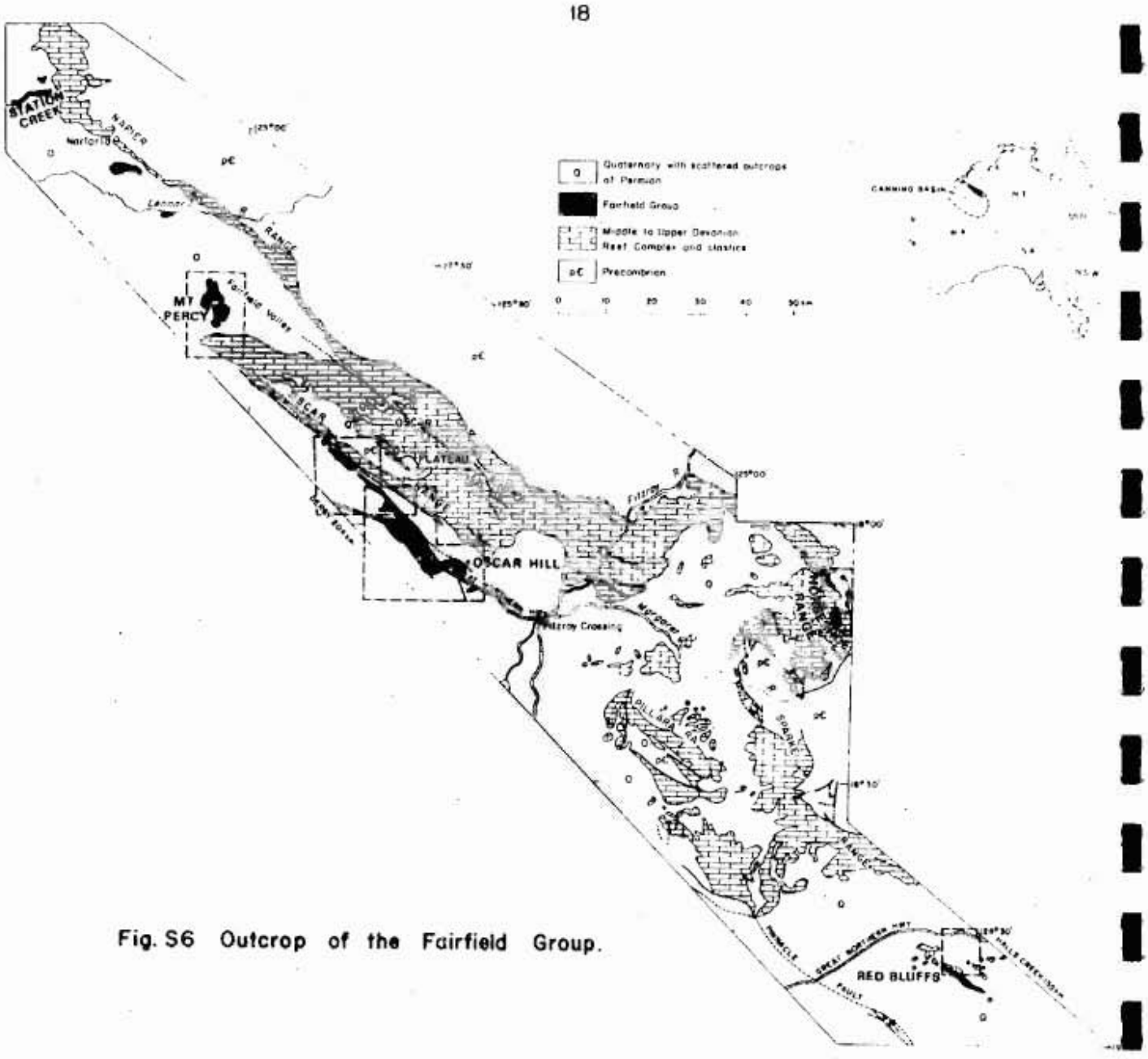


Fig. S6 Outcrop of the Fairfield Group.

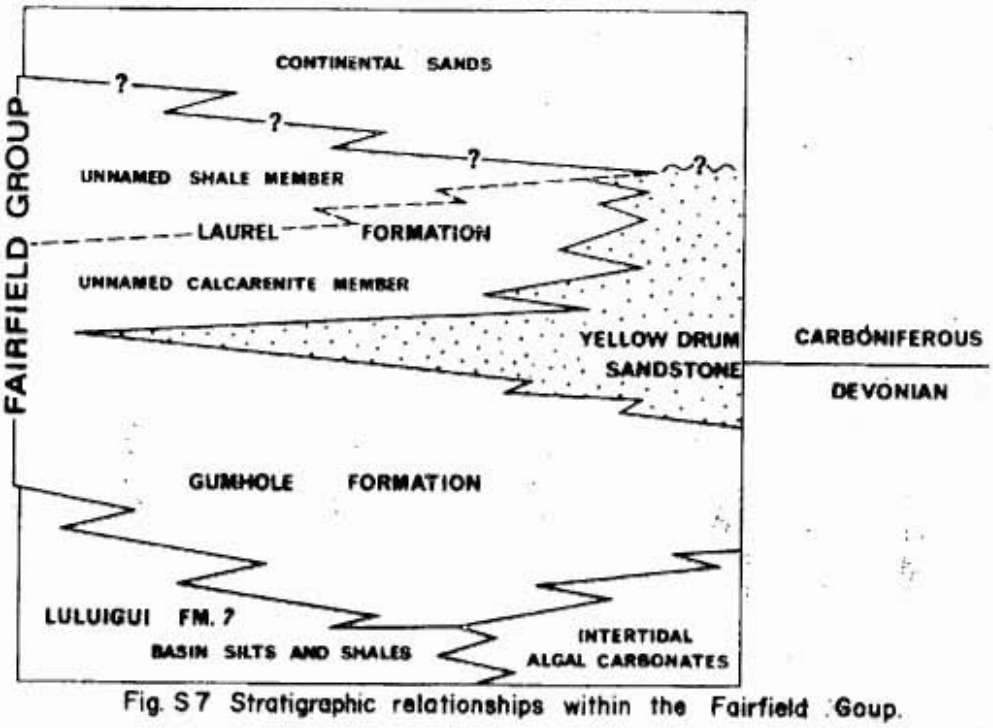
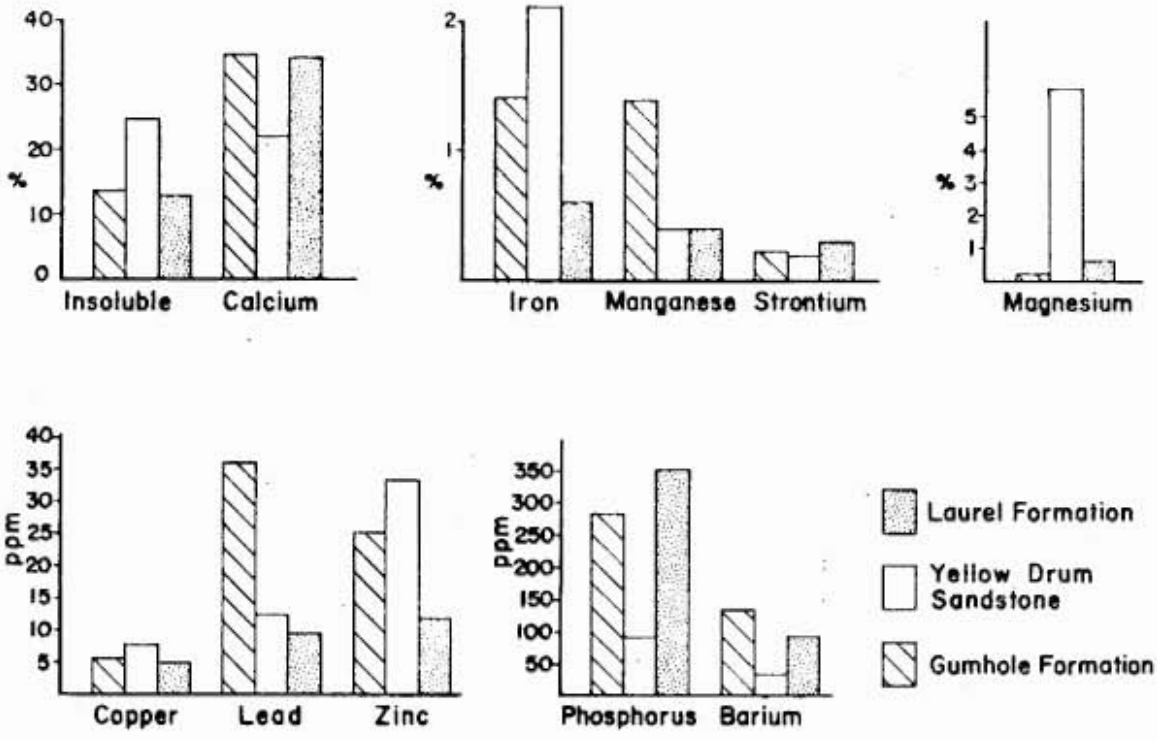
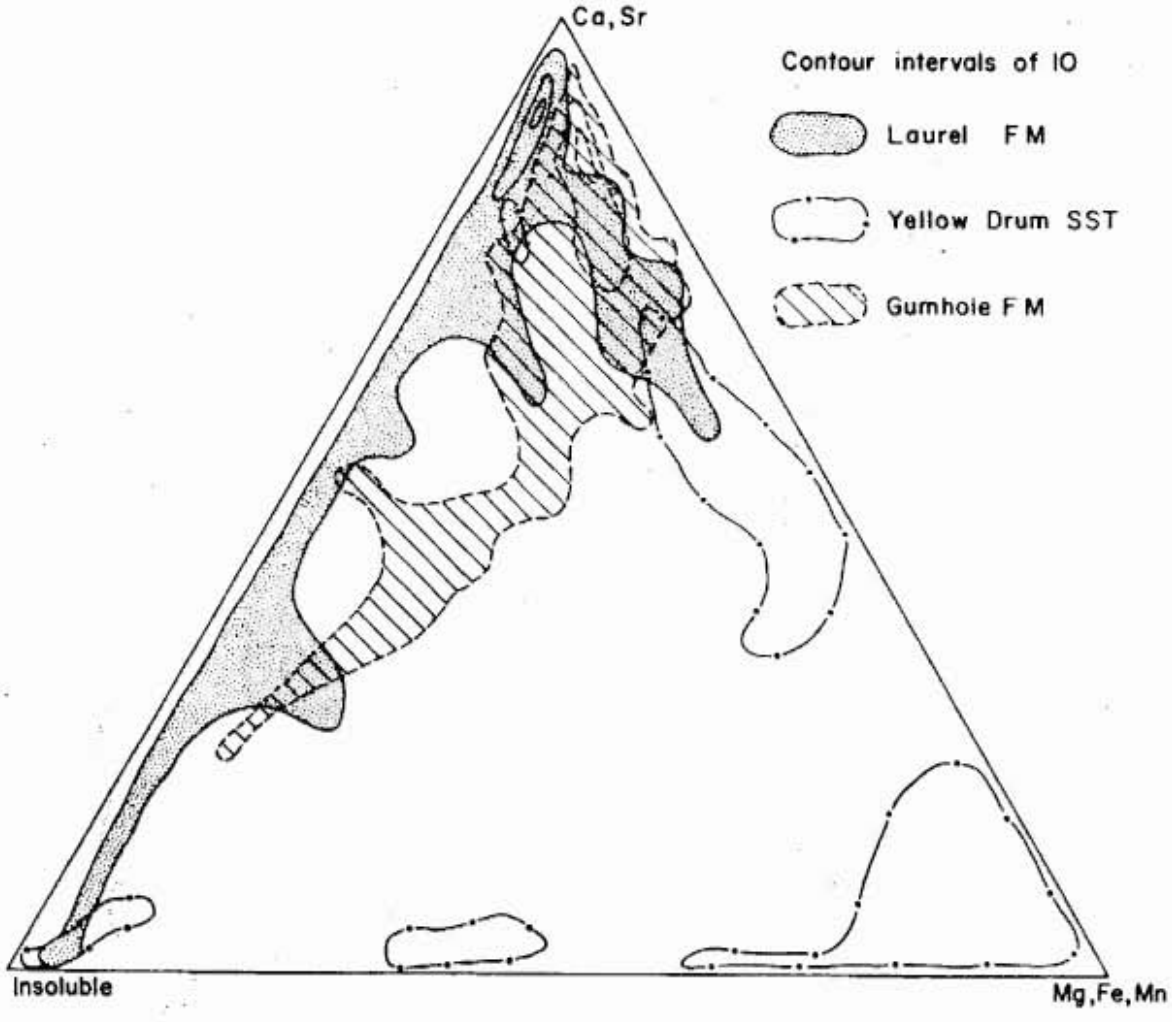


Fig. S7 Stratigraphic relationships within the Fairfield Goup.



(a) Mean element concentration, Fairfield Group Lithologies



(b) Q mode factor analysis of Fairfield Group Samples

Fig. S8 Geochemistry of Fairfield Group

GEORGINA BASIN PROJECT

by

E.C. Druce

STAFF: E.C. Druce, B.M. Radke, J.J. Draper, J.H. Shergold (part-time), G. Young (part-time), J. Pojeta (USGS)

The Georgina Basin Project is a detailed mapping project undertaken to improve the understanding of the geological history of the Georgina Basin and especially to elucidate the lithological and geochemical variation of units. It also includes a detailed study of the biota to aid in correlation, and palaeoenvironmental and palaeogeographical reconstructions. The results will aid the exploration for hydrocarbons, phosphate and base metals.

Field work in 1974 concentrated on the mapping of the Digby Peaks 1:100 000 Sheet so that (i) the lithological subdivisions of the Ninmaroo Formation (Tremadocian) could be studied and compared with the six informal members recognized to the south at Mount Unbunmaroo (Black Mountain), (ii) the upper Lower Ordovician Swift Formation could be examined in detail and its relationship to the Nimaroo Formation established, and (iii) the eastern margin of the Georgina Basin could be examined.

The study was undertaken by measuring 63 detailed sections together with comprehensive sampling for petrology, geochemistry and palaeontology. This was supplemented by six continuously cored stratigraphic holes (Fig. S9).

Preliminary results indicate that:

1. the informal members of the Ninmaroo Formation can be recognized in the Digby Peaks area;

2. the Ninmaroo Formation is composed of lithified shallow water sediments, fine terrigenous clastics, and carbonates which include ooid and algal peloidal grainstones, algal stromatolitic limestones, micritic and pelletal limestones with varying degrees of bioturbation, and both primary and secondary dolostone;

3. the Ninmaroo Formation was subjected to rapid lithification and brecciation to give intraformational conglomerates;

4. the Chatsworth Limestone, from which the Gola Beds could not be differentiated, is progressively sandier towards the top;

5. the extension of the Chatsworth Limestone beneath the observed base was shown in BMR Boulia No. 5 (140°20'E, 22°01'S) which was spudded in at the base of the type section - underlying the Chatsworth Limestone are limestones which are lithologically similar to the Pomegranate Limestone;

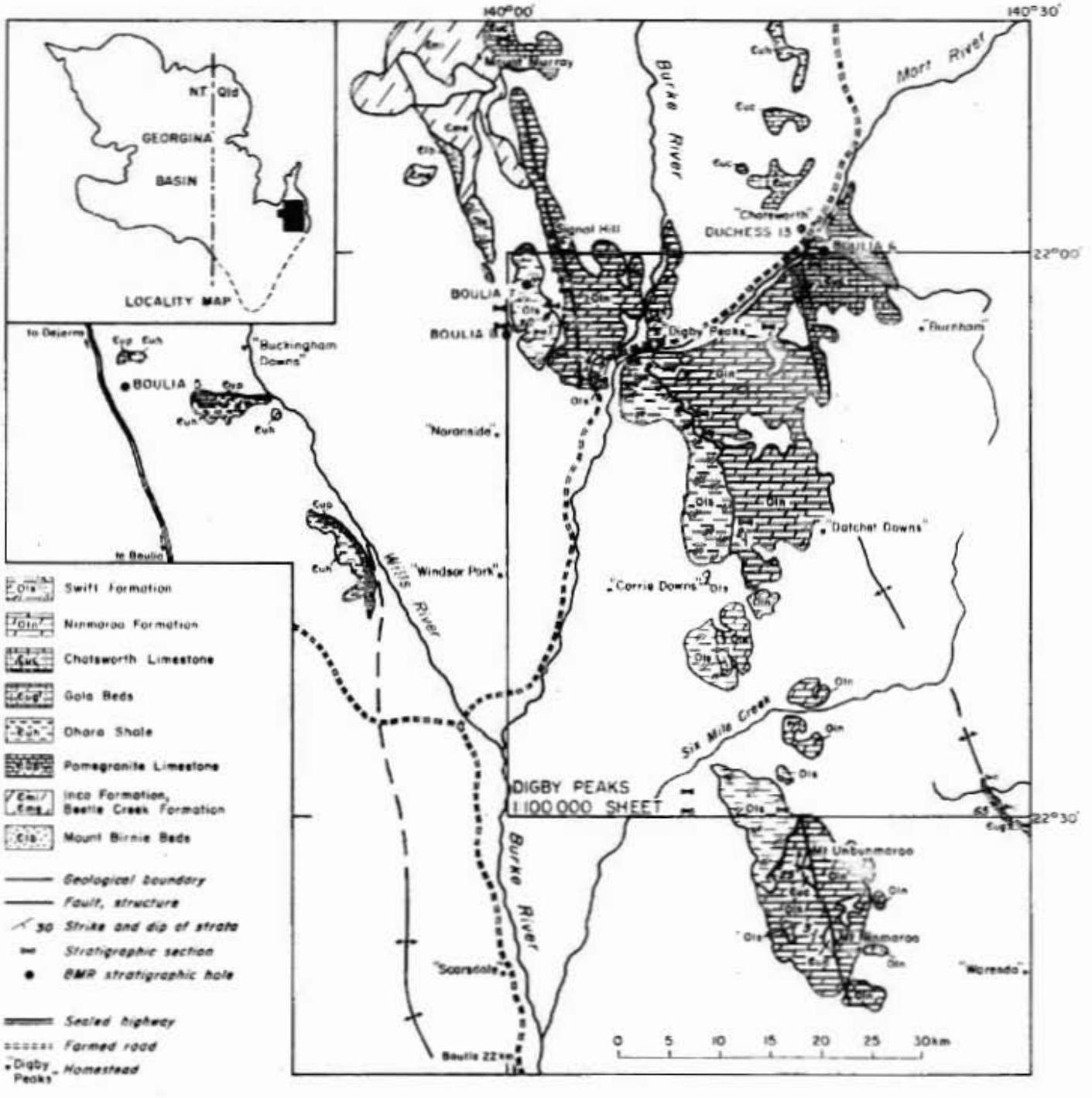


Fig. S 9 Burke River Structural Belt, Georgina Basin

6. the Swift Formation, in BMR Boulia No. 7 (140°02'E, 22°02'S) consists of porous white and brown manganiferous claystones with a few chert nodules, overlying silty peloidal limestones interbedded with shales - the sequence is extremely cavernous;

7. the proposed hiatus between the Ninmaroo and Swift Formations may not be present - apparent unconformable relationships may be due to cavern slumping and in several sequences the unit is conformable on the Ninmaroo Formation;

8. the Ninmaroo Formation and Chatsworth Limestone are missing on the upthrust Alderdey Block as shown in BMR Boulia No. 5 (139°38' 22°0'S) - the Cretaceous Wallumbilla Formation rests directly on Pomegranate Limestone (Lower Upper Cambrian) but whether this gap is due to non-deposition or subsequent massive erosion is unclear;

9. there is a strong WSW-ENE fault system developed in the Digby Peaks 1:100 000 Sheet area - the lateral movement is generally dextral;

10. the exposed Burke River Structural Belt is composed of at least three subparallel faults with blocks downthrown to the east;

11. and that colour aerial photography at 1:25 000 scale is of considerable benefit in interpreting outcrops of similar rock type were subtle colour contrasts cannot be seen with black and white photography.

E.C. Druce gave a paper on the Cambrian-Ordovician boundary in Australia with special reference to the Georgina Basin at the Palaeontology Specialists meeting in Hobart in February.

TANTANGARA - BRINDABELLA MAPPING PROJECT

by

M. Owen & D. Wyborn

The objectives of the Tantangara - Brindabella Mapping Project are: to assist in the revision of the Canberra 1:250 000 Geological Map, to provide basic information for engineering geological investigations and to obtain a better understanding of the igneous activity of the area in relation to mineralization.

November 1973 to early April 1974 were spent completing the mapping of the Brindabella 1:100 000 Sheet area. The map is being drafted and a record is being prepared. The preliminary edition of the Tantangara 1:100 000 geological map has been printed and the descriptive Record is with the editors.

Geochemical samples have been collected from the more important igneous rock units and selective K/Ar and Rb/Sr dating has been done. Seventy one samples have been analysed for major and trace elements this year bringing the total for the project to 192. K/Ar ages have been obtained from the Boggy Plain Granite (417 m.y.), Micalong Swamp Basic Igneous Complex (396 m.y.) and Peppercorn Hill basalt (23.6 m.y.). Rb/Sr isochron ages have been obtained from the Boggy Plain Granite (416 ± 5 m.y.) and acid volcanics from the Goobarragandra Beds (438 ± 16 m.y.).

A detailed interpretation of the geological history of the area can now be made. Each rock-unit has been assigned to a particular tectonic setting at its time of formation. The present distribution of these palaeotectonic units is shown in Figure S10. The area is underlain by a basement of ?Middle Ordovician oceanic crust that crops out about 15 km SSW of the area at Mt Jagungal in the core of a tightly folded north-trending anticline. Trace elements in these basement basalts and pillow lavas show that they belong to the abyssal tholeiite suite. The basalts are overlain by a thick sequence of deep water cherts and interbedded fine arenites, continuous in outcrop with the Darriwillian? Temperance Chert in the Happy Jacks area. The Boltons Beds are now thought to be a thick wedge of fine clastic rocks within the Temperance Chert. In the Late Darriwillian basic volcanic activity began in the region and chert accumulation gave way to mainly tuff deposition (Gisbornian Nine Mile Volcanics). These volcanics represent the southern limit of the Molong volcanic arc. Volcanism increased in intensity with time and lavas and flow breccias predominated in the upper part of the Nine Mile Volcanics. Much of the volcanics must have been submarine as pillow lavas are present north of Kiandra, but near Peppercorn Plain subaerial flows overlie tuffs and interbedded limestone lenses so volcanic islands were probably present in the region during the Late Ordovician. Trace element data for the volcanics indicate that they belong to the island arc tholeiite suite.

In the late Gisbornian or early Eastonian volcanism ceased and quartz-rich flysch sedimentation began. The relationship between the Gisbornian volcanics and the Eastonian flysch is not known, but the absence of any volcanic detritus in the flysch suggests that the flysch prograded over the volcanic arc from the west into a trough east of the arc. Flysch sequences of both proximal (Adaminaby Beds) and distal (Nungar Beds) aspect are present. Faunal evidence suggests that the Adaminaby Beds and Nungar Beds are partly lateral equivalents, though part of the Adaminaby Beds may be younger than the Nungar Beds. Deposition of the flysch sequences continued into the Bolindian and was followed at the close of the Ordovician by an early phase of deformation of the Benambran Orogeny, inferred mainly from the unconformity at the base of the Llandoverian Tantangara Beds. No syn-orogenic igneous rocks are associated with the folding. The Tantangara Beds represent a return to proximal flysch sedimentation and thick sediments were laid down before major isoclinal folding and uplift in the mid-Llandoverian. Sedimentation ceased in the area and intensive acid volcanism and granitic intrusion followed. By the Wenlockian two volcanic chains had developed, now represented by the Goobarragandra Beds in the west and the Uriarra Volcanics in the east. These two chains were separated by a shallow sea in which shelf sediments (the Cooleman Plains sequence) were deposited. To the north the seaway was more restricted and in the Yass 1:100 000 Sheet area the two volcanic chains coalesced, the deposits being known collectively as the Hawkins Volcanics. Subaerial acid

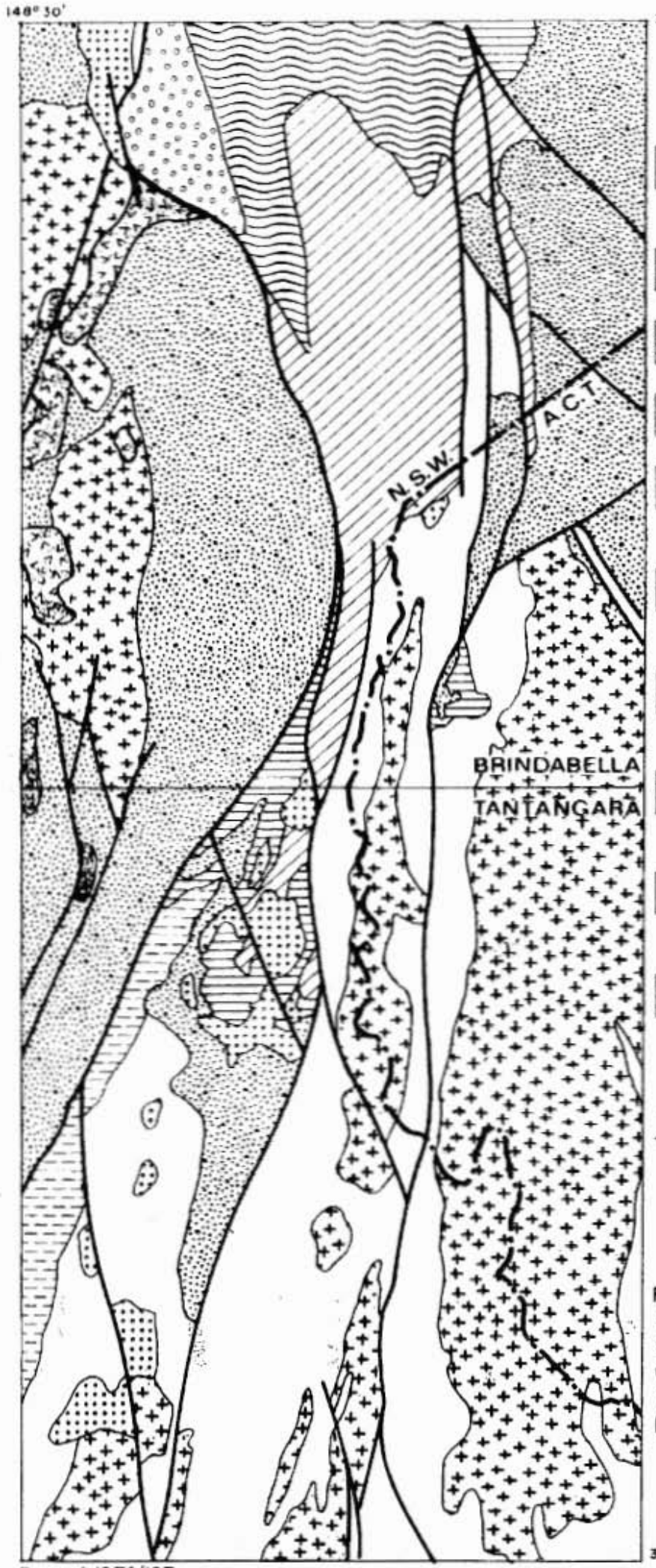


Fig. S10-Interpretation of the tectonic setting of the sedimentary and igneous rocks at time of formation, Tantangara and Brindabella 1:100 000 Sheet areas

volcanism continued into the Ludlovian (Goobarragandra Beds and Willow Bridge Tuff) and the shallow sea persisted until the Pridolian when another phase of folding took place. Folding was essentially of open style, on east-northeast-trending fold axes and was relatively minor compared to the Llandoverian folding. Acid volcanism followed the folding, the Pridolian Kelly's Plain Volcanics being deposited on the folded Cooleman Plains sequence. Trace element and strontium isotope geochemistry indicates that all the Silurian volcanics were derived by partial melting of sedimentary rocks together with smaller quantities of basic igneous rocks. While acid volcanism was taking place at the surface co-magmatic plutons were being intruded, mainly in anticlinorial zones. The oldest of these have been largely contaminated by partial assimilation of metasedimentary xenoliths and isotopic dating has been unsuccessful. These intrusions include the Clear Range, McLaughlin Flat, Willoona and Stewartfields Granodiorites. Younger uncontaminated adamellite and leucogranite give Pridolian isotopic ages of about 420 m.y. These intrusions include the Shannons Flat Adamellite, Yaouk Leucogranite, Gingera Granite, Happy Jacks Granite and possibly the Young Granodiorite.

The onset of the Devonian brought a marked change in the type of igneous activity. Tholeiitic gabbro, dolerite and anorthosite were intruded into the Goobarragandra Beds and Young Granodiorite in the west (the Micalong Swamp Basic Igneous Complex and the Pigeon Square Gabbro) and high level intermediate to acid intrusives (Boggy Plain Granite, Coolamine Igneous Complex, Jackson Granite and Burrinjuck Granite) were intruded to the east. Latite, rhyolite and high potassium rhyolite (Rolling Grounds Latite and Mountain Creek Volcanics) are associated with the intermediate to acid intrusives. These intrusives and associated volcanics are chemically very similar to island arc calc-alkaline and shoshonitic volcanics of the circumpacific belt. The strontium isotope content of the Boggy Plain Granite indicates a much deeper more primitive origin for the Early Devonian igneous rocks than for the Silurian igneous rocks. Rhyolitic volcanism decreased in the Emsian and was followed by the deposition of shelf sediments of the Murrumbidgee Group at Wee Jasper and Taemas and the Late ?Devonian terrestrial Hatchery Creek Conglomerate. The Mountain Creek Volcanics, Murrumbidgee Group and Hatchery Creek Conglomerate were all strongly folded on approximately north-south axes, probably at the end of the Devonian. The folding is most intense close to the pre-existing Long Plain Fault and may be related to movements on the fault below the Devonian volcanics and sediments.

Since the Devonian the area has been land with a subdued relief. Minor faulting, fluviatile sedimentation and alkali olivine basalt volcanism took place in the Tertiary.

HYDROGEOLOGICAL STUDIES

GREAT ARTESIAN BASIN PROJECT

by

M. Audibert

STAFF: R.S. Abell, M.A. Habermehl, G. Seidel (BMR);
M. Audibert, G. Krebs, P. Ungemach (BRGM)

The aim of the hydrogeological study of the Great Artesian Basin is to determine relevant hydraulic parameters so as to assess the groundwater resources of the basin and to enable predictions of the long-term consequences of a given exploitation scheme to be made. The tool selected for this study is a numerical model for which the computer program was written in 1972. By the end of 1973 three-quarters of the data had been collected and processed to suit the input requirements of the program.

Work during 1974 has involved: (1) The completion of the data gathering; (2) the re-assessment of the basin reservoir structure; (3) the preparation of and generation of basin input and calibration data; and (4) calibration of the model.

1. COMPLETION OF DATA GATHERING

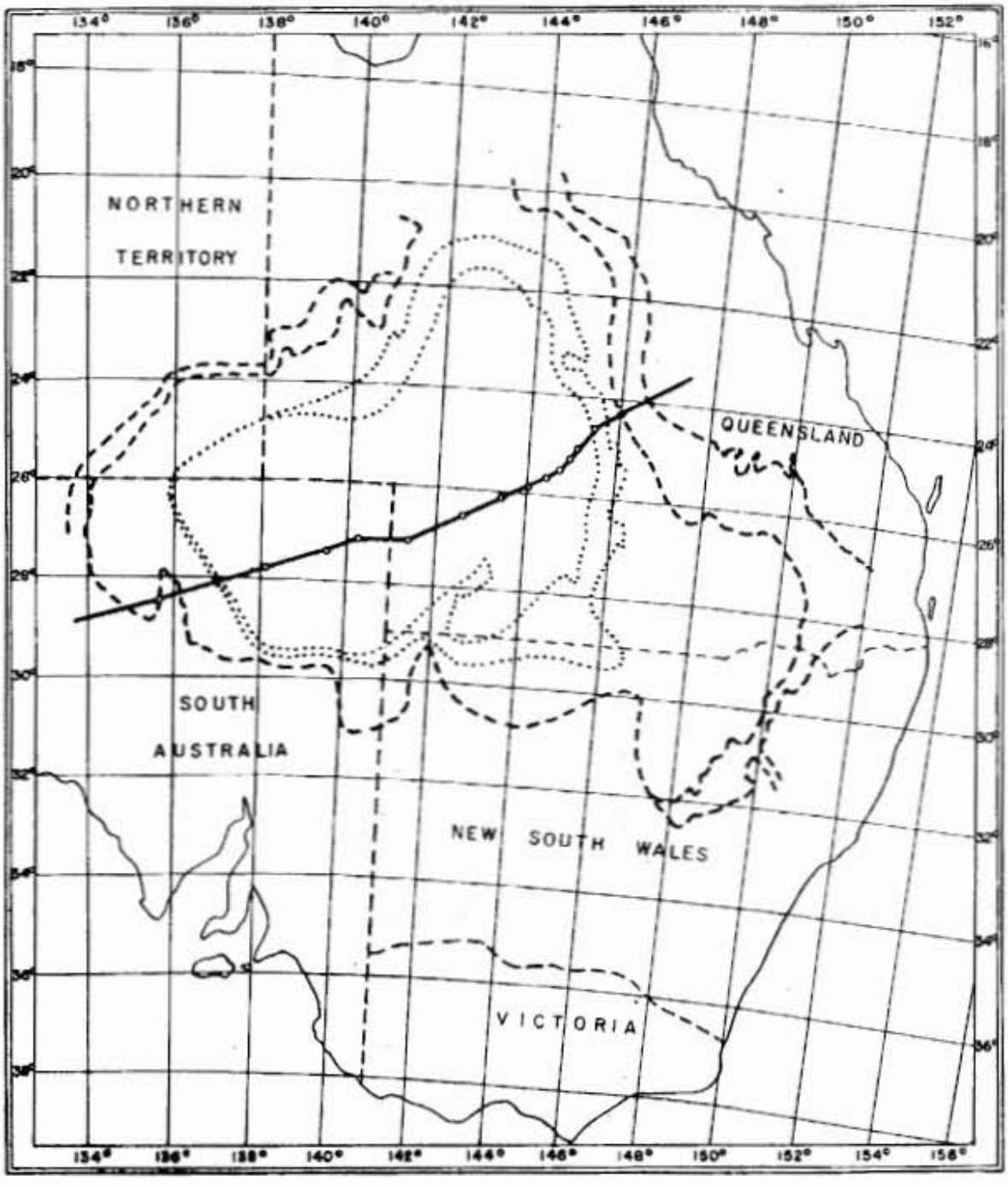
The process of coding and transferring all available hydrological data concerning artesian bores was completed in the early part of the year. Parts of South Australia were considered to lack sufficient hydrological information and moves were made to have field measurements made. Heavy rains during the year have prevented this however.

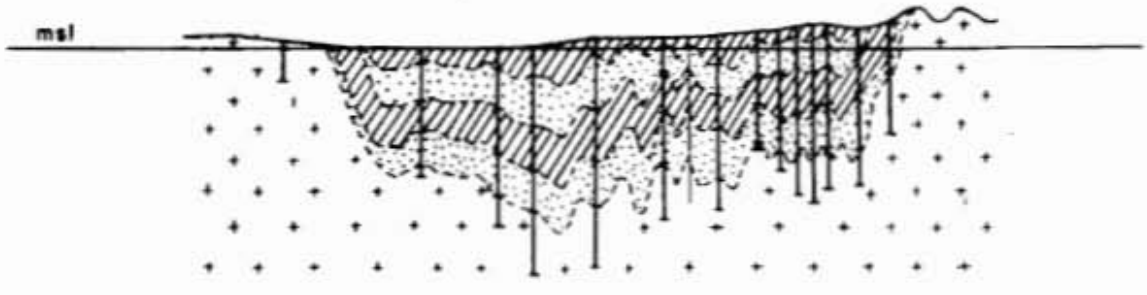
2. ASSESSMENT OF THE BASIC RESERVOIR STRUCTURE

A major change was effected during 1974 in the appraisal of the basin reservoir. By the end of 1973 the working assumption of the reservoir structure was that of a three-layered confined aquifer system, each aquifer within Jurassic and pre-Jurassic formations. Cretaceous rocks were then considered as a confining layer overlain by a water-table aquifer. Two factors necessitated a reconsideration of this picture:

a) It was realised that numerous subartesian bores and some artesian bores were tapping Cretaceous water-bearing layers and that the total discharge from these bores could not be reasonably ignored.

b) The preparation of potentiometric maps for the Jurassic aquifers showed that only minor differences in pressure, actually of the same order of magnitude as measurement errors, existed. Consequently the Jurassic aquifers should be simulated as a single aquifer. This view was supported by the fact that over 20 percent of the GAB area, one can lithologically distinguish no more than one single water-bearing formation in the Jurassic sequence.





Distribution of hydrogeological units

..... Outcrop limits CA1
— — — Outcrop limits CA2

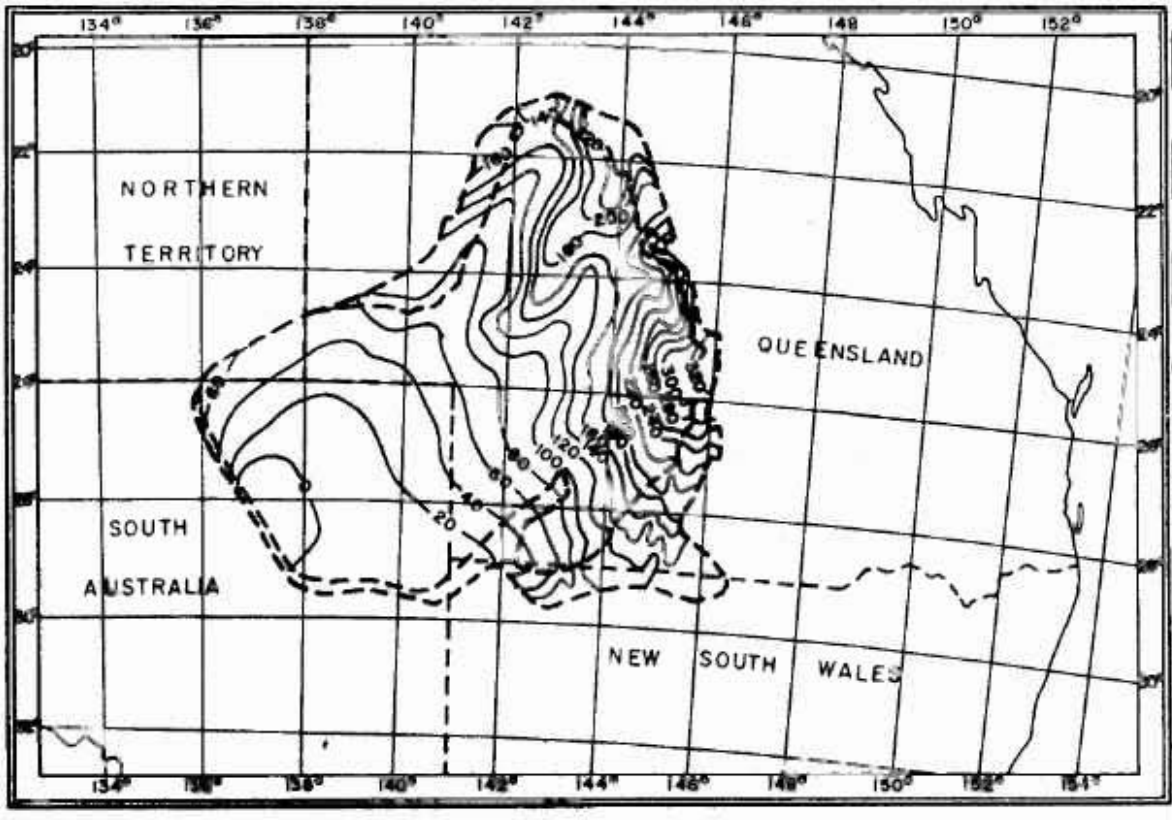
Aquifer

Confining beds

Hydrogeological basement

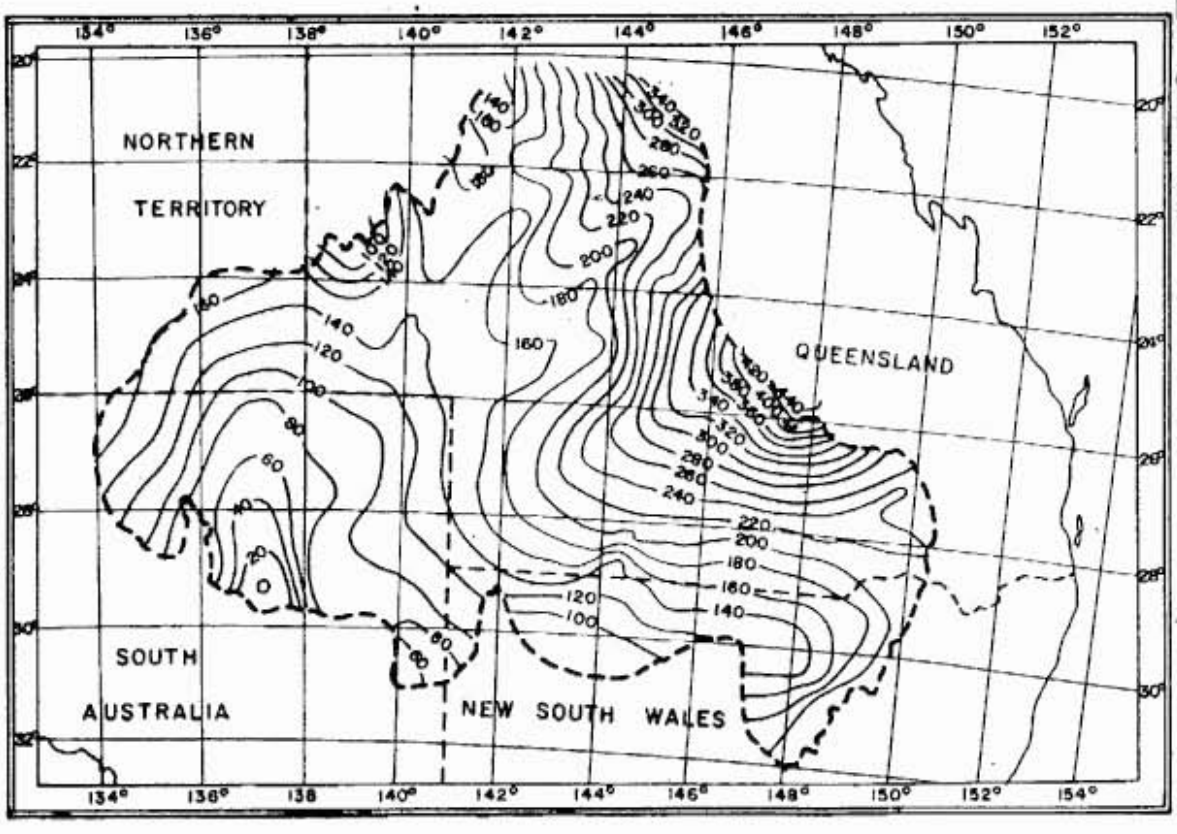
Scale : Horizontal 1:15000 000
Vertical 1:100 000 000

Fig. SII-Hydrological units in the Great Artesian Basin



Scale 1:15000 000

Potentiometric surface of confined aquifer CA1 (1970)



Scale 1:15000 000

Potentiometric surface of confined aquifer CA2 (1970)

Fig. S12 Potentiometric surface of confined aquifer in the Great Artesian Basin.

A special effort was then made to derive a "prototype" consisting of a water table aquifer and two confined aquifers, one in Cretaceous and the other in Jurassic formations (Fig. S11).

The hydrogeological prototype for the basin now used in the model is shown in Table S1.

Table S1. GAB hydrogeological prototype

Hydrogeological Unit	Symbol	Stratigraphic units
1st confining bed (includes water table)	CB1	Upper part of Winton Formation
1st confined aquifer	CA1	Lower part of Winton Formation, Mackunda Formation
2nd confining bed	CB2	Coreena Member, Doncaster Member, Allaru Mudstone
2nd confined aquifer	CA2	Cadna-Owie Formation, Hooray Sandstone, Injune Creek Group, Hutton Sandstone, Evergreen Formation, Precipice Sandstone, Moolayember Formation, Clematis Sandstone

3. PREPARATION AND GENERATION OF DATA

The input and calibration data were processed in two stages. Stage 1 consisted of:

a) preparing synthetic hydrogeological documents, which is a matter of interpolation or extrapolation of observed point values; examples of potentiometric maps prepared for confined aquifers CA1 and CA2 are illustrated in Figure S12.

b) assessing the geometry of the reservoir;

c) allocating to each node of the discretized fields the discharge figures.

Stage 2 dealt with the generation and storage on a disc-file of all necessary information in appropriate format relating to each node.

4. THE CALIBRATION

The aim of the calibration is to assess the correct values of hydraulic parameters. It is operated in two stages, referring respectively to the steady-state and the unsteady-state. The calibration is achieved when observed and calculated potentiometric values coincide.

4.1 Steady-state

The first eleven runs involved the simulation of both aquifers CA1 and CA2. The main trends of the potentiometry distribution in both aquifers were fairly well reproduced though all contours were smoothed. Another procedure was then adopted consisting of calibrating each aquifer separately. Two more runs using this method for CA1 have been completed and this aquifer is nearly calibrated. CA2 will soon be subjected to the same procedure.

4.2 Unsteady-state

The appropriate version of GABSIM will be run as soon as the calibration at steady-state is achieved. It has been necessary to design a segmentation tree for GABSIM in order to meet the core memory restrictions of the CYBER 76. The program is now ready to work after it has been checked on a theoretical case.

5. CONCLUSION

To sum up, this phase of the GAB project is approaching its conclusion. It is expected that the simulation of the GAB reservoir will be satisfactory in early 1975. Moreover the program GABSIM will be available in its different versions for usage in similar situations where a reservoir may be reduced to a multilayered system of aquifers and confining beds.

WIRE-LINE LOGGING OF WATERBORES IN THE GREAT ARTESIAN BASIN

by

N.F. Exon and N.A. Habermehl

LOGGING IN SOUTHERN QUEENSLAND

Fifty-four waterbores in the northeastern part of the Surat Basin were wireline-logged in late 1973 and early 1974 by Down Under Well Services Pty Ltd under contract to BMR. Gamma-ray, neutron anddifferential temperature logs were normally run and electric logs were run where it was feasible. A summary of the number of holes logged in each area is:

1:250 000 map sheet		bores logged	average depth	max. depth
Taroom	SG55-8	23	365 m	1052.1 m
Roma	SG55-12	11	365 m	566.9 m
Mundubbera	SG56-5	8	365 m	593.1 m
Chinchilla	SG56-9	12	365 m	760.4 m

Both artesian and sub-artesian bores were logged and the quality of the logs is good. The bores penetrated major aquifers in the Jurassic Precipice, Hutton and Gubberamunda Sandstones, and in the Cretaceous Mooga Sandstone.

The logging program in the Queensland part of the Surat Basin has now been completed, and Report 188 - Wireline logging of waterbores in the Surat Basin, 1960 to 1974 - has been prepared by N.F. Exon and Mrs Jean Morrissey.

Altogether 263 waterbores and 20 petroleum exploration wells converted to waterbores were logged in the Surat Basin; the basic scale used was 1 inch = 100 ft (1:1200). So far, the major use of the logs has been in stratigraphic correlation, but the program was also designed to aid aquifer studies.

LOGGING IN NEW SOUTH WALES

The contract for the logging of waterbores was awarded to Down Under Well Services Pty Ltd at the end of September, and operations are expected to start at the end of October 1974. This program will be carried out in the NSW part of the Surat Basin and in the Coonamble Embayment. Only sub-artesian wells and artesian wells which have ceased flowing are to be logged, restricting activities to the eastern and southeastern margins of this part of the basin. Considerable time was spent in 1974 identifying holes which could be logged and selecting the deepest for inclusion in the program.

Objectives of the logging are mainly the identification and correlation of stratigraphic units and aquifers using natural gamma-ray neutron and temperature logs.

DATA SYSTEM

Since the commencement of logging in 1960, about 1000 waterbores have been logged by BMR and its contractors.

The compilation was started of data on the bores logged, type of logs run, stratigraphical and hydrogeological information obtained, and the result of chemical analysis of the water.

HYDROGEOLOGY OF NORFOLK ISLAND

by

R.S. Aboll

The purpose of the study of the hydrogeology of Norfolk Island is to evaluate the possibilities of a supply of groundwater deeper than that being tapped at present. To achieve this the island was visited for 10 weeks between July and September 1974 to collect hydrogeological data to assess (1) the existing groundwater resources of the island and (2) what data will be needed to investigate more fully the existence of deeper groundwater.

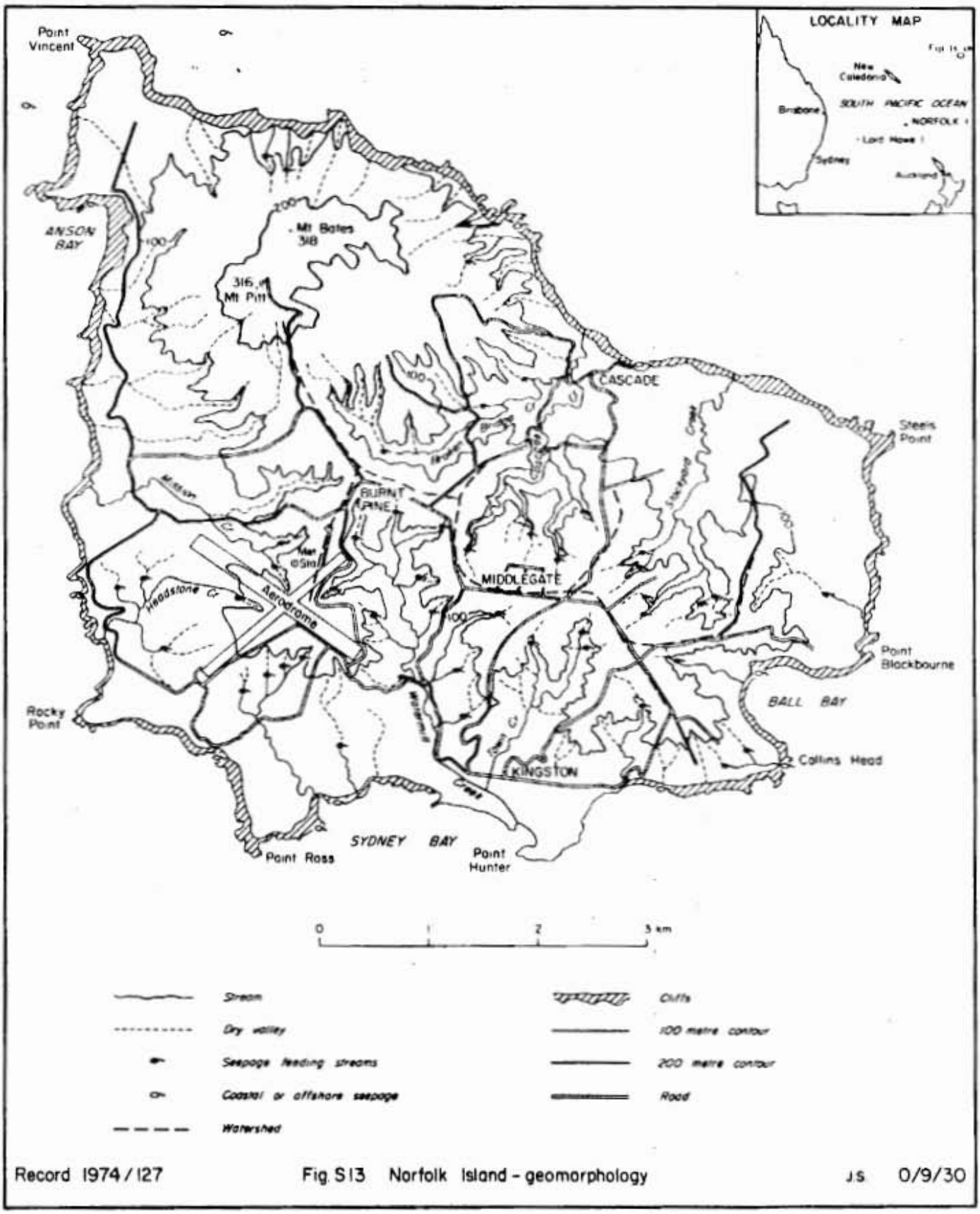
Norfolk Island lies in the southwest Pacific Ocean at latitude 29°S and longitude 168°E. It has an area of about 35 km^2 and rises as a small land mass from the Norfolk Ridge which extends from New Zealand to New Caledonia. The island is a deeply weathered erosional remnant of an extinct volcano constructed during several volcanic episodes between 3.05 and 2.3 m.y. ago. Volcanic activity ceased in the late Pliocene.

GEOMORPHOLOGY (Fig. S13)

Much of the island consists of a deeply dissected plateau which averages 100 m in altitude with Mt Pitt and Bates the highest points, rising to 318 m. Except for part of the south coast at Kingston, the island is bounded by cliffs up to 90 m high. In situ weathering and dense vegetation limit the exposure of fresh rock inland, but the 32 km coastline provides a continuous one dimensional picture of the geology. Weathering can reach depths of 65 m and is largely controlled by the sub-tropical climate and high permeability of the volcanic succession. The drainage pattern is radial to the main volcanic vent in the northwest, but over the remainder of the island an important NE-SW watershed links Mt Pitt with Ball Bay. The island is drained by streams fed in their higher reaches from seepages and to a large degree maintained along their courses by baseflow. Most streams flow during the winter months but in summer dry out or are reduced to disconnected pools and swamps. The upper tributaries in all catchments are dry. Stream valleys are not incised far below the zone of weathering and some streams discharge over the cliffs as a waterfall or series of rapids. None of the streams is presently gauged although some discharge figures are available for Watermill and Broken Bridge creeks from a program of stream gauging carried out in 1949-50. In some catchments where land clearing has created tracts of pasture, shallow groundwater has contributed to the development of soil creep and slumping. Post-eruptive marine erosion has truncated the drainage along the coastline and it appears from the maturity of the drainage pattern, wave cut platforms and sea stacks that the island was more extensive in the past.

GEOLOGY

Jones and McDougall (Jour. Geol. Soc. Aust. 1973, 20, 239-258) defined four volcanic formations based on stratigraphic, geochronological and palaeomagnetic polarity data. Basaltic sheet lavas, the commonest rock type on the island, are generally flat lying although locally they dip up to 10°. Individual flows up to 30 m thick are well jointed and



Record 1974/127 Fig. S13 Norfolk Island - geomorphology J.S. 0/9/30

vesicular. Yellow basaltic tuffs are interbedded with basalts and range in thickness from a few metres up to 30 m. They have been draped over erosion surfaces cut into basalt; their upper surfaces are in structural continuity with overlying lava flows. Sedimentary structures such as cross bedding, ripple marks, cut and fill structures and bedding expressed as abrupt changes in grain size suggest deposition in an aqueous environment. A quench zone consists of hackly jointed lava and flow-foot breccia. This lithofacies transgresses formation boundaries and is interpreted as the abrupt cooling of lava from air to water. Along the shore at Kingston crossbedded calcarenites containing water-worn basalt boulders overlie carbonaceous sandstone with wood fragments. These are the youngest rocks and dated as late Pleistocene.

GROUNDWATER RESOURCES

An average yearly rainfall of 1350 mm is both sufficient and reliable enough to provide runoff from roof catchments for storage in rainwater tanks. This is the most common type of water supply. Surface water is utilized either by pumping directly from streams or from small surface storages. There are presently 37 surface water abstraction points on the island. Groundwater recovered from bores and wells presently supplements rainfall except in summer and in times of below average rainfall. There is a growing dependence on groundwater with the expansion of the tourist industry. Most groundwater is used for domestic and garden purposes and some for stock, irrigation, light industry and one bore is used for the disposal of treated sewage effluent. A proportion of groundwater abstracted returns to the ground as outflow from a septic tank system operating on the island.

Yields are higher from bores and wells situated along valleys compared with those on watersheds. The manner in which land has been subdivided has attracted population growth to higher ground which has caused a major concentration of bores and wells in the Emu Pine-Middlegate residential-shopping complex.

An inventory of all bores and wells on the island shows that there are 176 hand dug wells and 114 rotary drilled bores. Ninety-four wells are currently in use and 82 abandoned (60 of these give water-level information). Sixty-eight bores are in use and 46 abandoned (30 of these give water level information although they were dry when pump tested on completion of drilling). Bore and well information collected include depth, casing, water level, yield, use, consumption, quality and pump details. The data available are probably sufficient for the production of a water table map.

All bores and wells tap a shallow, unconfined aquifer corresponding to the zone of deep weathering. The upper boundary of the aquifer is defined by a water table and its base by an irregular surface of unweathered volcanic rock. The lateral boundary is the margin of the island where the weathered zone is continuously exposed. Data on aquifer thickness are available from bores that have been drilled to bedrock. The weathered zone, exposed in numerous road cuttings, contains residual products typical of chemical weathering of volcanic rock in sub-tropical conditions, e.g. red-brown clays and basalts with spheroidal texture. The permeable nature of the weathering products facilitates a rapid infiltration of rainwater to deeper levels.

Water quality on the island is generally good (field electrical conductivity values are normally less than 1000 u mhos/cm^{-1}). Groundwater salinities increasing from the centre to the margin of the island may reflect contamination from salt spray. Chemical analyses already available show significant concentrations of Na^{+}, Fe^{+}, Cl^{-} and low pH values. Seawater intrusion is not presently a problem on the island, although two wells near Kingston contain brackish water which may indicate the existence of a saline/freshwater interface.

ADDITIONAL DATA REQUIRED

To assess the existence and location of groundwater beneath the weathered zone will require the following:

(1) A water balance study based on the relationship P (rainfall) = ET (Evapotranspiration) + D_A (Artifical groundwater abstraction) + D_N (Natural groundwater discharge.

(2) A photogeological study to plot the distribution of lineaments. These linear features are joints which influence the shape of the island, the drainage pattern and may facilitate downward leakage of groundwater from the presently exploited aquifer. A reconnaissance study shows a persistent NE-SW zone of joints parallel to the long axis of the island. Intersections of joints directions are potential drilling sites for deeper water supplies.

(3) A knowledge of permeability distribution in the unweathered volcanic sequence. From an examination of the coastal geology there appears to be irregular permeability particularly in sheet lavas where joints separate zones of dense impermeable basalt. Joints, which are more closely spaced in basalt lavas than tuffs, represent sites of increased vertical permeability. Horizontal permeability exists along joints and between lava flows. The occurrence of vesicular basalt, basaltic tuff and flow-foot breccias adds to the total permeability of the sequence. The calcarenite at Kingston has intergranular permeability. Seepages from coastal cliffs, and offshore springs observed by local people near Point Vincent suggest significant hydraulic conductivity exists at deeper levels.

SEDIMENTOLOGICAL STUDIES

LAKE FROME PROJECT

by

J.J. Draper

STAFF: A.R. Jensen, J.J. Draper

During 1973, a study was made of the surface and near-surface sediment in Lake Frome, South Australia. The aim of the study was to determine if the movement of sediments and fluids in an internal drainage basin in an arid climate could concentrate metals through evaporation or the action of sulphate-reducing bacteria.

SEDIMENT DISTRIBUTION

The distribution of sediment is normal for a lake, coarse sediment lying near the edges and finer sediment towards the centre. The thickest salt crust also lies, as would be expected, near the centre of the lake but it appears to lie just north of the present day deepest areas; this suggests relatively recent southwards tilting. The sequence of deposition of the top several metres of sediment records a transgressive phase followed by a regressive phase and then a period of erosion. A wedge of sandy sediment overlies the resultant disconformity. Radiocarbon dating carried out on organic-rich clays indicates that at least two metres of sediment have been deposited in the last 15,000 years.

BRINES

The surface waters and groundwaters of Lake Frome are extremely saline, the salinity (expressed as Total Dissolved Solids 180°C), ranging from 24 percent to 34 percent with a mean of 31 percent. Sodium and chloride are the major ions. The bicarbonate content is extremely low (less than 0.1 percent of total dissolved solids). There is no apparent concentration of minor ions in the brines.

Cyclic marine salts are not considered to be the main source of salt in the brines. The salts are almost certainly derived from the erosion of rocks within the drainage basin. The two rock groups considered to have contributed are: (a) marine Cretaceous rocks or (b) Adelaidean sediments containing above average quantities of saline minerals.

SEDIMENT GEOCHEMISTRY

The sediments were analysed for Cu, Pb, Zn, Mn, V, Fe, P, SO_4, U and organic carbon. The range histograms (Fig. S14) shows the generally low values obtained. From a detailed study of the sediments the following observations can be made:

(a) There is no apparent concentration of metals by evaporative processes;

(b) The distribution of the elements appears to be controlled by provenance;

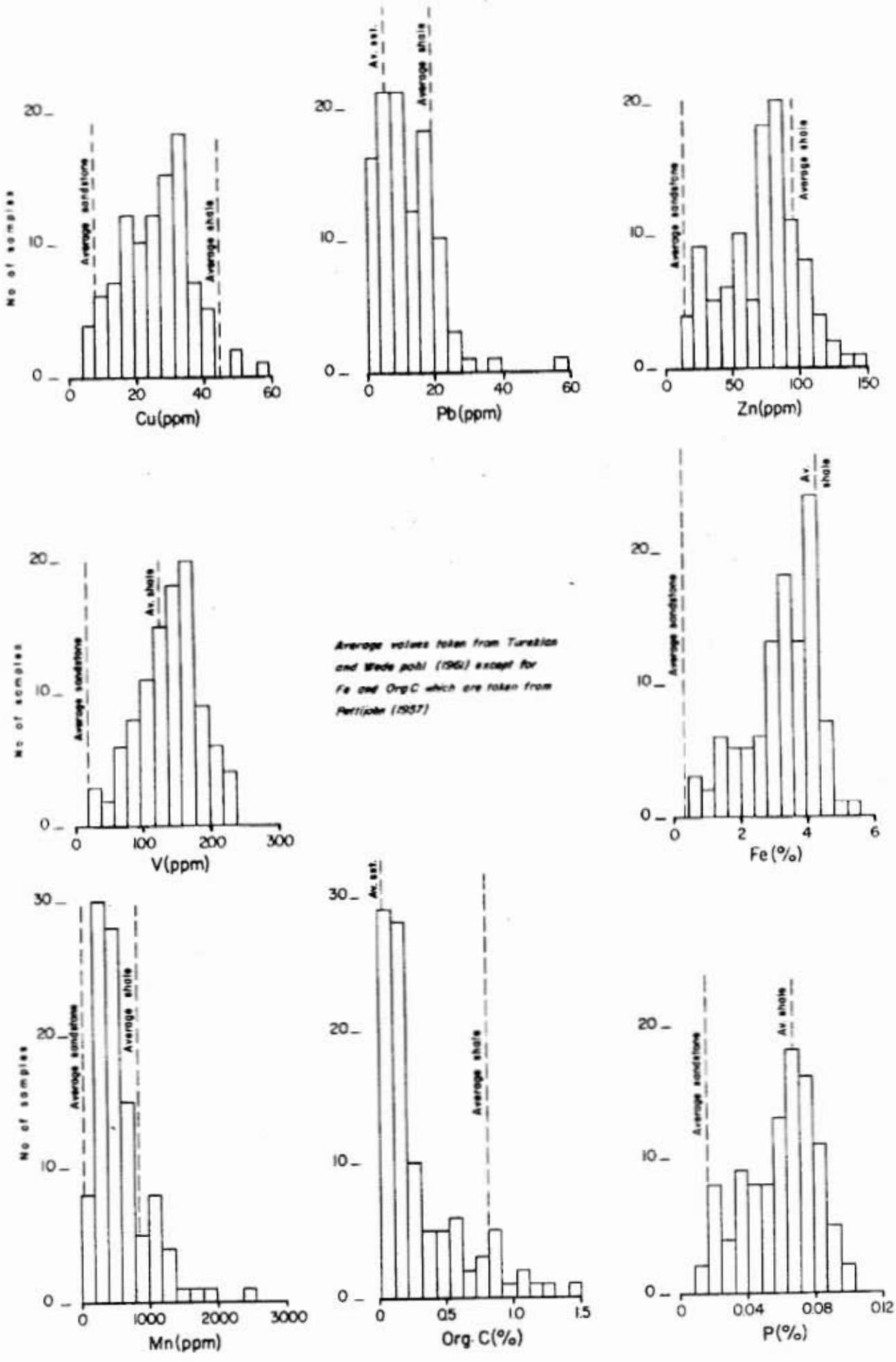


Fig. S 14 Range histograms – minor elements, Lake Frome, S. A.

(c) Algae have concentrated manganese in some areas of the lake;

(d) Lead is probably being leached from the sediments as highly soluble chloride complexes, but there are no obvious signs of reconcentration in the sediment examined;

(e) Lake Frome is unsuitable for the study of uranium deposition since uraniun is deposited from groundwater prior to its entry into the area of the lake.

MOUND SPRINGS

Two types of mound springs were observed, the northern ones are composed of clastic material and the southern ones of carbonate. It is suggested that the water issuing from the springs is primarily artesian water from the Great Artesian Basin mixed with minor amounts of near-surface brines.

LAUREL-FAIRFIELD PROJECT, CANNING BASIN

by

B.M. Radke

INTRODUCTION

Field work for the Laurel-Fairfield project was completed in 1972; laboratory studies and analysis were completed early in 1974 and the manuscript of the report on the work is well advanced.

The study covers the area of outcrop of the Fairfield Group (Fig. S6) on the Lennard Shelf, Canning Basin. A revised nomenclature of the sequence is shown in figure S7. The Fairfield Group which is equivalent to the Fairfield Formation of Playford & Lowry (1966), comprises the Gumhole Formation (equivalent of the Fairfield Beds), Yellow Drum Sandstone (new formation) and the overlying Laurel Formation. The carbonate sequences of the Gumhole and Laurel Formations were recognized before the present survey, but their differentiation was a problem.

It was by stratigraphic drilling in 1972 that the presence of the Yellow Drum Sandstone lying between the two formations was established.

The objectives of the project were twofold:

(i) To resolve lithologic criteria for the differentiation of limestones from the Laurel and Gumhole Formations. (This was critical to the study prior to the recognition of the Yellow Drum Sandstone); and

(ii) To study the lithostratigraphy and determine the depositional history and controls of sedimentation.

DIFFERENTIATION OF FAIRFIELD GROUP LIMESTONES

Multivariate analysis of petrographic and geochemical data required use of a taxonometric technique, commonly known as a "cluster" of "classificatory" analysis. This incorporated hierarchical classification programs (MULTBET, MULCLAS), and ordination programs (GOWER, MAXGOWER) which produced the classification models. Supplementary diagnostic programs (GROUPER, GOWBCOR) evaluated the significance of petrographic and geochemical attributes in the classifications. Using two group samples, each of over 100 individuals, the petrographic and geochemical data were analysed separately and the conclusions reached were:

(1) The ordination method produced the maximum differentiation (75% of the sample);

(2) The Gumhole and Laurel limestones are readily differentiated both petrographically and geochemically;

(3) Bryozoans, a dominance of ooids or brachiopods, and high values of manganese, iron, lead and Ca/Mg ratios typify the Gumhole Formation. Pelecypods, silt, and relatively high values of strontium, Sr/Ca ratios, magnesium and calcium typify the Laurel Formation.

DEPOSITIONAL HISTORY OF THE FAIRFIELD GROUP

Within measured sections, different facies were recognized on the basis of carbonate petrography. The depositional environment of each facies was interpreted from sediment texture, sedimentary structures and fauna, allowing the depositional history of the sequence to be interpreted.

Gumhole Formation

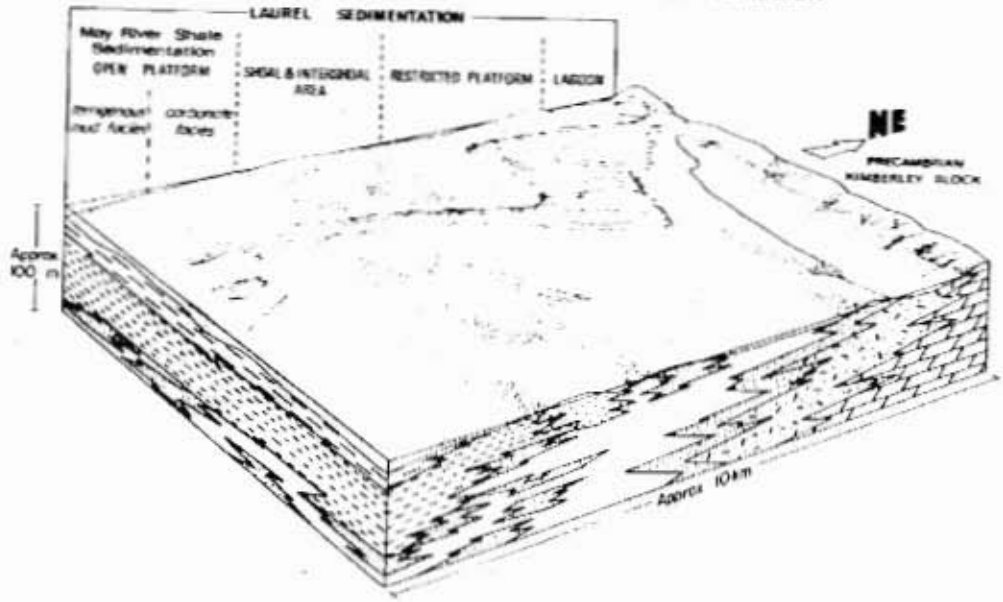
Sedimentation occurred in shallow water on a broad marine platform which sloped gently seawards. The platform is subdivided into three zones (Fig. S15), (i) the open platform with scattered small bioherms, (ii) a shoal area with active development and migration of shoals in response to tidal and onshore currents, and (iii) an intertidal zone with algal laminated carbonates. This distinctive latter sequence, which is laterally equivalent to the Gumhole Formation has not, as yet, been named.

During deposition of the Gumhole Formation there was an initial transgression (Fig. S15) followed by a stillstand period and a final regression.

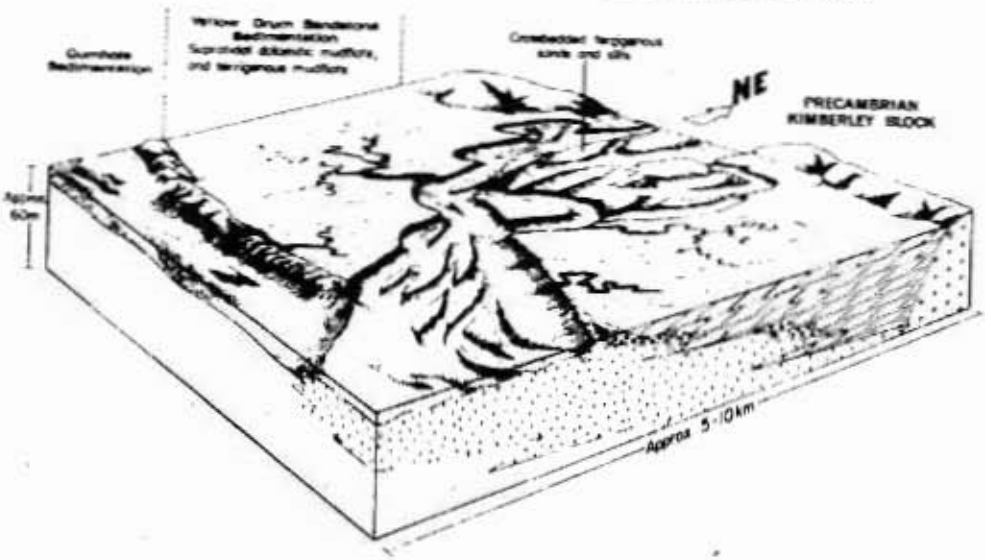
Yellow Drum Sandstone

Deposition resulted from a greater influx of terrigenous sediment and caused a sand sheet to prograde over the Gumhole Formation. Tectonic and, or climatic effects were responsible and an abundant pteridophyte flora suggests a high rainfall.

DEPOSITIONAL ENVIRONMENT OF THE LAUREL FORMATION



DEPOSITIONAL ENVIRONMENT OF THE YELLOW DRUM SANDSTONE



DEPOSITIONAL ENVIRONMENT OF THE GUMHOLE FORMATION

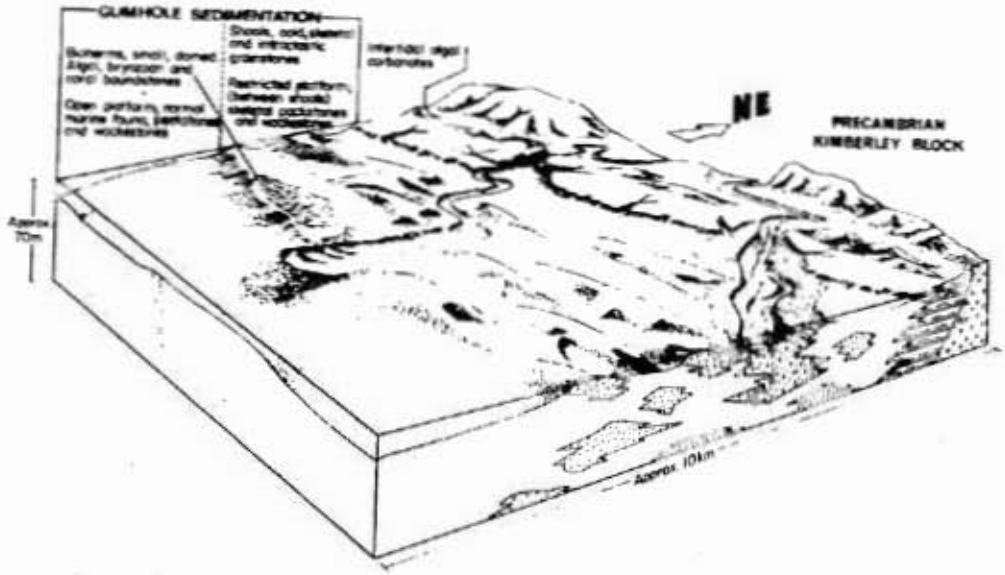


Fig. SI5 Facies distribution and depositional environments of the Fairfield Group

A broad coastal flat with subtidal, intertidal, supratidal and fluvial environments was produced. Marine inundations over the supratidal areas were infrequent and when brief, laminated dolomite was precipitated. Longer submergence allowed for bioturbation of these sediments. Estuarine conditions developed in the broad mouths of the major rivers.

Laurel Formation

Following progradation of the Yellow Drum Sandstone, sedimentation continued during a relative rise in sea level, in quieter conditions with less terrigenous material, producing an onlapping sequence of shallow water carbonates. Deposition was on a broad, shallow, gently sloping platform with low but variable energy conditions in four depositional environments:

(i) an open platform with deposition of both terrigenous and carbonate mud;

(ii) a shoal and intershoal area with subdued relief subjected to moderate current energy;

(iii) restricted platform shoreward of the shoals and adjacent to

(iv) a longshore lagoon.

As shown in Figure S15, the environments are of transgressive facies which advanced over the Yellow Drum Sandstone.

HEAVY MINERAL SAND STUDY

by

A.R. Jensen

STAFF: K.A. Heighway, A.R. Jensen

A study was commenced in 1973 of samples collected by drilling in waters adjacent to New South Wales and Queensland. The aim of the study was to see if the sampling method used by Planet Mining Co. Pty Ltd would enable identification of stratigraphic units and to ascertain the origin and nature of any units recognized.

The study involves the examination of approximately 300 samples from about 20 holes, each sample representing material from a 1.5 m interval. The examination includes the analysis of composition, colour, grainsize and heavy mineral content of each sample, and the results were initially plotted on a series of cross-sections.

The project was continued during the second half of the year and a re-assessment of our early work confirmed the results of the compositional, grainsize and heavy mineral analyses, but significant changes were necessary

in colour index. Detailed investigation of the type of shell fragments present in each sample proved to be of no value in the differentiation of one stratigraphic unit from another; colour and amount of carbonate remain the most useful properties for this purpose.

Six stratigraphic units, an increase of three over the number in 1973, were recognized and correlated from hole to hole. Isopach and structure contour maps are now being prepared for each unit.

PHOTOGEOLOGY AND REMOTE SENSING

by

C. Maffi and C.J. Simpson

PHOTO-INTERPRETATION

BMR MAPPING PROJECTS

Assistance with photo-interpretation was given to the following field parties:

Rum Jungle and Alligator River (problem areas using colour air photographs).

Georgina Basin (study of Cambrian and Ordovician outcrops on the Digby Peaks 1:100 000 Sheet and parts of Boulia and Duchess 1:250 000 Sheets).

Georgetown (part of the Gilberton 1:100 000 Sheet area using colour air photographs).

Norfolk Island Hydrological Project (interpretation problems using colour air photographs).

BURDEKIN DELTA

Colour infrared photographs were studied to evaluate their usefulness for detecting movement of near-surface groundwater, salt contamination, and water-table recharge patterns after irrigation. The study suggested that such photography may assist soil and agricultural mapping but is of limited value in underground water movement studies.

CARPENTARIA BASIN

From 12-16 January Simpson carried out aerial reconnaissance of flooded areas in the Carpentaria Basin with F. Doutch. Colour, infrared, and panchromatic photographs were taken with hand held cameras. The photographs will assist interpretation of ERTS imagery acquired during the "wet" season.

REMOTE SENSING

(see also Australian Committee for ERTS, p46)

ERTS-1

A draft of the final report on the BMR investigation of ERTS images of the Mount Isa, Alice Springs and Canberra test areas (Record 1974/50) was despatched to NASA on 28 February.

Some existing geological information was confirmed and some new information obtained. The images proved to be a useful aid to small-scale geological mapping, particularly for the detection of regional structural features. Maximum amount of information was obtained from bands 5 (red) and 7 (infrared), from stereoscopic images, and from images taken with low sun-elevation angle.

SKYLAB

Two EREP photographic passes only were attempted over Australia during the NASA "Skylab" project. During Skylab-3, photographs were taken continuously from near Yuendumu Mission, N.T., to near Bega, N.S.W. During Skylab-4 the same ground track was photographed from near Yuendumu to near Rodinga, N.T. Only a few frames were sufficiently cloud-free to allow interpretation to be carried out.

Evaluation of the Skylab-3 photography was commenced and a quarterly progress report was sent to NASA in August 1974. Preliminary results show that the information content of Skylab photographs is considerably more than that of ERTS imagery mainly because of better resolution, stereoscopic cover, and absence of scan lines.

MOUNT ISA SLAR PROJECT

The evaluation of the usefulness of Side Looking Airborne Radar imagery for the geological mapping of an Australian semi-arid area was completed and the report was submitted as a Record. The study has:

(a) confirmed some well known SLAR properties, such as all-weather capability, uniformity of illumination, direction, emphasis on effect of relief, synoptic view of terrain and suitability for reconnaissance geological mapping.

(b) Shown that, generally, sandstones, quartzites, intrusive rocks and volcanic rocks can easily be interpreted; shales, siltstones and schists are difficult to separate.

(c) Shown that SLAR imagery is particularly suitable for structural interpretation: many lineaments, sets of weathered joints and bedding trends have distinct radar signatures.

Some previously un-marked faults and lineaments were detected. The number of faults longer than 1 km detected from SLAR imagery is approximately the same as that of the faults in recent 1:100 000 scale geological maps. Faults shorter than 1 km are much more abundant in the geological maps than in the SLAR interpretation. Faults longer than 10 km are more abundant in SLAR.

The cost effectiveness of SLAR in Australian semi-arid conditions depends on the importance that some of its properties may have for the solution of the particular problem being considered. These properties are the combination of relief enhancement with synotpic view of the terrain, and the capability of detecting linear features that would be difficult or impossible to detect on air photos or on satellite images.

MISCELLANEOUS ACTIVITIES

DISPLAYS

Remote sensing exhibitions were provided for display to the following:

Seminar of the Economic and Social Commission for Asia and the Pacific (ESCAP) on the "Application of remote sensing technology to natural resources development" - Thailand, 30 September - 7 October.

Australian Water Resources Council/Australian Environmental Council remote sensing course - Sydney, 21-22 October.

Australian Mineral Foundation - Adelaide, October.

BMR Open Day

BMR Foyer

ECAFE (now ESCAP) SEMINAR

Brief notes on the use of remote sensing techniques for geological purposes in Australia were prepared for the ESCAP Seminar.

EXPERIMENTAL 70mm PHOTOGRAPHY

Indexing of the photographs, and preparation of flight diagrams for all past BMR 70mm aerial photographic projects were commenced. Flight diagrams and films will be delivered to the Division of National Mapping for storage in their Melbourne air photo library.

TRAINING

Two Colombo Plan students (from the Philippines and Indonesia) and two BMR geologists were instructed in basic photogeological interpretation techniques.

Simpson delivered four lectures on general photogeological interpretation and remote sensing techniques to the Canberra College of Advanced Education in November.

Perry, Maffi and Simpson carried out the revision of the course manual, and assisted in the organization of the second Australian Mineral Foundation workshop course on Photo-interpretation for Exploration and Survey Geologists which was conducted in Adelaide from 14-25 October.

EQUIPMENT

An I^2S Multispectral Viewer was installed at BMR in June. The viewer allows the simultaneous projection of four 70 mm diapositives onto a screen; coloured filters can be inserted in the optical path, thus making possible the formation of an additive-colour image from monochromatic views of the same area. Subject to Bureau requirements, the viewer is available by arrangement for use by non-BMR scientists.

A Bausch & Lomb Zoom-Transfer-Scope was acquired in April. This equipment is designed for simultaneous viewing and matching of two images or maps at different scales and projections, thus permitting detail to be readily transferred from one document to another.

OVERSEA VISITS

C. Maffi attended a one-month course on remote sensing at Tarbes, France, and completed a two-month teaching appointment for UNESCO at the University of Bahia, Brazil. In Brazil he visited the National Space Research Institute (INPE) at Sao Jose dos Campos and the headquarters of the RADAM Project for the reconnaissance mapping of the Amazon Region, at Belem. His report of the visit was issued as BMR Record 1974/46.

W.J. Perry attended the ESCAP Seminar at Bangkok, then proceeded to Canada and the USA as a member of an ACERTS multidisciplinary team sent to investigate what practical use is being made of ERTS-1 data and of remote sensing generally. He is scheduled to return from USA in mid-November.

AUSTRALIAN COMMITTEE FOR ERTS (ACERTS)

by

W.J. Perry

The Branch continued to provide the Secretariat for the inter-departmental Committee ACERTS, which is concerned principally with Australian participation in the United States Earth Technology Satellite and Skylab programs. Dr N.H. Fisher was Chairman until his retirement at the end of September, when Mr B.P. Lambert, Director, Division of National Mapping, took over.

Secretary, C.J. Slater, transferred to the Department of Tourism and Recreation at the end of 1973, and E. Petrushevski then filled the position until its abolition in August 1974. W.J. Perry continued to attend to technical matters.

One meeting of ACERTS was held during the period, although several meetings of the Working Group took place to consider particular issues referred to it by the main Committee.

Results of Australian studies of ERTS-1 imagery were discussed at an informal symposium attended by most Australian investigators, held at the Bureau on 3 and 4 December, 1973. Abstracts were circulated to all investigators, but no papers published. Draft final reports from 39 investigators were submitted to NASA at the end of February 1974, and a summary of reported results is given in Record 1974/70. In September NASA requested that the thirty nine draft reports be edited and arranged by disciplines into a single comprehensive report. This work was still in progress at the end of the period.

In response to a special request for ERTS-1 imagery of the serious flooding in eastern, central and northern Australia during the early part of 1973, NASA acquired some scattered coverage, and this imagery has been obtained for study by four State authorities.

In May, Dr Nicholas Short, Team Leader for Geology at NASA Goddard Space Flight Centre gave a one-day presentation at the Bureau on geological aspects of the ERTS-1 program; a review of Dr Short's presentation is given by Marshall in Vol. 1, Part 1 of the Bulletin of the Remote Sensing Association of Australia, 1974. He conveyed the information that the one operative tape recorder on ERTS-1 had failed completely during April, and therefore there was no further possibility of obtaining imagery of Australia.

A multispectral viewer designed to accept ERTS 70 mm film chips and 23 cm multiband film was installed at the Bureau in June, primarily for the use of Canberra-based scientists working with ERTS imagery and multiband photography.

The Government accepted a recommendation from ACERTS to send a five man multidisciplinary team to Canada, Brazil and the United States in October-November to find out what practical uses are being made of ERTS data and of remote sensing in general. It is expected that reports from the team will provide guidance in future consideration of the expenditure of resources in the application of such technology in Australia.

In December 1973, Skylab astronauts, during the third manned mission of the spacecraft took only a few more photographs of Australia; these are in the Alice Springs area on the same ground track as the previous photography taken in August 1973 during the second manned mission. They have not been examined and only a preliminary appraisal of the August photography has been made, owing to delays in obtaining copies for investigators to work with, but the study so far indicates that more information can be obtained from the Skylab photographs than from ERTS imagery of the same area because of the photographs' stereo cover and finer resolution. Copies of all Skylab photographs are available through the Division of National Mapping.

In August notification was received from NASA that only six Australian investigators have been provisionally selected to take part in the ERTS-B program out of forty-two who sought participation. NASA has stated that of more than two hundred international proposals submitted, less than fifty have been accepted.

MARINE GEOLOGY

COASTAL STUDIES

by

P.J. Cook

BROAD SOUND

STAFF: P.J. Cook, W. Mayo

No fieldwork was undertaken during 1974. The draft of the first bulletin dealing with the sedimentology and Holocene history of Broad Sound was completed and work commenced on the second bulletin which discusses the geochemistry of the estuary. Utilizing a number of textural and mineralogical parameters, it was possible to establish the pattern of sediment distribution within Broad Sound and determine the relative abundance of land-derived and marine-derived sediment. Compilation of radiocarbon information and elevations, indicated that there has been quite major uplift (several metres in the past 6000 years) on the east side of Broad Sound.

Initial interpretation of (i) the inter-relationships between variables within each Broad Sound Sedimentary unit (ii) the geochemical links between the catchment and the estuary and (iii) geochemical aspects of the rock, stream and soil samples in the catchment is currently underway.

MALLACOOTA INLET

STAFF: G.E. Reinson (A.N.U.)

Work on Mallacoota Inlet was completed during 1974 and results compiled for a Ph.D. thesis submitted to the Australian National University and modified for a BMR Bulletin. Reinson concluded from his studies that the estuary has a two-layer flow system, with some entrainment of salt water. The hydrological circulation pattern in the estuary is reflected in the texture, mineralogy and geochemistry of the bottom sediments in most areas. Because of the abundance of data for Mallacoota Inlet, it may serve as a temperate estuarine model which will aid in the interpretation of comparable ancient sedimentary environments.

SOUTHEASTERN SOUTH AUSTRALIA

STAFF: P.J. Cook

As eustatic sea-level changes are important to the formation of heavy mineral deposits, the determination of a sea level curve, using Australian information, may have long-term economic significance. An extensive series of calcareous beach ridges is developed on the coastal plain of southeastern South Australia, and it is hoped that this sequence will assist in establishing a Quaternary sea-level curve. The ridge sequence, which extends for at least 100 km inland, was examined briefly in July, and it was determined that the stratigraphy of the coast between Robe and Naracoorte should be examined in some detail. This will be done by drilling a series of holes through the Quaternary section at a number of localities on the coastal plain (Fig. S16). Drilling commenced in October, but results are not available as yet.

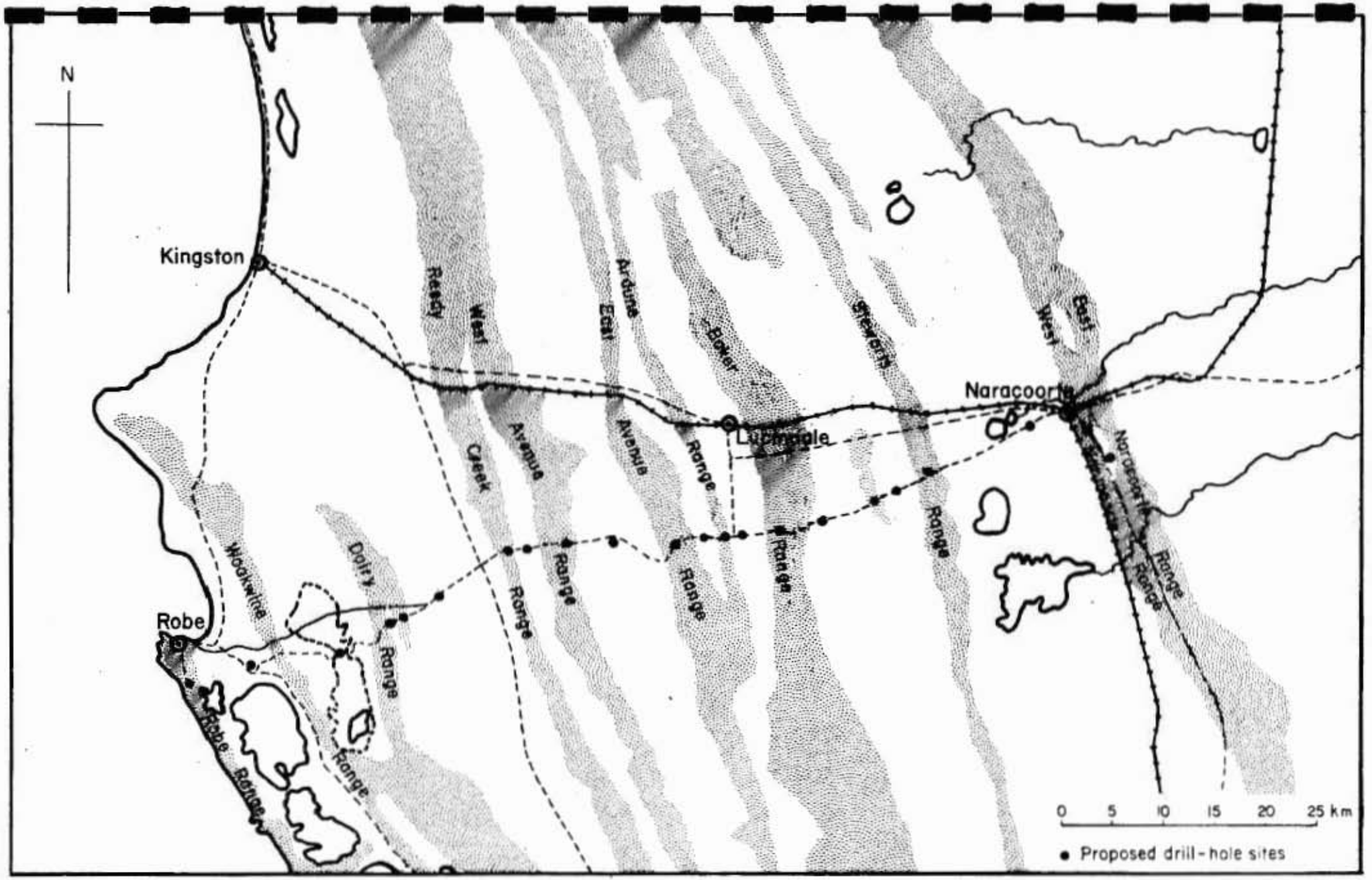


Fig. S 16 Proposed drilling program, southeast South Australia

S/A 21

DEEP SEA DRILLING

by

P.J. Cook

P.J. Cook attended the post-cruise conference for DSDP leg 27 at the Scripps Institution of Oceanography. Subsequently he attended an open meeting of the JOIDES executive in Zurich, held to discuss the setting up of the International Program for Ocean Drilling. The results of this meeting are reported in Record 1973/194. Work commenced on a paper summarizing sedimentological results from the Deep Sea Drilling Project in the Indian Ocean. Lectures on the DSDP results were given during the year to the Geological Society of Australia and the Challenger Centenary Symposium.

Geochemical work continued on material from DSDP Site 262 (Timor Trough). Stable isotope (delta C^{13} and delta O^{18}) analyses were undertaken by Teledyne and Isotopes Inc. The isotope values were found to change progressively down the drill hole, probably as a result of diagenesis. Delta S^{34} values which were determined by J. Donelly (Baas-Becking) appear to be consistent with bacterial reduction of sulphate, where the supply of sulphate was limited. Hydrocarbon extractions of the Timor Trough material are currently being undertaken by D. McKirdy. Yields of soluble hydrocarbons appear to be particularly high, but detailed analyses of the extracts are not available as yet.

EAST AUSTRALIAN CONTINENTAL SHELF

by

H.A. Jones

STAFF: H.A. Jones, P.J. Davies, J.F. Marshall

No field work was undertaken in 1974. Interpretation of sedimentological, seismic, and bathymetric data from BMR and other sources continued. Two Bulletins on the geology of the continental shelf are in preparation and several aspects of the work have been reported in BMR Records and in outside publications. These include the following:

CONTINENTAL SHELF MORPHOLOGY

Bathymetric data acquired by the Division of National Mapping off the central coast of New South Wales in 1972 were studied with the objective of delineating fossil beaches and other features which may be associated with concentrations of heavy minerals.

The continental shelf is narrow and relatively steeply inclined; there is evidence of fairly extensive outcrops of bedrock on the inner shelf, and the cover of sediments is generally thin to a depth of about 80 m. Bottom currents are likely to be strong on the middle and outer shelf, and large-scale sediment transport probably occurs.

The conditions of shallow or exposed bedrock do not favour the development of distinctive shoreline abrasion platforms and cliffs during the relatively short periods of low sea-level stillstands. Also, the existing high-energy conditions on the shelf must have resulted in destruction or modification of unconsolidated sand bodies. Thus, although notches and changes of slope which may be related to fossil shorelines were identified in many profiles, they are commonly of limited extent and difficult to recognize. The best developed occur at depths of about 105, 84, and 28 m.

The rocky and irregular nature of the inner shelf indicates that conditions suitable for entrapment of heavy mineral accumulations are likely to have occurred locally during low sea level stands. If such deposits exist they may not be suitably placed for mining by large-scale dredging techniques.

SHALLOW SEISMIC STRUCTURE

An interpretation was made of 3000 km of seismic profiles across the New South Wales shelf obtained during the 1972 BMR marine geology cruise. Acoustic basement consists of Lower Palaeozoic or Permo-Triassic rocks underlying relatively unconsolidated sediments of Tertiary to Holocene age. The profiles show the basement surface sloping eastwards from the coast to the middle or inner part of the shelf where there is either a ridge (offshore Sydney Basin) or a step (offshore from the Southern Highlands fold belt). This basement ridge or step separates thin or non-existent sedimentary cover to the west from a sequence to the east thickening seawards. Much larger basement highs cross the shelf in the Sugarloaf Point and Shoalwater areas. The former is oriented northwest-southeast and the latter northeast-southwest. Major basement depressions occur southeast of Newcastle and off Disaster Bay.

In the offshore Sydney Basin, a marked disconformity is identifiable in the sedimentary sequence above seismic basement: it may be due to erosion in the Early to Middle Pliocene, and if so the rate of sedimentation since that time has been approximately 2cm/1000 years.

ORIGIN OF THE SHELF BREAK

A study of seismic reflection data off the east coast, using mainly the continental margin contract survey profiles, suggests that in some areas the shelf break has at no time been influenced by eustatic events. This conclusion is at variance with generally accepted ideas on the origin of the shelf break. It appears that in some places off southeast Australia insufficient sediment has accumulated along the rifted continental margin since the opening of the Tasman Sea to compensate for subsidence and to raise the sea floor to within reach of wave-base erosive influences during low sea levels. In some instances (Profile 4, Fig. S17) there is no evidence of outbuilding, and the sediments are draped over basement structures; thus the change of slope at the shelf break is the surface expression of basement relief and changes in the depth of the shelf break are related to changes in depth of basement. Erosion at times of low sea level has played no part in the development of the shelf break, and therefore it is not necessary to invoke neotectonism to explain variations in its depth.

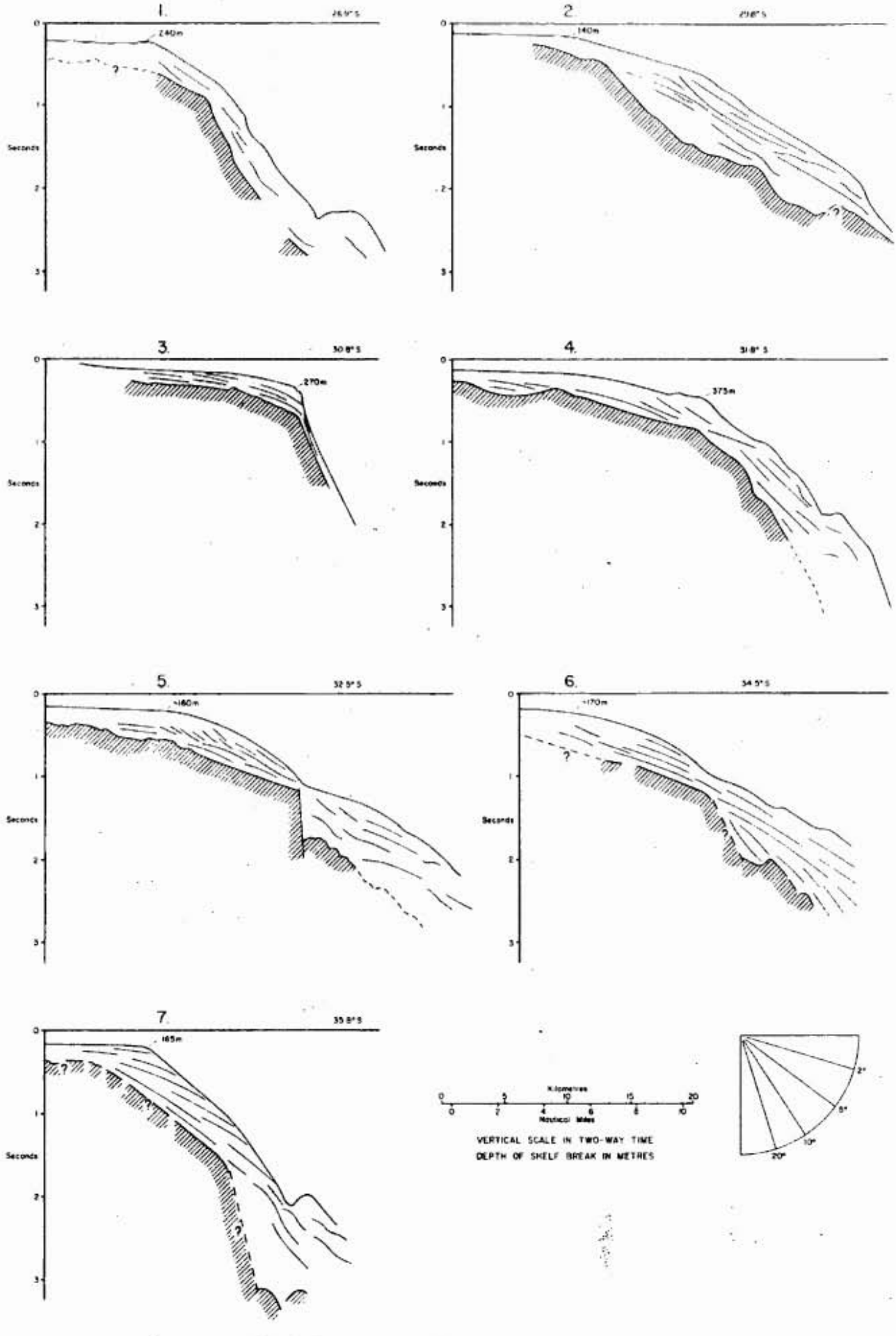


Fig. S17 Diagrammatic seismic sections

Other seismic sections reveal clear evidence of outbuilding of the wedge of sediments which accords with the generally accepted concept of continental shelf developing (Profiles 5 & 7, Fig. S17). It is suggested that moulding of the major morphological elements of the outer shelf and development of the shelf break may have occurred as early as the late Miocene.

The buried basement surface is commonly smooth at the crest of the continental slope, and irregular under the shelf (Profiles 4, 5 & 6, Fig. S17). The smooth surface may be a marine abrasion platform formed during the initial transgression across the continental margin after rifting and opening of the Tasman Sea in the Late Cretaceous. The basal sediments resting on irregular basement under the outer shelf are probably continental in origin.

ARSENIC IN SURFACE SEDIMENTS

Grab samples collected on the southeast Australian continental shelf were analysed for arsenic by atomic absorbtion. The distribution of arsenic over this area is shown in Fig. S18. Sediments with low arsenic contents (less than 10 ppm) are almost entirely restricted to the inshore zone. Seawards, the arsenic content increases. South of Jervis Bay, the maximum arsenic content in the sediments is less than 50 ppm. North of Jervis Bay, and especially between Port Kembla and Newcastle, arsenic contents on the middle and outer shelf average between 50–100 ppm. The arsenic is derived from the hinterland either by natural erosion, but urban and industrial effluents are more likely sources. Complexing of arsenic with colloidal manganese compounds results in its deposition on the quieter areas of the middle to outer shelf.

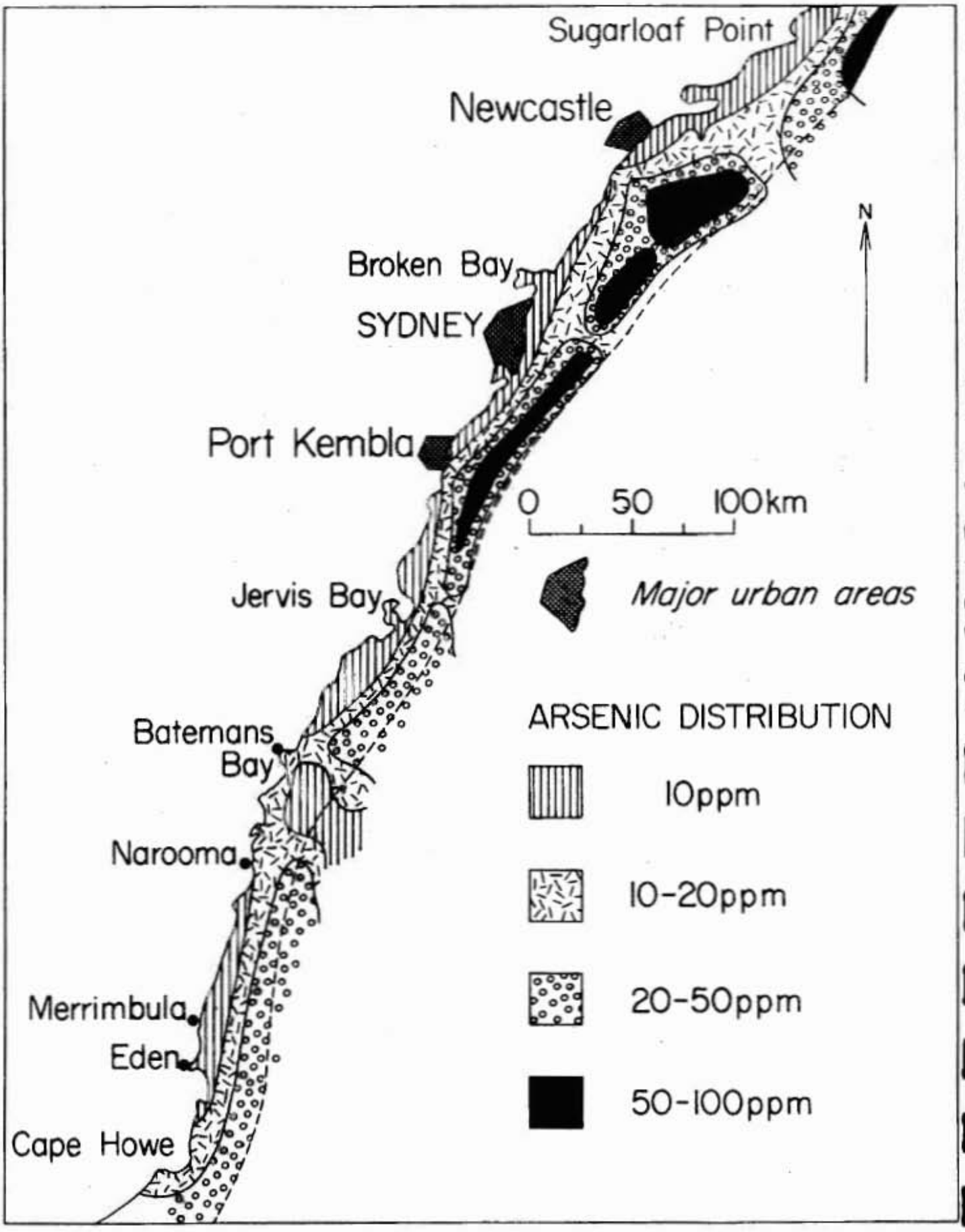


Fig. S18 Arsenic distribution on the Continental Shelf of southeast Australia

GEOLOGY OF SEDIMENTARY MINERAL DEPOSITS

PHOSPHATE DEPOSITS

by

P.J. Cook

During the year P.J. Cook prepared a review paper on phosphorites, for an Elsevier book on sedimentary ore deposits. It now appears that earlier hypotheses involving upwelling and inorganic precipitation of apatite require extensive modification. Apatite probably forms below the sediment-water interface, producing phosphatization of sediments. These phosphatic sediments are then upgraded to phosphorites by reworking, leaving a coarser lag deposit of phosphate pellets and nodules.

Investigations into the organic geochemistry of phosphorites, undertaken by T.G. Powell, P.J. Cook, and D. McKirdy, showed that the organic matter in phosphorites is primarily algal in origin. The nature of the kerogens is consistent with a strongly euxinic depositional environment. The high proportion of soluble organic matter in unaltered phosphorites suggests that phosphorites can constitute important source rocks for petroleum and that the oils derived from these phosphorites are capable of migration at an early stage of diagenesis.

Using data compiled by C. Robison, a paper on phosphorites in the S.W. Pacific was prepared by P.J. Cook for the CCOP-SOPAC conference in W. Samoa. Utilizing chemical, bathymetric, and biological information, it was possible to indicate a number of guyots in the region between Nauru and the Line Islands where submarine phosphorites may be present.

QUATERNARY COASTAL AND HEAVY MINERAL DEPOSITS

by

J.E. Skinner

A bibliographic study of Quaternary coastal deposits and heavy minerals commenced in March 1974 with the twofold aim of producing (i) an A.D.P. based bibliography of relevant published and unpublished documents and (ii) a series of maps at a scale of 1:2 500 000 portraying factors fundamental to the accumulation of heavy minerals along the Australian coastline.

To date a total of 300 published and unpublished references has been collected. As a result of visits to the libraries of both the New South Wales and Queensland Geological Surveys, discussions with Dr B. Thom (A.N.U.) and a search of relevant literature, the list of publications dealing with the eastern coastline of Australia is almost complete.

The bibliography is based on the SURFAUST system, which sorts the references on the basis of keywords, author's name, year of publication, and 1:1000 000 and 1:250 000 sheet areas. Twenty-nine keywords have been

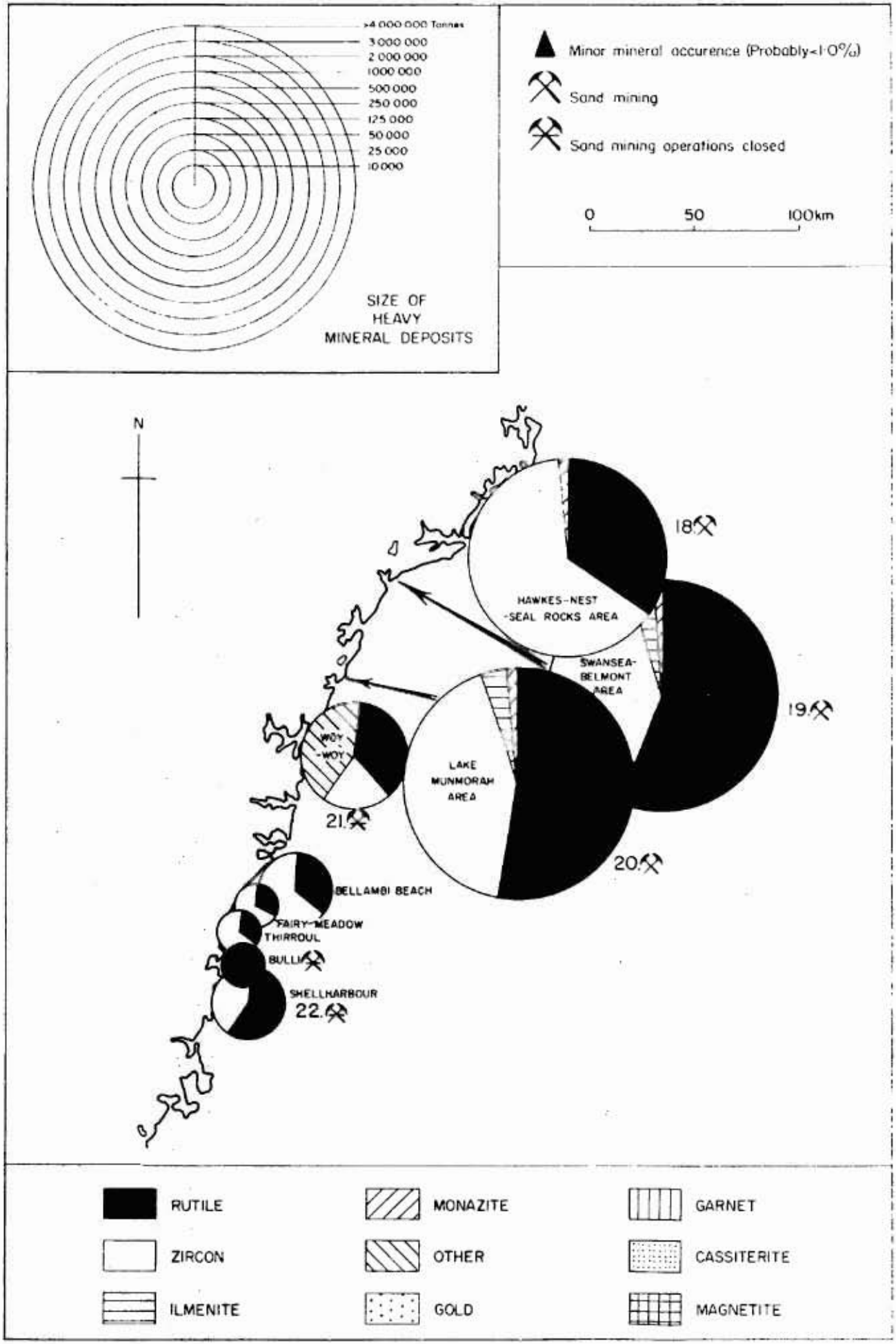


Fig. S19 Section of the map entitled "Heavy mineral sand deposits along the eastern coastline of Australia."

used covering topics such as physiographic environment and the type of heavy mineral mined or present in a particular area. Keywords for the latter topic include rutile, zircon, monazite, ilmenite, garnet, cassiterite and magnetite.

Compilation of the preliminary 1:2.5 million map series has progressed to the stage where four maps have been drawn for the Queensland and four for the New South Wales coastline. These maps portray: (1) heavy mineral sand deposits, (2) Quaternary Coastal geomorphology, (3) climatic and oceanographic data and (4) geological provenance.

Before construction of the maps of heavy mineral sand deposits, data were collected on the distribution, size and type of deposits mainly from files of the New South Wales and Queensland Geological Surveys, Associated Minerals Pty Ltd, Mineral Deposits Pty Ltd and company reports. Over nine million tonnes of heavy minerals have been mined from sands of the east coast of Australia, between Punsand Bay (Torres Strait) and Shell Harbour (NSW).

Dry mill production figures were used to calculate the size of the deposits. Estimated reserves were only given for areas where there had been no mining but where deposits were known to exist. For the purposes of generalization it has been assumed that the proportions of individual heavy minerals in the concentrate reflect the proportions found in the original deposit. A second assumption has been made regarding the relative contributions of wet mill plants to the centralized dry mill plants. As concentrate figures are only available from dry mills, contributions from the surrounding wet mills are based on throughput and period of plant operation.

Data on heavy mineral sand deposits are shown on the maps by a variety of symbols, the size of the deposit for example is shown on the maps as a circle, the diameter of which represents the tonnages of total heavy mineral produced or, where deposits are known but not developed, the diameter of the circle represents estimated reserves. Segments within each of these circles indicates the percentage of each type of mineral mined or estimated (see Fig. S19). Accompanying these maps is a table (for example see Table S2 which complements Fig. S19) providing detailed information on tonnages of heavy minerals mined, the number of years of mining and the mining companies working in the region.

Aerial photography, the Australian 1:250 000 series maps, the BMR 1:250 000 Geological series maps and references discussing coastal areas provided the basis of information for the compilation of the Quaternary Coastal Geomorphic maps. Owing to the small scale of the maps, however, little geomorphic detail could be shown; in fact the coastal region has been represented by seven commonly occurring coastal features. These features include beach ridges, transgressive dunes, sand sheets, narrow sandy beaches, pocket beaches, rocky and muddy coasts. The extent of Quaternary coastal deposits is also shown on the maps.

It is generally accepted that there is a primary and secondary concentration of heavy minerals, primary concentrations being produced by swash action and secondary concentrations being derived from the primary deposits by deflation and subsequent deposition. Hence the maps showing climatic and oceanographic data were constructed to show as much detail as possible on the processes aiding heavy mineral concentration. Climatic

	MINING COMPANIES	Years of Mining	Tonnes of Heavy Mineral Mined - According to type of Mineral								
			Il.	R.	Zr.	Mz.	Sn.	Gt.	Au.	Other	Total Heavy Mineral Mined
AREA 18, Location: Hawkes Nest-Seal Rocks											
Hawkes Nest	. Mineral Deposits Pty Ltd	1966-1970		124 014	240 462						
Myall Rv. Bigg Gibber	. "										
Sandbar	. "	1966-1973		45 840	46 517	28					
Bluey's Beach	. "	1970		7 824	7 311						471 996
AREA 19, Location: Belmont-Swansea Area											
Swan Bay	. Associated Minerals	1965-1973		159 232	189 424						
Catherine Hill Bay	. Limwood Sands Syn.	1949-1961	5 700	71 562	50 456	389					
	. Crescent Rutile ML	1957-1961		1 726	1 832						
	. Rutile & Zircon Mines	1966-1967	15 127	97 445	72 459	587					
Kilcare and Putty Beaches	. Crescent Rutile ML	1957-1967		11 469	14 497						691 905
AREA 20, Location: Lake Munmorah Area											
Lake Munmorah	. Wyong Rutile Pty Ltd	1957-1959	3 781	57 087	43 865	225					
	. Associated Minerals	1967-1973	3 917	138 377	112 154	213					
Wyong	. Wyong Rutile Pty Ltd	1957-1959		7 571	5 014						
Tuggerah Lakes	. Associated Minerals	1969-1973		37 849	26 189						
North Budgewoi	. Wyong Rutile Pty Ltd	1957-1959	1 691	16 892	43 865	50					
Elizabeth Bay	. Wyong Alluvials	1957-1959	4 724	56 748	44 865	30					604 907
AREA 21, Location: Woy Woy Area											
Soldiers Beach	. Northern Rivers Rutile Pty Ltd	1964-1971	250	5 041	9 437	55					
Terrigal Haven	. " "		1 135	7 722	7 993	47					31 680
AREA 22, Location: Shell Harbour Area											
Bulli	. Upton Bors	1953-1955		15							
Shell Harbour	. Beach Mining Aust Ltd	1955-1959		6 817	6 335						13 167

TABLE 52. An example from the table showing Production of Heavy Minerals From Coastal Sands in Eastern Australia

Il - Ilmenite R - rutile Zr - zircon Mz - monazite Sn - cassiterite
Gt - garnet Au - gold

information portrayed on the maps includes annual average rainfall, cyclonic activity and wind direction, frequency and strength for particular coastal areas. Tidal range, percentage frequency of waves higher than 2.75 m, bathymetry and sediment movement are the oceanographic components displayed.

In order to delineate those geological subdivisions of the coastal regions thought to constitute different provenances for detrital heavy minerals, geological provenance was generalized into four basic types; intrusive, extrusive; sedimentary and metamorphic. Areas of Quaternary sediment are shown separately. Information was taken exclusively from the tectonic map of Australia 1960 edition. The watersheds of the major rivers draining towards the coast were superimposed on the provenance divisions. Eventually it is aimed that a table will be produced to accompany these maps giving percentages of each rock type within the major watersheds.

Currently a record is being written summarizing the information collected in 1974 on coastal sands and heavy mineral deposits of the eastern coastline of Australia. The preliminary maps and bibliography on eastern Australia will also be included in the record. The plans for 1975 are: (1) to finalize the collection of data for the rest of Australia, (2) complete the bibliography of Quaternary coastal deposits and, (3) to construct a further series of maps entitled coastal drainage showing such data as sediment discharge, river gradient and river drainage patterns offshore.

EVAPORITE STUDY PROJECTS

by

A.T. Wells and A.J. Stewart

The objectives of the evaporite study project are to continuously review new data on Australian evaporites as it becomes available, to publish the results of a current review, and to synthesise the information obtained from field exploration of evaporites.

No field activities were undertaken in 1974 and most work involved preparing Records and publications. A current review of Australian evaporites is being revised for publication and a report on the exploration of the Officer Basin salt domes (Woolnough Hills and Madley) was completed in first draft. The evaporite-bearing formation in the core of the Woolnough Hills salt dome probably originally consisted of mainly halite, dolomitic anhydrite and anhydritic chert. No evidence of economic mineralization was discovered by the drilling; however less than 100 m of halite was sampled and the possibility of discovering occurrences of potassium and sulphur cannot be entirely discounted. At Madley Domes the exploratory drilling did not conclusively confirm the presence of intrusive halite and only the dololutite, gypsum and anhydrite of the cap rock was sampled. No minerals of immediate economic interest were found.

Increased interest by companies has been shown in trace elements in evaporite deposits, particularly lithium and beryllium. These elements will apparently be increasingly used by industry in the future but very few analyses for them are available from Australian evaporite deposits, brines and ground waters. However an initial investigation of evaporites in the Officer and Amadeus Basins for these elements was not encouraging.

The results of the geochemical study of the Ringwood evaporite deposit, N.T. were written up and will be published as Report 186. Record 1969/7 (Supplement), 'Amendments to Record 1969/7, "Completion report, BMR Alice Springs No. 3 (Ringwood)"' was issued.

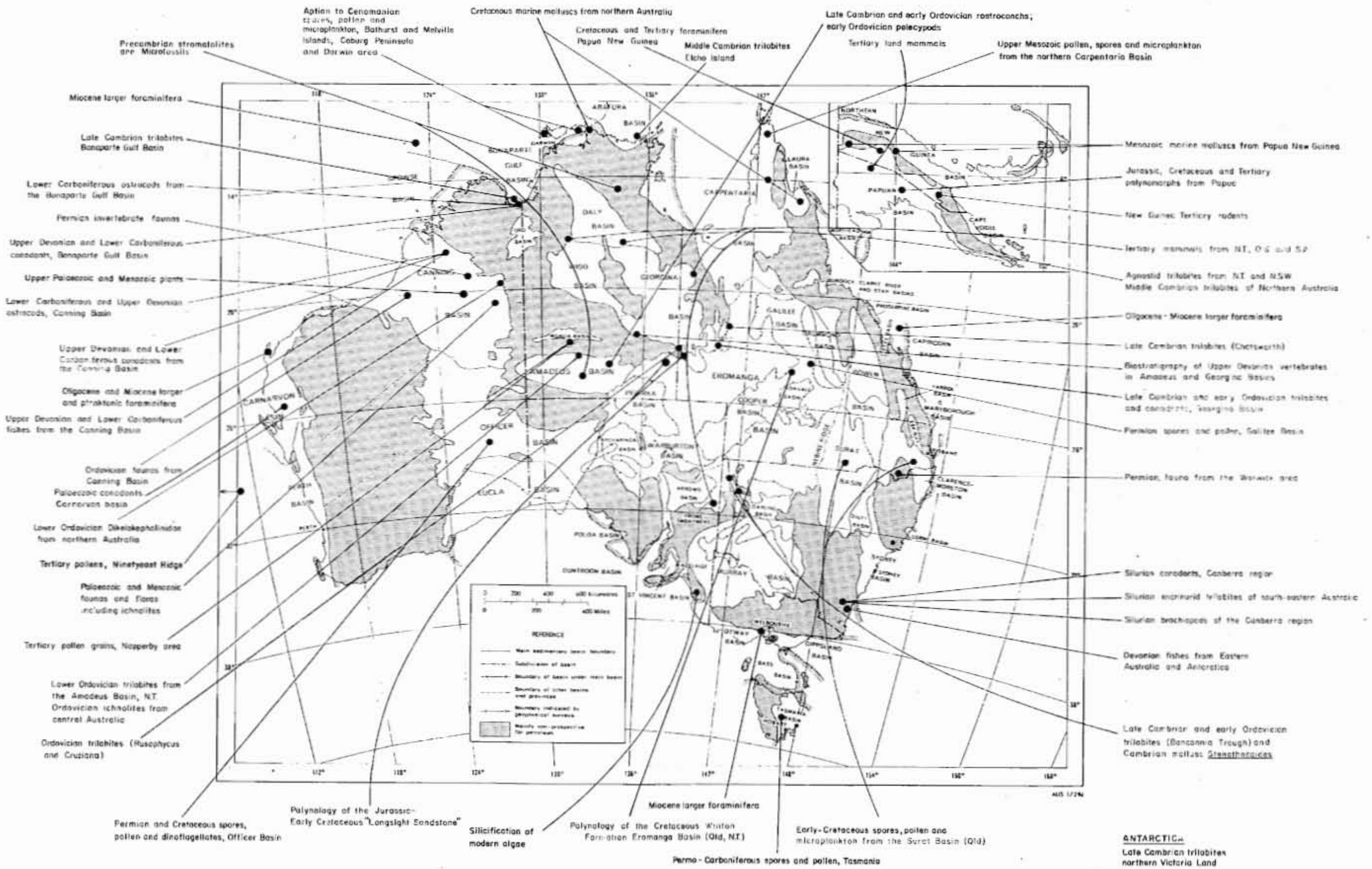


FIG S 20 CURRENT PALAEONTOLOGICAL PROJECTS

Record 1974/127

M(P) 658

PALAEONTOLOGICAL STUDIES

INTRODUCTION

G.C. Chaproniere joined the Group in October, 1973. He has been working on the planktonic and larger foraminifera of Western Australia for a Ph.D. degree and he will continue his work on the larger foraminifera of Australia and New Guinea.

S.K. Skwarko who was seconded for almost three years to the Geological Survey of Papua New Guinea returned to Canberra in January 1974 and is continuing his work on Mesozoic faunas and stratigraphy.

G.C. Young was awarded a 2-year Australian Public Service scholarship to study fossil fish and left Australia to take up the scholarship at the British Museum (Natural History) and the Imperial College, London in September.

P. Rich spent June and part of August at BMR working on her manuscript for a BMR Bulletin on the giant Tertiary ground birds of Australia.

M.D. Muir of the Imperial College, London, worked with BMR from August to the end of October. In Canberra she examined microfossiliferous Precambrian cherts and siltstones from the McArthur Basin and in the field studied the black cherts at the classical Bitter Springs localities and other potentially fossiliferous formations in the Amadeus Basin and visited the recently discovered Boorthanna localities in South Australia.

J. Pojeta Jnr of the United States Geological Survey arrived in July to spend a year with BMR under the USGS-BMR exchange agreement. He is working on the Cambrian and Ordovician Molluscan classes Rostroconchia and Pelecypoda of Northern Australia and their stratigraphical implications.

A submission was prepared for the Museums Enquiry on the future of the Australian Palaeontological Collections.

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

ACTIVITIES

J.M. Dickins

Work in collaboration with the field parties in the Northeast Canning Basin was continued and collections made during the 1973 field season were examined. A month was spent in the field mainly in the Noonkanbah Sheet area. The Upper Permian marine sequence was delineated and faunal subdivisions in the Noonkanbah Formation were investigated.

Papers on the Permian climate of Australia and the correlation of the Permian System in Australia were completed and are being edited and a Permian fauna from Warwick area, Queensland which gives stratigraphical and climatic information is being described.

Activities were undertaken for the Gondwana Sub-commission of IUGS and the newly founded Association of Australasian Palaeontologists.

M. Plane

Work continued on the mammal faunas from Bullock Creek, N.T., Riversleigh, Qld, and Lake Ngapakaldi, S.A.

No field work was possible in the Tirari Desert of South Australia as the lakes to the east of Lake Eyre were flooded for the first time this century. It is hoped to be able to work in the area during 1975.

Field work at Nerriga, N.S.W. in the early Tertiary Titringo Creek Siltstone has, so far, produced no vertebrate fossils. Processing of the material from this potentially important site continues.

Dr Tedford is continuing preparation in New York of the material recovered during the 1973 field work at Lake Pinpa, S.A.

The paper on 'Biostratigraphy, Chronology, and the Continental Mammal Record of Australia and New Guinea' has been revised and rewritten for publication by the Geological Society of America.

J.H. Shergold

The major part of the year was occupied with the technical preparation of late Cambrian, late Idamean to pre-Payntonian, trilobite faunas from the Chatsworth area, western Queensland. To date some 2000 specimens from 60 collecting horizons on sections at Lily Creek, Horse Creek and Mount Murray, and collecting points on the Chatsworth Plains, have been isolated for systematic description. Description of this voluminous material has commenced with analysis of the Family Kaolishaniidae. This study will complete the late Cambrian carbonate belt trilobite biostratigraphy of the Burke River Structural Belt.

The period late May to early August was spent on field activities with the Georgina Basin Party. June and early July were occupied with the formulation of an itinerary for IGC excursion Q4C. Dr J. Pojeta (USGS) was escorted around the Georgina Basin during July in a search for Cambrian and early Ordovician Rostroconchia (Mollusca). Examination of Georgina Basin Party materials continues.

Further activities were as follows:

1. Co-convened Section D 'Precision in Correlation', a symposium organised by the GSA Specialist Group in Palaeontology and Stratigraphy, Hobart, February.

2. Served on the Editorial Panel of the newly formed Association of Australasian Palaeontologists.

3. Was engaged in preparations for Open Day.

4. Produced Circular 3 of the Early Palaeozoic Working Group, IUGS Subcommission on Gondwana Stratigraphy.

5. Reported on Middle Cambrian trilobites discovered on Elcho Island, N.T., for the N.T. Administration and Champlin Philippines Inc.

D.L. Strusz

D.L. Strusz is engaged in a stratigraphic and palaeontological study of the A.C.T. and the surrounding region, which is a key area for understanding the development of the Lachlan Geosyncline.

Late 1973 was spent in preliminary editing of the Record by the Tantangara Party on the Tantangara 1:100 000 Sheet. In addition, graptolites collected by that party from the Cotter Valley were examined, and determined to be of probably Eastonian (Late Ordovician) age.

By July 1974 drafts had been completed of contributions to two projects. The first, undertaken at the request of the Stratigraphic Nomenclature Committee, is a revision of those parts of the Australian Code dealing with lithostratigraphy and procedures. The draft, whose compilation drew heavily on the writer's experience in dealing with problems raised by BMR parties, has been sent to the State Subcommittees for circulation and comment. It will probably be discussed during the Canberra ANZAAS Congress.

The second project, undertaken in cooperation with the N.S.W. Geological Survey, is a contribution to a forthcoming publication on the Silurian System in N.S.W. and the A.C.T. The stratigraphy of the Canberra Rise (the Molong Geanticline south of Yass) has been written up, and the draft is now being examined by the coordinator for the work Dr J. Pickett of the Geological and Mining Museum.

In August, work was resumed on a study of the Silurian encrinurid trilobites from the Canberra region. Preparation and documentation of specimens is now well advanced, and writing should start before the end of 1974. The Asian genus Coronocephalus has been recognised in material from several localities in and near Canberra.

S.K. Skwarko

S.K. Skwarko recommenced duties at the Bureau of Mineral Resources on 14 January, after resigning from the Papua New Guinea Geological Survey.

His main initial task was the completion of the compilation of stratigraphical tables for the Explanatory Notes to accompany the 1:1 000 000 geological map of Papua New Guinea, but he also succeeded in bringing up to date the computerized bibliography of the Mesozoic macrofossils and Ordovician graptolites. Skwarko also spent 2½ months in central and northern Australia examining the recently mapped Cretaceous sediments, and collecting fossils.

J. Gilbert-Tomlinson

J. Gilbert-Tomlinson continued systematic work on (1) Ordovician dikelokephalinid trilobites of northern Australia, and (2) Cambrian and Ordovician Rostroconchia (Mollusca) of northern Australia, the latter a joint project with John Pojeta Jr and J.H. Shergold. The first study, to be published in the Bulletin series presents a general review of the state of knowledge of the family Dikelokephalinidae - taxonomy, stratigraphy,

palaeogeography, and palaeoecology. Four new genera (3 endemic) are erected; one established genus is suppressed, and one extra-Australian (Chinese) genus is recorded. The second study comprises descriptions of 23 new species (all endemic) distributed among 13 general (6 new and endemic); available stratigraphic data are included. The number of indigenous late Cambrian taxa - 4 genera and 9 species (including 1 genus and 2 species described separately by J. Pojeta and B. Runnegar) - is especially noteworthy.

Continuing projects include the studies of Early Ordovician pelecypods from northern Australia (joint project with John Pojeta Jr), Early Palaeozoic ichnolites from central Australia, and Early Palaeozoic molluscs from northern Australia. Miscellaneous activities included a lecture on Australian Ordovician Palaeogeography (BMR Wednesday series), a preliminary examination of early Middle Cambrian fossils from Elcho Island, N.T.

G.C. Young

Before leaving in September, G.C. Young prepared Devonian fish material from the Amadeus Basin, Central Australia and from Taemas/Wee Jasper area of New South Wales. He prepared a paper on the geographical and stratigraphical distribution of Australian Devonian fish for the Hobart Conference of the Association of Australasian Palaeontologists and continued preparation of manuscripts on Devonian fish from the Canning Basin and Bothriolepis from Antarctica and Victoria. He carried out field work in the Georgina Basin collecting vertebrates from the Dulcie Range. In the Museum he was engaged in curatorial duties. In London he will be working on Australian Devonian fish.

D.J. Belford

Foraminiferal work continued on material from Papua New Guinea, concerned mainly with regional mapping projects. Samples were submitted both by Bureau field parties, and the Papua New Guinea Geological Survey. One sample of early Paleocene age (Subbotina trinidadensis zone) and another of early Eocene age were collected in the Wabag area. For the Papua New Guinea Geological Survey samples from the Kikori 1:250 000 Sheet area, and from Manus, New Hanover, Djaul and Mussau Islands were examined. Four core samples from the Keram No. 1 Well were also examined for Continental Oil Company.

Some progress was made in the systematic study and illustration of planktonic foraminifera of early Paleocene to late Miocene age from the Wabag and Blucher Range 1:250 000 Sheet areas Papua New Guinea. Brief descriptions and illustrations of carbonate rocks from these areas were also prepared.

Curation of the foraminiferal collection continued. Modifications to the computer retrieval program were begun, in an attempt to make this compatible with field data sheets; this involves a change from a FORTRAN to an INFOL program.

Establishment of the ECAFE Fossil Reference Collection continued. At present, about 150 foraminiferal species, 200 thin sections of limestones illustrating the faunal sequence on Christmas Island, Indian Ocean, and moulds and casts of brachiopods from the University of New England are in the collection.

An overseas visit to the United States, England, Germany and Switzerland was made from 27 July to 21 September, primarily for the purpose of comparing specimens of planktonic foraminifera from Papua New Guinea with type and other specimens held in overseas institutions. In the United States, organisations visited were the University of California, Los Angeles; Scripps Institution, La Jolla; Smithsonian Institution, Washington; and the American Museum of Natural History, New York. In England, the British Museum (Natural History) and the B.P. Research Centre, Sunbury, were visited.

From 9-13 September the Third International Planktonic Conference was attended at Kiel, Germany, and a visit to Professor P. Bronnimann, Department of Geology, University of Geneva, was made from 16-19 September.

P.J. Jones

P.J. Jones continued on the main project - the systematic palaeontology of the Lower Carboniferous (Tournaisian-Visean) Ostracoda from the Bonaparte Gulf Basin. Faunal descriptions and photography, now complete, involve 97 species (14 Beyrichicopida; 10 Platycopida; 72 Podocopida; 1 Cladocopida), many of which are closely related to those described from the Early Carboniferous of Siberia (Kuznetsk Basin, and the area bordering the mouth of the River Lena), western Europe (Belgium and Britain), and North America (Cordillerah and Upper Mississippi Valley regions). This shows that the geographic distribution of ostracod species during the Early Carboniferous was probably more widespread than has been previously thought. Biostratigraphic and biogeographic results are now being documented. The entire MS is being prepared for publication as a BMR Bulletin.

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

M.R. Walter

1. Metazoans from the lower Arumbera Sandstone, Amadeus Basin

Bedding plane impressions have been interpreted as moulds and casts of cup-shaped organisms 5-25 cm high by 5-15 cm wide. These organisms were attached to the underlying sand at the base of each cup. They were gregarious, and are very abundant on some bedding planes. The cups consisted of thin, flexible, ribbed membranes. These and similar fossils from latest Precambrian rocks in South-West Africa and the USSR were probably coelenterates. The Arumbera fossils were studied in cooperation with M.F. Glaessner; they are described in a paper which is ready for submission.

2. Megascopic algae from the Belt Supergroup, Montana.

Grey, ribbon-shaped fossils from the Greyson Shale were interpreted by C.D. Walcott as trace fossils and were named by him Helminthoidichnites meeki, H.?neihartensis and H. ?spiralis. Walcott's samples were restudied in cooperation with J.H. and D.Z. Oehler of the Baas Becking Laboratory and were shown to be body fossils, not trace fossils. They are not interpreted as fossil megascopic algae. As such they are very significant in

reconstructing the Precambrian history of the algae since they are 1300 million years old, at least 400 million years older than any previously described megascopic algae. They are described in a paper which has been submitted for publication.

3. Stromatolites and stromatolite-like geyserite from hot springs in Yellowstone National Park, Wyoming.

These were studied prior to joining the BMR because of their relevance in interpreting Precambrian stromatolites and microfossils. Most of this work is now complete. Three manuscripts describe the stromatolites (including a form of Conophyton), the geyserite, and the sediment types and distribution.

4. Trace fossils in the Proterozoic of the Amadeus Basin.

The search for trace fossils in the Winnall Beds, Pertatataka Formation and lower Arumbera Sandstone continued this year. Possible burrows were discovered in the Julie Member of the Pertatataka Formation, but this interpretation has not yet been confirmed by detailed work. Minute trails of a legged organism only about 1 mm wide have been found in the lower Arumbera Sandstone. Meandering "worm" trails have been collected from the upper Arumbera Sandstone.

5. Stromatolite biostratigraphy

Amadeus Basin stromatolites are being serial-sectioned and thin-sectioned ready for study. A Conophyton-like stromatolite was discovered in the Bitter Springs Formation at the Ringwood Dome. This work is a continuation of previous research and is aimed at providing a relative age framework for the Precambrian.

6. Microfossils in stromatolites

Numerous thin sections of stromatolites from the Amadeus and McArthur Basins have been prepared and many have been searched for microfossils. Abundant microfossils have been found in stratiform stromatolites of the Bitter Springs Formation but so far none are known from columnar or cumulate stromatolites. The fungus (?) Eomycetopsis has been found to form sheet-like mats.

7. Microfossils and stromatolites in a newly discovered granular iron formation in Western Australia.

Mining company geologists were advised to look for stromatolites in a granular iron formation which in hand specimens closely resembles the stromatolitic Biwabik Iron Formation of Minnesota (one of the main sources of North American iron ore). They were successful and a thin section study has revealed very abundant microfossils of several kinds, probably including both blue-green algae and bacteria. Both the facies and the fossils closely resemble those of the Gunflint Iron Formation of Ontario, which is of a comparable age.

8. Precambrian sedimentary phosphorites

Rich phosphorites occur in beds of stromatolites in India. Stromatolites are very useful tools in palaeoenvironmental analysis and can be used to locate potentially phosphoritic former carbonate shelf margins. When current theories of phosphorite deposition are applied to the Adelaide Geosyncline certain exploration targets are very clearly indicated: Brighton Limestone equivalents in the Orrorroo district and elsewhere; the Brighton Limestone south of Adelaide and on Kangaroo Island; the Topley Hill Formation (particularly the Tindelpina Shale Member) in the Orrorroo district and elsewhere in the eastern Mt Lofty Ranges. No basin analyses have been undertaken in other Precambrian basins, so confident prediction is impossible, but other potentially phosphoritic areas can be suggested. However the common Phanerozoic and Holocene shale-chert-phosphorite rock association cannot be expected in the Precambrian due to the absence of silica-secreting organisms from the Precambrian oceans.

A study of the distribution of phosphate in Precambrian stromatolites has commenced. Early results indicate that most stromatolites contain 0.01-0.05% P_2O_5. Some anomalously high values have been obtained and these will be investigated further.

9. Editing "Stromatolites", a book to be published by the Elsevier Scientific Publishing Company

Editing continued throughout the year. Thirty-one manuscripts have been received and more are expected in the near future. Publication is expected during 1975.

10. Talks were given to the Geological Society of Australia in Adelaide and at the meeting of the Specialist Group on Palaeontology and Biostratigraphy in Hobart.

11. Co-operation with both the Bureau and the Baas Becking Laboratory is continuing at Imperial College, London, where attention has been focused on Precambrian microfossils from the McArthur Group (M.D. Muir), Roper Group (M.D. Muir & C.J. Peat) and Bungle Bungle Dolomite (W.L. Diver). New finds have been made in the McArthur Group Cooley Dolomite (Manganese bacteria - composition confirmed by X-ray Microanalysis), and Balbirini Dolomite. Some of the microfossils from the Amelia Dolomite appear to have some connection with sulphide minerals, and the environment of deposition of the Amelia appears to have been supratidal or high intertidal. Similar interpretations can be made for the Bungle Bungle Dolomite, where also possibly the earliest eukaryotic cells with internal organelles have been discovered. In contrast, the environment represented by the Roper Group samples appears to have been very different - a euxinic basin into which much of the organic matter must have been washed. A wide variety of microfossils is present, and many of these are first known occurrences, of large 'seaweed-like' fossils, of possibly animal microfossils and of very large spheroids etc. Future examination of shale, rather than stromatolitic chert environments, will greatly enlarge our knowledge of Precambrian microbiotas.

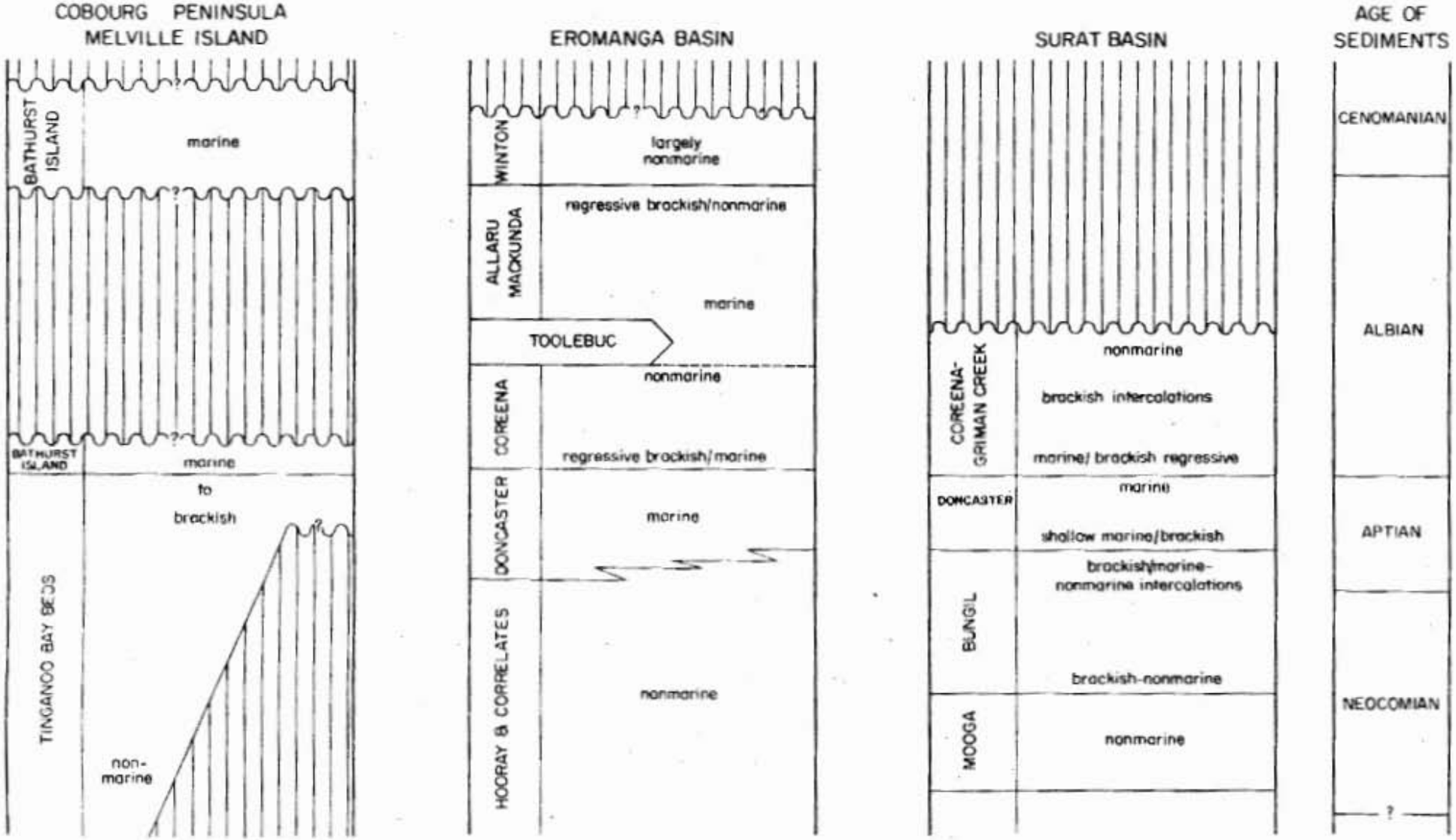


Fig S 21 Correlation of Cretaceous sediments

M(S) 353

D. Burger

The study of the Cretaceous palynology of northern Australia continued. Regional studies in the Northern Territory advanced considerably in the wake of recent field activity by the Bureau in Cobourg Peninsula. The material studied was collected from outcrop and subsurface by the Bureau and the Department of Mines in Darwin. Although present results are based mainly on (still) poorly known geological distribution of fossil dinoflagellate species, they already indicate that a substantial portion of the Albian rock sequence is missing from Melville Island and the Peninsula.

In the Great Artesian Basin project, first priority was given to the study of the Surat Basin, which is now well advanced. Statistical analyses of microfloral assemblages contribute towards a clearer environmental picture and suggest solutions for correlation of poorly dated subsurface sections. A short initial paper on some problematic plant microfossils from the Neocomian-Aptian is in press.

An initial attempt at correlating Cretaceous rock sequences throughout northern Australia is given in Figure S21.

Other activities of the past 12 months included:

a) Administrative activities; curating of palynomorph types described in the period 1970-1973; and extending the edge punchcard data storage and retrieval system for plant microfossils.

b) A visit to the following Institutions (April): Burmah Oil Company, West Australian Petroleum Pty Ltd, Geological Survey of Western Australia, the University of Western Australia and the Geological Survey of South Australia.

c) Working out new methods for the preparation of fossils for fluorescence palynology, in which aggressive chemical treatment used in our standard techniques is avoided.

d) Laboratory output: in the period October 1973 - September 1974 Mrs Kracuik processed and registered 343 rock samples, mainly from the Mesozoic of Australia, for palynological analysis.

G.C. Chaproniere

The principal work this year has been documenting a study on the Oligo-Miocene Larger Foraminifera from northwestern Western Australia. This study has involved material collected from surface and subsurface sections in that region. It was necessary to first correlate the studied sections into the existing rock-stratigraphic subdivision for that area, and secondly to study the planktonic foraminifera to relate the rock-stratigraphy to the planktonic biostratigraphic zonation schemes. The larger foraminiferal studies, which form the main part of the project, have been used to provide a biostratigraphic zonation, separate from the planktonic scheme. Correlation within the zonation is being achieved by biometric procedures, which have involved some computer time. A palaeoecological study of the larger foraminifera, using published information of modern foraminifera, has provided a great deal of information on the palaeoenvironmental ranges of this group of organisms.

Phylogenetic studies, based on the biometric data, suggest that the Australian larger foraminifera, after establishing themselves in the region, have evolved in lineages independent from those elsewhere in the Indo-Pacific area.

In addition to the project outlined above, back-up work for the Papua New Guinea Geological Survey field parties, in conjunction with Dr D.J. Belford, has resulted in two reports. Additional work has involved the building up of the ECAFE collection and searching the BMR collections from Victoria as a basis for redescribing the larger foraminifera, using similar biometric techniques to those employed for the Western Australian study.

E.M. (Kemp) Truswell

Research associated with Leg 28 of the Deep Sea Drilling Project was continued. In addition to lithological descriptions for three of the sites drilled on this cruise, projects dealing with the palynology of offshore Antarctic sediments, and with changes in biogenic sediment type in the southern ocean were completed. The latter project involved the tracing of the boundary between siliceous and calcareous pelagic sediments, and interpretation of this facies change in terms of climatic cooling through the Tertiary. Manuscripts describing these projects are in press in the Initial Reports volume for Leg 28 (published for the U.S. National Science Foundation).

A post-cruise meeting to discuss the results of Leg 28 drilling and to co-ordinate the presentation of data was attended in La Jolla, California, in January 1974. A summary of the major results of this drilling program was presented at the Challenger Centenary - Deep Sea Drilling Symposium at Macquarie University, Sydney, in August. An abstract of this paper is to be published in the proceedings of this symposium.

Further work on the palynology of drillsites on the Ninetyeast Ridge, Indian Ocean, is currently being undertaken in collaboration with W.K. Harris, of the Geological Survey of South Australia. This elaborates preliminary papers already completed for the Leg 22 and 26 Initial Reports volumes. Basic systematic studies of late Oligocene to early Miocene spore and pollen assemblages from Site 254, at the southern end of the ridge, are almost complete.

Palynological studies of Cretaceous and Permian sequences in the Officer Basin of Western Australia were completed and results are in press (BMR Bulletin 160). Studies were based on samples from BMR stratigraphic drillholes, and from oil exploration wells.

An attempt was made to instigate a program of Tertiary palynology, with examination of samples from BMR boreholes on the Alcoota and Canterbury sheet areas. However, all samples proved barren, due probably to weathering contemporaneous with sediment deposition.

The palynological examination of Permo-Carboniferous samples from outcrop and drilled sequences in Tasmania was undertaken. To date, microfloras have been recovered from tillitic sequences at Wynyard and Strahan, and from post-glacial sediments at Lake River, Beaconsfield, Sassafras and in the Fisher Tunnel.

Detailed discussions have been held with M. Norvick concerning the palynostratigraphy of Permian sequences in the Galilee Basin Queensland, prior to the commencement of taxonomic studies on selected dispersed spores.

Since the Gondwana Symposium in August 1973, Elizabeth Kemp has been acting as convenor for the Working Group on a Permo-Carboniferous time-scale for Gondwanaland; this group was set up under the auspices of the IUGS Gondwana Subcommission. In 1974, two newsletters outlining the aims of the group, and reporting on the activities of its members, were prepared and circulated. A visit was paid to Hobart in February to discuss plans with Australian members of the working group.

Other activities during 1974 included completion of a manuscript on the late Palaeozoic glaciation of Asia, with L.A. Frakes and J.C. Crowell (in press in the Bulletin of the Geological Society of America); the presentation of a talk entitled 'Aspects of Antarctic glacial history' to the BMR in April, and consultations with members of the Basins Study Group concerning the interpretation of palynological reports.

Robert S. Nicoll

Conodont material collected in conjunction with the Tantangara Party from the Silurian Peppercorn Beds on Long Plain was examined and an oral report, co-authored by Dr Carl B. Rexroad, Indiana Geological Survey, was presented at the North Central Section Meetings of the Geological Society of America. This material is being prepared for publication.

Conodont material from the Carboniferous to Devonian Laurel-Fairfield of the Canning Basin, W.A., has been studied and the text material is ready for editing. Several limestone samples collected by the Tantangara Party have been studied and ages determined for those containing conodont faunas.

Nine weeks was spent in the Carnarvon Basin, W.A. collecting Devonian, Carboniferous and Permian rocks for conodont biostratigraphic study. This material is now being processed at the BMR Acid Laboratory at Fyshwick.

M. Norvick

A bulletin, under joint authorship with D. Burger, on Cenomanian microplankton, spores and pollen from Bathurst Island, Northern Territory is in press. The manuscript for a Report was completed on the Late Carboniferous and Permian stratigraphic palynology of the Galilee Basin, Queensland, and initially will be issued as a Record.

Micropalaeontology Laboratory (F. Hadzel; A.T. Wilson; P.W. Davis)

Material was processed as follows:

Washed: 2076 samples (including 1032 in H_2O_2)

Sectioned: 701 samples (1012 sections - slides)

Polished: 124 samples

Dissolved in acid: 1900 samples, approximately 2060 kg in weight

Dissolved in acid in field: 200 samples of 800 kg.

Picked: 2278 samples

Photographed: 1940 photographs

Translated (from German): 51 pages of different publications

Reorganizing of the laboratories: 15 working days

OTHER SEDIMENTARY SECTION ACTIVITIES

COMPUTING GROUP

by

W. Mayo

STAFF: W. Mayo, K.A. Summers

NEW PROGRAMMING

The following new programming has been carried out and added to the Geological Branch program library :

1. Subroutine to obtain the real and complex roots of any polynomial.

2. XRF program (with iterative improvement of the result) to handle the minor element output.

3. Subroutine to obtain the minimum of any multi-dimensional function.

4. Adaption and modification of a Q-mode cluster analysis program originally written in the USA and the addition of a dendrogram plotting subroutine.

5. Subroutine to obtain the solution of a set of simultaneous linear equations.

6. Extension of the Q-mode factor analysis program to accept up to 1500 samples.

7. Addition of R-mode cluster analysis in conjunction with the Q-mode analysis.

8. Addition of subroutines to the R-mode factor analysis to allow oblique rotation of the Varimose factor matrix.

9. Additions to the SURFAUST system (for storage and retrieval and sorting of data sets) to allow more flexibility of field types and optional limitations on the type of samples sorted.

10. Frequency distribution plots and comparison of means added to a general statistics and X-Y plotting program.

11. Subroutine added to the CIPW norm program to allow optional data transformation.

CONVERSION TO THE CYBER 76

The Geological Branch program library, GEOLPROGS, now consists of 40 FORTRAN programs and subroutines working on the Cyber 76. This library includes most of the Branch geological programs written in the past and only 6 programs remain to be fully converted to the Cyber 76.

These programs are now stored on a magnetic tape in UPDATE (a CSIRO system) format so that additions can be easily effected. Only a few appropriate control cards are needed to assess each program or subroutine.

The control cards and the associated data format for each of these programs is fully explained in the documentation (see below) of each program.

PROGRAM DOCUMENTATION

Each of the above 40 routines is fully documented in computer card form under the headings,

1. Author
2. Keywords
3. Purpose
   (a) General
   (b) Input
   (c) Output
   (d) Limitations
4. Driving Instructions

The documentation set will also be stored on magnetic tape in UPDATE format for easy updating. When run as a data set through program OUTREC from the GEOLPROGS tape, a complete listing in BMR Record format of all the program documentations is obtained. As with the conversion only 6 programs remain to be fully documented.

STORAGE/RETRIEVAL

The SURFAUST system (which incorporates the sample submission data) has emerged as the most suitable storage/retrieval/sorting system for sampling projects with associated numeric data. INFOL is generally more appropriate for information type data such as bibliographies and fossil or mineral assemblages. Other general storage systems available are UPDATE and SORT/MERGE.

Using INFOL a central index to hold all the relevant information concerning each set of stored data has been initiated. This information would include where the data and samples are stored, units of the measured variables, publications, sheet areas etc. Searching the index, for example, for all the sediments sampled in Queensland with Ca CO_3 measured would result in a listing of all the information for each project with corresponding data.

If this index works successfully it may be a workable alternative to the present sample submission system.

URANIUM SERIES DATING

by

J.F. Marshall

The Uranium Series Dating Project was initiated in an attempt to date material collected by the Marine Geology Section during previous cruises. The dating technique is based upon the observation that marine carbonates, in particular corals and oolites, contain measurable amounts of uranium, but are essentially free of its decay product Th^{230}. The growth of Th^{230} toward a state of radioactive equilibrium with its parent U^{238} can be used as a measure of age. The method can be used over the range from a few tens of thousands to several hundred thousand years.

The initial work consisted of calibrating the alpha-spectrometer and determining its efficiency. Once this had been established and the spectrometer gave consistent and reproduceable results, the activity of the U^{232} spike was measured. The U^{232} spike is used in conjunction with Th^{234} as a yield tracer. Background activities of both the U^{232}/Th^{228} and the Th^{234} tracer were also carried out. During these procedures the method of separating the uranium and thorium isotopes using ion exchange resin, and the electroplating of the isotopes onto metal discs were perfected. Dating of samples is now in progress.

INTERNATIONAL GEOLOGICAL CONGRESS

Various members of the Sedimentary Section have been involved in preparatory work for IGC excursions to be conducted in August 1976. Besides undertaking the usual administrative work involved in organizing an excursion, A.T. Wells made arrangements to obtain oblique and vertical coloured aerial photographs of many of the prominent and well exposed features of the Amadeus Basin.

During their 1974 field season, members of the Georgina Basin party went over the proposed route of the IGC excursion to that area. Important outcrops were photographed for the guidebook and problems of logistics were examined.

A.R. Jensen and N.F. Exon visited areas in the Surat and Bowen Basins in June with officers of the Geological Survey of Queensland to select locations to be visited by excursion 3C and to prepare a detailed itinerary. Road cuttings in Mesozoic sandstone sequences were examined in some detail to provide notes for the guidebook.

METALLIFEROUS SECTION

GEOLOGICAL INVESTIGATIONS IN NORTHERN TERRITORY, WESTERN AUSTRALIA, AND ANTARCTICA

ARUNTA COMPLEX

by

R.D. Shaw, A.J. Stewart, R.G. Warren, A.P. Langworthy, and B.E. Hobbs (Monash University)

STAFF: R.D. Shaw, A.J. Stewart, R.G. Warren (overseas), A.P. Langworthy, L.A. Offe, L.P. Black (part time), A.Y. Glikson (part time), R.W. Marjoribanks (part time; previously ANU); J.L. Funk and M.J. Rickard, both from ANU; and B.E. Hobbs, J. Granath, V. Hirsinger, and J. Wilkie, all from Monash University; and D.B. Clarke, Geol. Survey of N.T., are associated with the project.

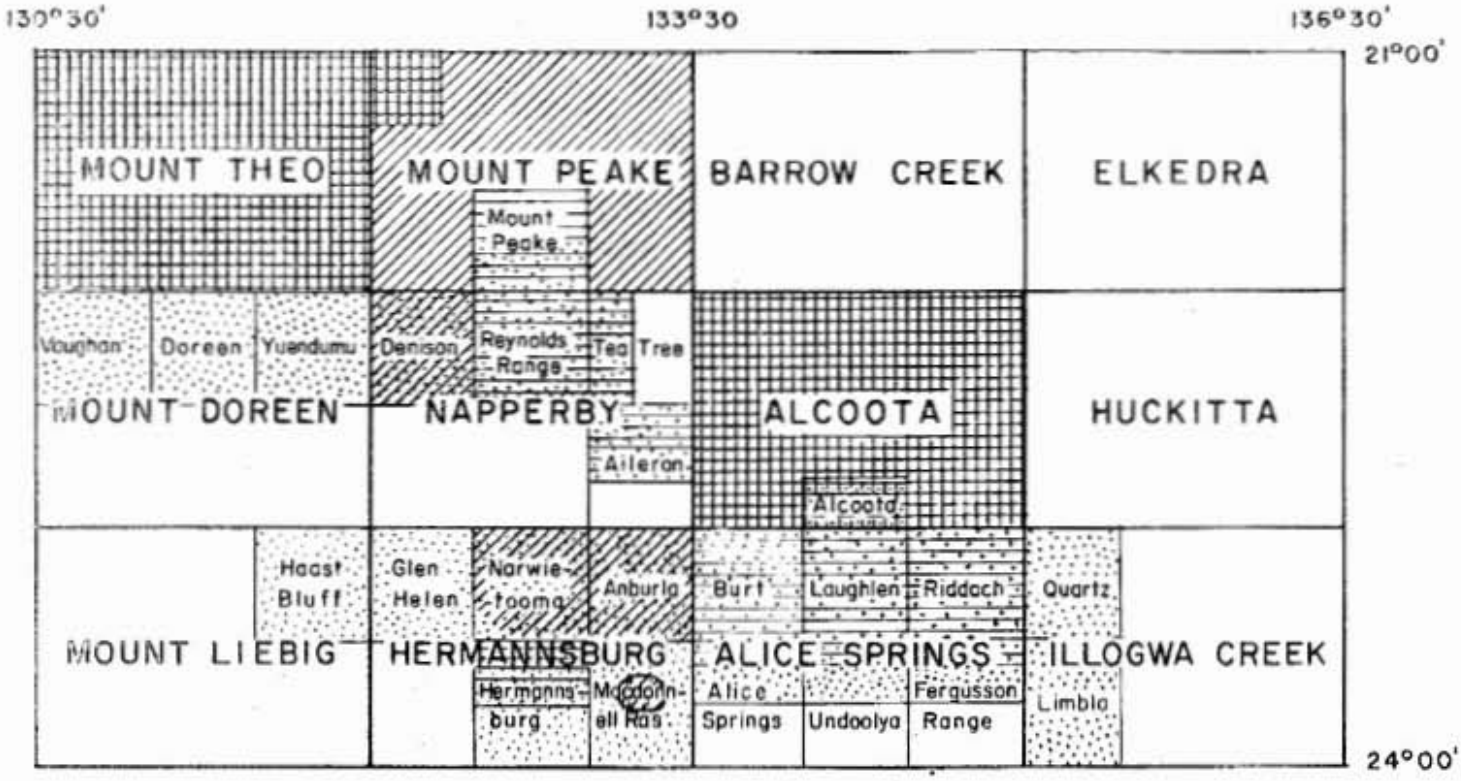
Basement rocks of the Arunta Block which were mapped in only a cursory way during mapping of the Amadeus Basin in the 1960's are now being mapped systematically, and their economic potential assessed. Complex regions are being mapped at 1:100 000 scale. Post-graduate students and staff from ANU and Monash University assisted by continuing detailed studies in areas of particular interest to them.

The project has progressed to a stage where a stratigraphic and tectonic framework is emerging, and preliminary accounts on these topics were outlined at a symposium on the Arunta Complex at the December (1973) meeting of the Geological Society of Australia (Territories Division). The most recent tectonic interpretations have been published (1) under the title "The gravity effects of three large uplifted granulite blocks in separate Australian Shield areas" by Anfiloff (Geophysical Branch) and Shaw, presented at a symposium on the Earth's Gravitational Field and Secular Variations in Position, University of NSW, and (2)as a letter to Nature (Physical Science) headed "Orogenic zones in central Australia; intraplate tectonics?" by B.A. Duff and Langworthy. Members of the Arunta project also participated in the formulation of a lithologic colour scheme for geological maps, and the scheme is being considered for use in special maps.

Areas so far mapped are shown in Fig. M2.

ISOTOPIC DATING IN ARUNTA BLOCK

Record 1974/79, "Rubidium-strontium dates and excess argon in the Arltunga Nappe Complex" by R.L. Armstrong (University of British Columbia) and Stewart was issued. This report has been accepted for publication in the Journal of the Geological Society of Australia. The results of dating by Black are presented in the report for the Geochronological Laboratory.



1:250 000 Field mapping complete

1:100 000 Field mapping complete

Field mapping 1974

Existing colour photographs (1:25000)

Fig. M 2—Arunta project: coverage of mapping and colour photographs

INVESTIGATION OF MINERAL DEPOSITS

Warren spent the year at the Imperial College of Science and Technology, London, where part of her work included a thesis entitled "Genesis of the Conagalabi Group of Deposits, Arunta Complex, central Australia". Record 74/117, 'Summary of information on mineral deposits of the Arunta Complex, Alice Springs area, N.T.,' by Warren, Stewart, and Shaw is about to be issued. The distribution of mineral deposits in the Arunta Complex is shown in Fig. M3.

Potentially Economic Mineral Deposits

The Arunta Complex and peripheral on-lapping sedimentary basins and superficial cover rocks contain a number of mineral deposits that have been mined or are being explored and developed; the principal ventures are summarized in Table M1. The area is particularly prospective for uranium, lead, copper, tungsten, and fluorite.

Uranium has been found by Central Pacific Minerals N.L. in the Carboniferous Mount Eclipse Sandstone (Colorado Plateau type) and in superficial calcrete in the Mount Doreen Sheet area. Details of grade are not yet available. Large areas of superficial cover north and south of the Stuart Bluff Range are being actively investigated. Additional areas of similar sediments cover parts of the Arunta Complex. Granite in the Reynolds Range has a total radioactivity level equal to or greater than six times the standard deviation of the radioactivity of the surrounding rocks, so drainage basins filled by young sediments flanking this granite may be particularly favourable.

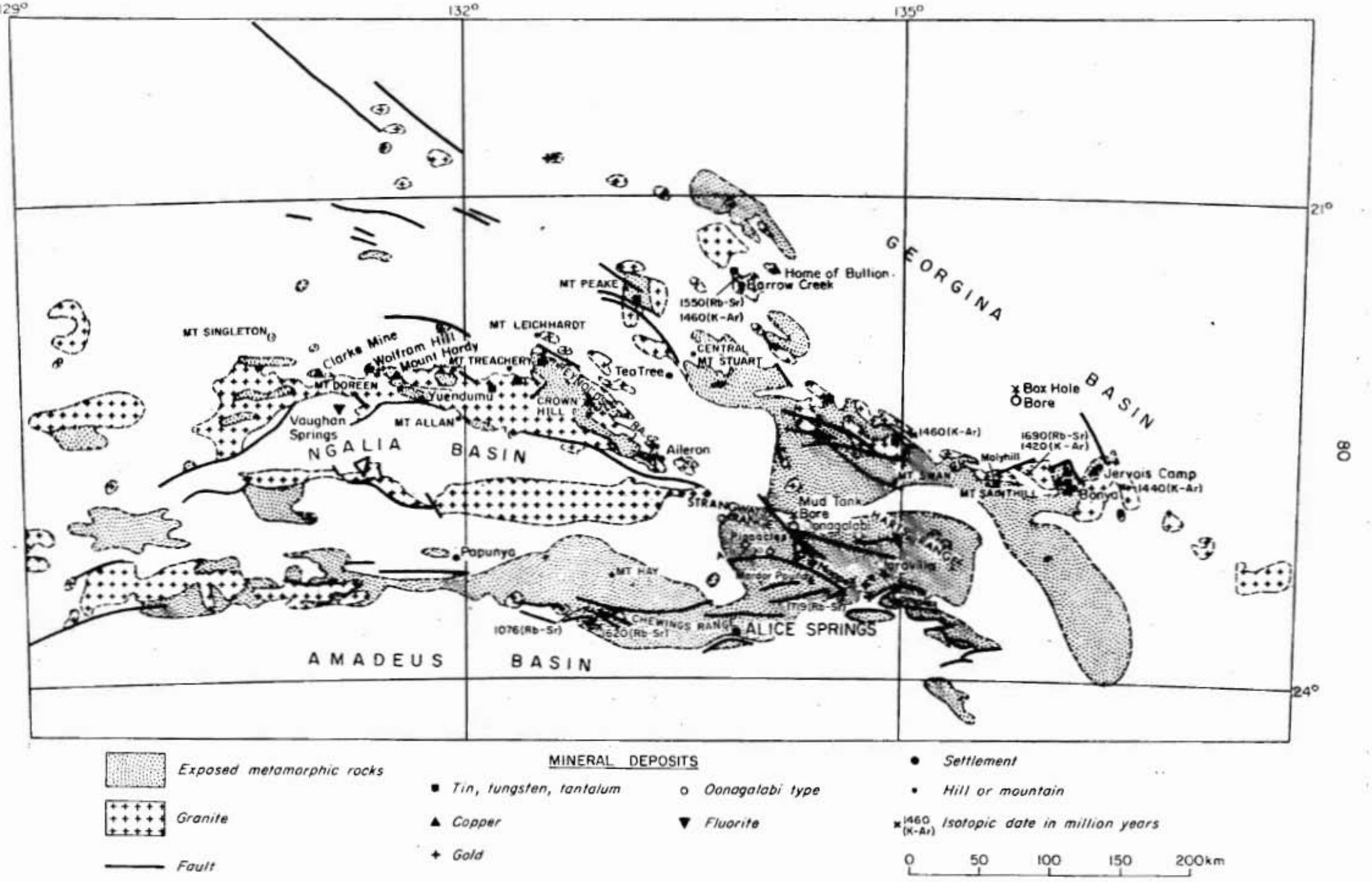
Copper lodes with associated metals at Jervois and Conagalabi are stratiform, and probably also stratabound. Investigation of the metamorphic facies and stratigraphic position of these lodes may show that parts of the Alice Springs, Huckitta, and Illogwa Creek Sheet areas are prospective for similar deposits.

Tungsten minerals have been found in a broad zone from Jervois to Mount Singleton, north of the Ngalia Basin. In the Bonya and Molyhil areas, scheelite is found in calcareous rocks adjacent to granitic intrusions. Similar situations throughout the zone of tungsten mineralization should be considered prospective.

Lead minerals in carbonate rocks of the Georgina Basin have been found at Box Hole Bore, and similar minerals may occur in carbonate rocks of the Amadeus and Ngalia Basins, and in carbonates of the Harts Range Group and the Reynolds Range Group in the Arunta Complex.

Carbonatite and Ultrabasic Rocks

The probable carbonatite at Mud Tank and the ultrabasic complex at Mordor Pound are situated near the intersections of major deformed zones in the Arunta Block. Carbonatites and rocks with kimberlitic affinities like the Mordor Ultrabasic Complex (provisional name) occur in Africa along long, narrow deformed zones with little surface expression.



Record 1974/127

Fig. M 3 Distribution of mineral deposits in Arunta Block, N.T.

G.A.X. NT/A/420

TABLE M 1. CURRENT MINING AND EXPLORATION VENTURES IN THE ARUNTA COMPLEX

METAL	LOCATION	1:250 000 SHEET AREA	DEVELOPMENT & PRODUCTION	RESERVES	ASSOCIATED METALS
Copper	Mount Hardy	Mount Doreen	Small production of oxidized ore	12000 tonnes of 3-4% Cu in oxidized zone	
	Jervois	Huckitta	Drilling, open cuts, exploration shaft	5 m tonnes of variable grades to 3% Cu, 9% Pb	Pb, Zn, Bi, W, F
	Oonagalabi	Alice Springs	Percussion drilling, costeans	10 m tonnes, reported grades up to 1% Cu, 1.6% Zn	Zn, Au
	Home of Bullion	Barrow Creek	Three shafts (2 open), surface workings. Has produced small parcels of oxidized ore and secondary sulphides	6000 tonnes 20% Cu (1953)	Pb
Fluorite	Vaughan Springs district	Mount Doreen	Surface workings	Unknown	?Pb
	Jinka	Huckitta	Costeans, drilling	Confidential	
Tungsten	Molyhil	Huckitta	Surface workings; several tons of scheelite	Not assessed	
	Jericho	Huckitta	Open cut, production not available, estimated at 100+ tonnes of scheelite ore	Confidential	Cu
	Bonya district	Huckitta	Costeans, drilling	Confidential	
Uranium	Ngalia Basin prospects	Mount Doreen	Costeaning and drilling	Not available	V

The carbonatite at Mud Tank contains apatite (locally up to 65% of the rock), magnetite, ilmenite, and zircon. Geopeko Ltd tested the prospect in 1966 as a possible source of apatite. Average trace element abundances, especially the high Nb (78 ppm), La (173 ppm), and Y (137 ppm), and to a lesser extent moderately high Ba and Sr, are characteristic of carbonatites.

The ultramafic complex at Mordor Pound consists of phlogopite-bearing basic to ultramafic alkalic rocks. Their Ni content ranges from 350 to 1000 ppm, and Cu from 25 to 5000 ppm. Uranium (uranophane) has been identified in cross-cutting pegmatites from which one sample assayed 2.88% U. The petrology of the complex is further described in the section on the Laughlen 1:100 000 Sheet area.

HERMANNSBURG 1:250 000 SHEET AREA

Mapping of the Hermannsburg 1:100 000 Sheet area is complete, and a Record has been prepared and submitted to the Supervisor editing. Mapping of the Anburla and Narwietooma 1:100 000 Sheet areas is almost complete, although field checking will be required following petrographic study. Most of the accessible exposures in the Chewings Range in the MacDonnell Ranges 1:100 000 Sheet area have been visited, and completion of the mapping is expected in 1975.

Anburla 1:100 000 Sheet area

The principal outcrop within this area is the Mount Hay massif; minor outcrops are situated in the Burt Plain. The Mount Hay massif consists of a monotonous sequence of basic granulites, which abound in small segregations of sodic plagioclase, and commonly include rapakivi-textured porphyroblastic augen. A large body of anorthosite was mapped along the northern flanks of this massif. Isolated outcrops of gneiss, gneiss with granulite inclusions, and some anorthosite occur in the Burt Plain. The granulite is difficult to separate into mappable units. Further details for this and the Narwietooma Sheet area are given in the report for the Petrological Laboratory.

Narwietooma 1:100 000 Sheet area

The principal outcrops within this Sheet area are the Mount Chapple range, Redbank Hill, part of the basement north of the Chewings Range, and isolated outcrops in the Burt Plain. Parts of Redbank Hill and the Chewings Range were mapped by Marjoribanks in 1971. The Mount Chapple Range consists of distinct units of basic granulite and gneiss. The Redbank Hill area consists of granitic to hybrid gneiss with abundant granulite inclusions of various sizes. Similar rocks crop out in isolated hills in the Burt Plain.

MacDonnell Ranges 1:100 000 Sheet Area

The structural relationships within the area mapped are complex. In the east, near Jay Creek, the main range formed by the Chewings Range Quartzite is essentially synformal, whereas in the west near Hugh Gorge it is antiformal. A strongly lineated augen gneiss containing potash feldspars up to 5 cm across adjoins the Quartzite along the northern side of the range, dipping southerly under the Quartzite at 30° in the east. However, in the west the Quartzite dips northerly under the gneiss at about 10-20°. The gneiss extends northwards to an E-W line running a little to the north of the Old Hamilton Downs homestead. On the southern flank of the Chewings Range, the Quartzite dips south, and is in contact with augen gneiss and quartz-feldspar-biotite gneiss from Hugh Gorge to the western side of Mt Conway; thin quartzite slices commonly occur south of the main range within the gneiss, and dip predominantly north at about 70°. From Mt Conway eastwards, the Quartzite is in contact with layered quartz schist and pelite, although the augen gneiss and quartz-feldspar-biotite gneiss crop out farther towards the Heavitree Range.

Within the Chewings Range proper the Quartzite is intercalated with the augen gneiss in the west and with pelite and thinly layered quartzite in the east. In the vicinity of Brinkley Bluff there is a closed outcrop of augen gneiss within the Quartzite, which occupies a complicated refolded antiform within which the Quartzite both overlies and underlies the gneisses.

To the west of Standley Chasm a very large reclined fold approximately 2 km across plunges gently northwest, but is modified on its northeastern limb by a series of large kink-like folds which are responsible for regionally changing the overall dip of foliation from gently north to steeply south. The reclined folds appear to be superimposed on an older set of isoclinal folds, so there is evidence for three regional-scale fold episodes.

Clarke made preliminary traverses in the Stuart Pass area, where Chewings Range Quartzite overlies granite, and is overlain by gneiss and schist.

The Undoolya Siltstone, Temple Bar Sandstone, Fenn Cap Conglomerate, and Blatherskite Quartzite Members of the Heavitree Quartzite are continuous across the Sheet area. The Undoolya Siltstone is poorly exposed and conglomeratic.

Hermannsburg 1:100 000 Sheet area

The effects of five deformational and metamorphic events have been distinguished; three major orogenic events correspond to isotopic dates around 1600 m.y., 1100 m.y., and 400 m.y.. The Redbank deformed zone separating the granulite of the Mount Hay area from amphibolite facies rocks to the south was initiated about 1600 m.y. ago, and reactivated 400 m.y. ago. A rise in the geothermal gradient coupled with metasomatism and granite intrusion produced a wide migmatite complex north of the Chewings Range. The Razorback Nappe, which may have involved a southward translation of 20 km or more, was emplaced at about 400 m.y. ago.

ALICE SPRINGS 1:250 000 SHEET AREA

Arltunga Nappe Complex

Shaw assisted Anfiloff (Geophysical Branch) in constructing a geological model to account for the gravity profile across the Nappe Complex in the Alice Springs Sheet area, and on to the Alcoota 1:250 000 Sheet area. The structure of the Heavitree Quartzite in the Arltunga Bore area was re-examined during the 1974 field season, and found to be very complex, involving major north-plunging reclinded folds as well as thrusting. Granulites and related rocks of lower metamorphic grade form the core of the main and over-riding nappe.

Alice Springs 1:100 000 Sheet area

Compilation sheets have been prepared of 1973 mapping, and 100 thin sections described. 1974 field checks confirmed that the granite and migmatite dated at about 1100 m.y. in the Hermannsburg 1:100 000 Sheet area extend eastwards at least as far as Alice Springs. The sequence south of the Charles River Fault is correlated with the southernmost rocks in the Hermannsburg 1:100 000 Sheet area, and is tentatively correlated with the Reynolds Range Group in the Napperby 1:250 000 Sheet area.

Burt and Laughlen 1:100 000 Sheet areas

Compilation sheets have been prepared of the Laughlen 1:100 000 Sheet area, and photo-overlays of the Burt 1:100 000 are ready for compilation. A preliminary petrographic investigation was made, and 15 samples submitted for chemical analysis.

The ultrabasic complex (at Mordor Pound) consists of stocks of mica peridotite, olivine-phlogopite pyroxenite, melamonzonite, shonkinite, and biotite rock and carbonate-rich shonkinite; the complex intrudes a homogeneous coarse-grained syenite. The ultramafic parts of the complex are cut by numerous pegmatite and carbonate veins.

The ultrabasic rocks are low in aluminium and total alkali-metals, but high in calcium and magnesium, whereas the more fractionated phases of the intrusion show affinity with the shoshonite association, being rich in aluminium, alkali metals, and calcium, and low in titanium. The ultrabasic suite differs from other alkali ultrabasic rocks in having a very high K_2O/Na_2O ratio, and being considerably enriched in barium (up to 1.5% Ba). Although the complex shows kimberlitic affinities it lacks high-pressure assemblages. One cordierite-spinel-hypersthene xenolith suggests an equilibration pressure less than 6 kb. Several of the ultrabasic bodies are rich in carbonate, and the cross-cutting carbonate veins resemble altered carbonatite.

Riddoch 1:100 000 Sheet area

The relationship between the Harts Range Group and the underlying Cadney Gneiss was examined in the field, and found to be a probable unconformity that has been subjected to various amounts of thrusting. Compilation was continued by Rickard.

ALCOOTA 1:250 000 SHEET AREA

The Explanatory Notes are in press, and the map is being fairdrawn. A Record dealing with the geology in some detail is being edited within the Section.

NAPPERBY 1:250 000 SHEET AREA

The first draft of a Record on the 'Geology of the Reynolds Range, Mount Peake, Tea Tree, and Aileron 1:100 000 Sheet Areas, Arunta Complex, N.T.' by Stewart, Glikson, Offe, and Warren was written and submitted for supervisor's edit.

Reynolds Range and Tea Tree 1:100 000 Sheet Areas

Photo-scale overlays of these Sheet areas were compiled and reduced, and drafting of both Sheets for Preliminary Edition has started. Outcrops previously unvisited in the northern part of the Tea Tree Sheet area and in the southwestern part of the Reynolds Range Sheet area were examined and mapped during the 1974 field season.

Aileron 1:100 000 Sheet Area

The map is being prepared for Preliminary Edition.

Denison 1:100 000 Sheet Area

The Denison 1:100 000 Sheet area was mapped during the 1974 field season. The oldest rocks crop out in the northwestern part of the Sheet area, and consist of pelitic and psammitic metasediments of the Lander Rock Beds interbedded with spotted and layered cordierite hornfelses of the Mount Stafford Beds; the latter grade into metapelitic granulite. In the northeastern part of the area, the Giles Range consists of white and hematitic quartzites of the Mount Thomas Quartzite conformably overlain by feldspathic sandstone and schist of the Pine Hill Formation; the two formations are part of the Reynolds Range Group, which unconformably overlies the Lander Rock Beds in the adjoining Reynolds Range 1:100 000 Sheet area. In the eastern, central, and northern parts of the Denison Sheet area, small exposures of brown impure metaquartzite, calc-silicate rock and calc-silicate marble, and foliated hematitic porphyry are present, and are assigned tentatively to the Wickstead Creek Beds (defined in the Aileron 1:100 000 Sheet area). Andalusite-bearing schist in the eastern part of the Sheet area, and slate, schist and porphyry in the south are mapped as Lander Rock Beds. All these metasediments are intruded by various types of granite, the oldest of which are a coarse porphyritic gneissic granite in

the southern part of the Sheet area, a contorted gneissic leucogranite with ptygmatically folded pegmatite layers in the northern part of the Sheet area, and a medium-grained strongly foliated biotite gneiss of granitic composition in the extreme west. These are in turn intruded by the most extensive granite, a coarse porphyritic variety with a prominent parallelism of platy phenocrysts; in a few places, the granite is even-grained. It in turn is intruded by numerous other types of granite (including melanocratic and leucocratic varieties), by porphyritic micro-granite, by numerous pegmatites and aplites, and by dolerite dykes.

At Crown Hill and Mount Treachery, granite is overlain unconformably by feldspathic quartz sandstone of the Central Mount Stuart Beds (Upper Proterozoic-Lower Cambrian), with small amounts of tillite and shale at Crown Hill, and at Mount Allan (just off the Sheet area to the west) by the Vaughan Springs Quartzite (Upper Proterozoic) of the Ngalia Basin sequence. In the Denison Sheet area itself, the Vaughan Springs Quartzite is faulted against the granite; it consists of flaggy orthoquartzite and kaolinitic quartz sandstone. Isolated exposures of the sediments of the Ngalia Basin are present in the southwest, and include flaggy red-brown quartz sandstone of the Yuendumu Sandstone (Upper Proterozoic), and pebbly quartz sandstone and cobble conglomerate of the Mount Eclipse Sandstone (Carboniferous).

All the rocks in the area are cut by major faults and fault zones, commonly containing prominent ridges of brecciated vein quartz.

Mineral deposits in the Denison Sheet area include tin, tungsten, and tantalum, which occur as cassiterite, wolframite, and tantalite (respectively) in pegmatites; only the Mount Allan Tin Mine is working at present. The Mount Eclipse Sandstone in the neighbouring Yuendumu 1:100 000 Sheet area contains uranium (as carnotite and pitchblende), so this unit may warrant prospecting in the Denison Sheet area.

MOUNT PEAKE 1:250 000 SHEET AREA

The Preliminary Edition of the Mount Peake 1:100 000 Sheet was issued. The remainder of the Mount Peake 1:250 000 Sheet area was mapped during the 1974 field season, and thereby completed the geological surveying of the Northern Territory at 1:250 000 scale. The rocks in the Sheet area can be grouped into six units: 1. The Lander Rock Beds: these are the oldest rocks in the area, and consist of closely folded metapelitic schist, hornfels, and amphibolite of medium metamorphic grade. These are intruded by (2a), granite, which in places is itself intruded by fluorite-bearing quartz veins, and by (2b) cassiterite-bearing pegmatite. Both these units are unconformably overlain by (3) the Central Mount Stuart Beds, which are a varied clastic sequence beginning with local tillite, arkosic conglomerate, and calcareous pelite at the base, which are overlain by lutite, arkose, and coarse-grained feldspathic quartz sandstone, respectively; in the eastern part of the Sheet area, the Beds begin with a distinctive orthoquartzite about 20 m thick, which is overlain by more feldspathic quartz sandstone. All three units are cut by major faults which are marked by prominent ridges of brecciated vein quartz, hematite-quartz, and limonite-quartz (4). The Vaughan Springs Quartzite (5) crops out only in the southwestern part of the Sheet area, and unconformably overlies granite and flaser granite; it consists of quartzite (feldspathic in places), pebbly quartz sandstone, and purple ferruginous shale and sandstone. Most of the Sheet area is covered by superficial Cainozoic

deposits (6). Deposits of economic minerals in the Sheet area are small, and include the Mount Peake Lead Show (galena in vein quartz), the Anningie Tin Field (cassiterite in pegmatites), occurrences of fluorite in quartz veins intruding granite, and pyrite and malachite in fault-zones.

MOUNT THEO 1:250 000 SHEET AREA

The Preliminary Edition of the Mount Theo 1:250 000 Sheet was issued, and the Explanatory Notes (which include an Appendix of Petrographic Descriptions) and map are being edited for First Edition. Four samples of laterite from the Sheet area were analysed for Fe; the maximum content found was 35.6%.

THE GRANITES-TANAMI PROJECT

by

D.H. Blake

STAFF: D.H. Blake (Party Leader), I.M. Hodgson (to August, 1974), P.C. Muhling (GSWA), part time.

INTRODUCTION

Reconnaissance geological mapping of The Granites-Tanami region, southeast of the Kimberleys, was started in 1971, and fieldwork was completed in 1973. The region is covered by parts of ten 1:250 000 Sheet areas (Fig. M4) of which eight were mapped during the present survey: Birrindudu and Tanami in 1971, The Granites, Billiluna, Lucas, and Stansmore in 1972, and Webb and Highland Rocks in 1973; Gordon Downs and Lake Mackay had been mapped previously.

The Party has spent this year in Canberra preparing maps and reports. This work has included:

1. preparing Preliminary Edition maps of the Webb and Highland Rocks 1:250 000 Sheet areas;

2. reporting the geology of the Webb and Highland Rocks Sheet areas (Records 1974/54 and 1974/120);

3. preparing a Record (1974/104) on stratigraphic drilling carried out in the survey area between 1971 and 1973;

4. editing the report of the 1972 field season (Record 1973/171) for publication in the Report Series;

5. editing the Preliminary Edition maps of the Birrindudu, Tanami, and The Granites Sheet areas for 1st edition publication, and the Preliminary Edition maps of the Billiluna, Lucas, and Stansmore Sheet areas for 2nd edition publication;

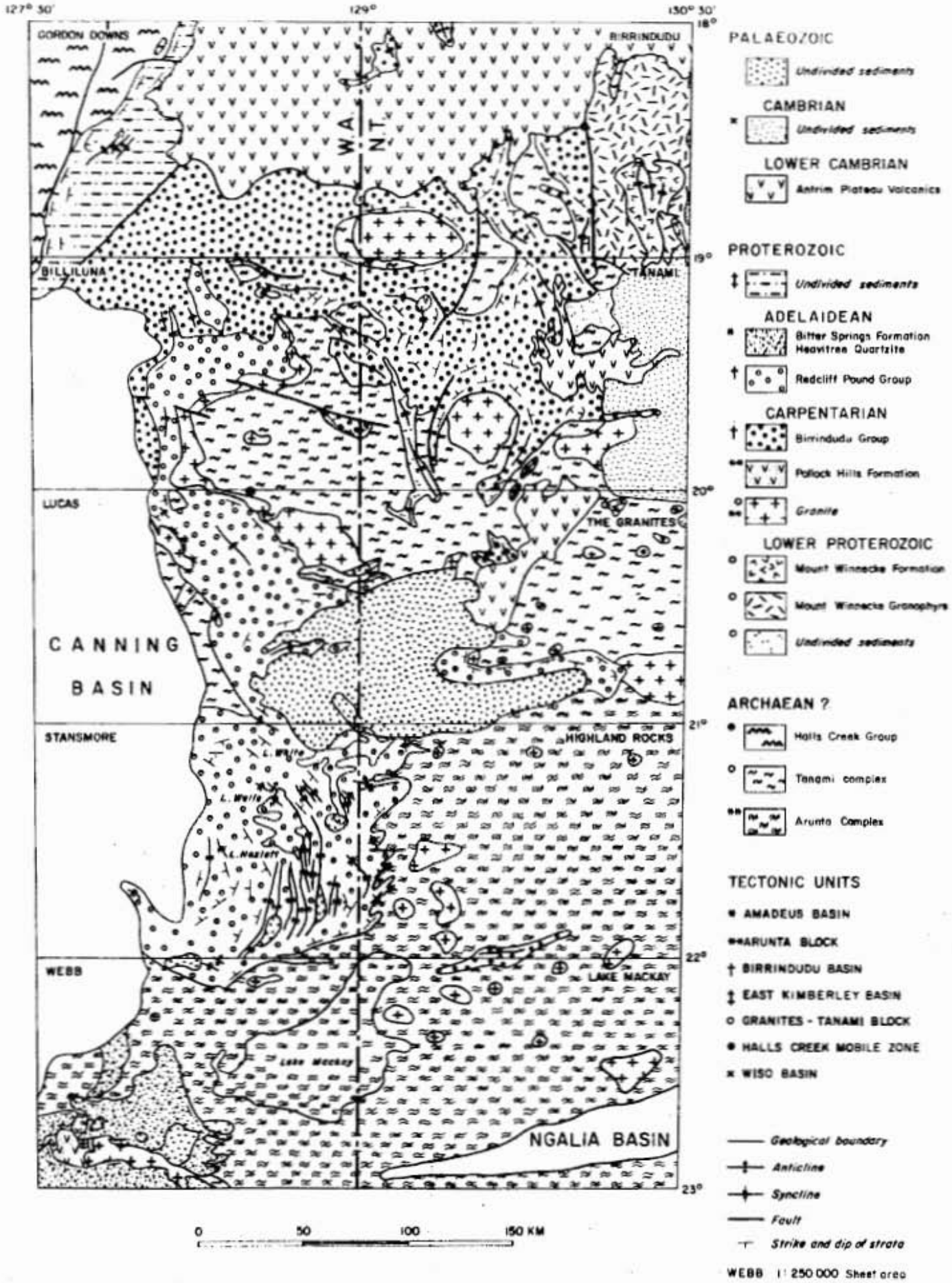


Fig. M 4 Geological map of The Granites - Tanami region

6. preparing Explanatory Notes to accompany the 1st and 2nd edition maps.

In addition, a start has been made on a Bulletin on the geology of the region; the text is expected to be completed early in 1975.

SUMMARY OF GEOLOGY

The Granites–Tanami region lies between the mainly Precambrian Kimberley, Victoria River, and Arunta areas to the northwest, north, and south, respectively, and the Phanerozoic Canning and Wiso Basins to the west and east. It consists of mainly Precambrian rocks which are largely concealed by Cainozoic superficial sediments.

The oldest rocks exposed, which belong to the possibly Archaean Tanami complex, are schistose to phyllitic greywacke, siltstone, shale, tuff, basic and acid volcanics, chert, arenite, and quartzite. They are steeply dipping and tightly folded, and have been subjected to low-grade regional metamorphism (lower greenschist facies). Gold and minor copper mineralization occur within the Tanami complex at Tanami and The Granites. Gossans are common locally, but are not known to be associated with significant mineralization.

The Tanami complex is correlated with the lithologically similar Halls Creek Group in the Halls Creek Mobile Zone of the Kimberley region, and with gneiss, schist, and quartzite of the Arunta Complex cropping out to the south. It is overlain unconformably by Lower Proterozoic and younger rocks, and is intruded by granite.

The overlying Lower Proterozoic rocks consist of steeply dipping unmetamorphosed clastic sediments and, in the Mount Winnecke Formation, acid lavas and pyroclastics. The acid volcanics and some of the granite intrusions have been dated isotopically (Rb–Sr whole-rock method) by R.W. Page. The acid volcanics and the Winnecke Granophyre, which crop out in the northeast, are dated at 1800 m.y., and are probably comagmatic. Granite intrusions in the Billiluna, Lucas, and The Granites Sheet areas are dated at 1700–1750 m.y.. The intrusions and older rocks together make up the Granites–Tanami Block.

In the southwest, in the Webb Sheet area, metamorphic rocks of the Arunta Complex and clastic sediments and acid volcanics of the Pollock Hills Formation are also intruded by granite. Both the acid volcanics and the granite are dated isotopically at about 1500 m.y., and are probably comagmatic. The granite, Pollock Hills Formation, and Arunta Complex here form part of the Arunta Block.

The Granites–Tanami Block is overlain unconformably by the mainly gently dipping sedimentary rocks of the Birrindudu Basin. The oldest beds deposited in the basin are those of the Birrindudu Group, the basal unit of which, the Gardiner Sandstone, has been dated at 1550–1600 m.y. (K–Ar and Rb–Sr determinations on glauconite). The Birrindudu Group consists mainly of clastic sediments, especially quartz-rich sandstone, but also includes some partly stromatolitic chert. It is correlated with the Mount Parker Sandstone and Bungle Bungle Dolomite of the East Kimberley basin and the Limbunya Group of the Victoria River region. Minor uranium and rare earth mineralization is present at the base of the Birrindudu Group in the southern part of the Billiluna Sheet area, near the W.A./N.T. border. This is the only mineralization known in the Birrindudu Basin.

The Redcliff Pound Group, which overlies the Birrindudu Group unconformably, also consists mainly of quartz-rich clastic sediments. It is correlated with the Heavitree Quartzite and Bitter Springs Formation of the Amadeus Basin, the Vaughan Springs Quartzite of the Ngalia Basin, and the Wattie Group of the Victoria River Basin. The Proterozoic succession overlying the Bungle Bungle Dolomite in the East Kimberley basin appears to be younger than the Redcliff Pound Group. The East Kimberley basin is inferred to be separated from the Birrindudu Basin by a major fault.

The Cambrian Antrim Plateau Volcanics, mainly basaltic lava flows, unconformably overlie the Precambrian rocks in the north, and extend south to the centre of The Granites Sheet area. Here they are overlain by terrestrial Palaeozoic sediments which crop out to the south and west. Palaeozoic sediments of the Canning and Wiso Basins overlap the Precambrian rocks of the region to the west and east, respectively.

The widespread Cainozoic superficial cover (omitted from Fig. M4) consists predominantly of Tertiary laterite, calcrete, and clay, and Quaternary aeolian sand, alluvial and lacustrine silt and clay, and evaporitic halite and gypsum. The cover is generally less than 5 m thick, but reaches more than 30 m locally. Salt lakes, the largest of which are Lakes Mackay, White, Wells, and Hazlett, are present in the south.

VICTORIA RIVER BASIN PROJECT

by

I.P. Sweet

The project was undertaken to obtain basic geological information about an area of about 100 000 km^2 in the northwestern part of the Northern Territory which had not previously been systematically mapped. Fieldwork was completed in 1970.

The project involved the mapping of nine 1:250 000 Sheet areas. All nine geological sheets and Explanatory Notes have now been published, the last two - Waterloo and Victoria River Downs - having been released during 1974. Two out of three Reports (Nos. 161 and 166) dealing with the region were also released during the year.

During 1974 a draft manuscript of a Bulletin summarizing the geology of the region was revised and returned to the editors. A geological map at 1:500 000 scale, which will accompany the Bulletin, was edited and corrected during the year.

THE ANTRIM PLATEAU VOLCANICS AND CORRELATIVES, NORTHERN AUSTRALIA

by

R.J. Bultitude

The draft of a Record on the geology and petrology of the Antrim Plateau Volcanics and correlatives was completed during the year.

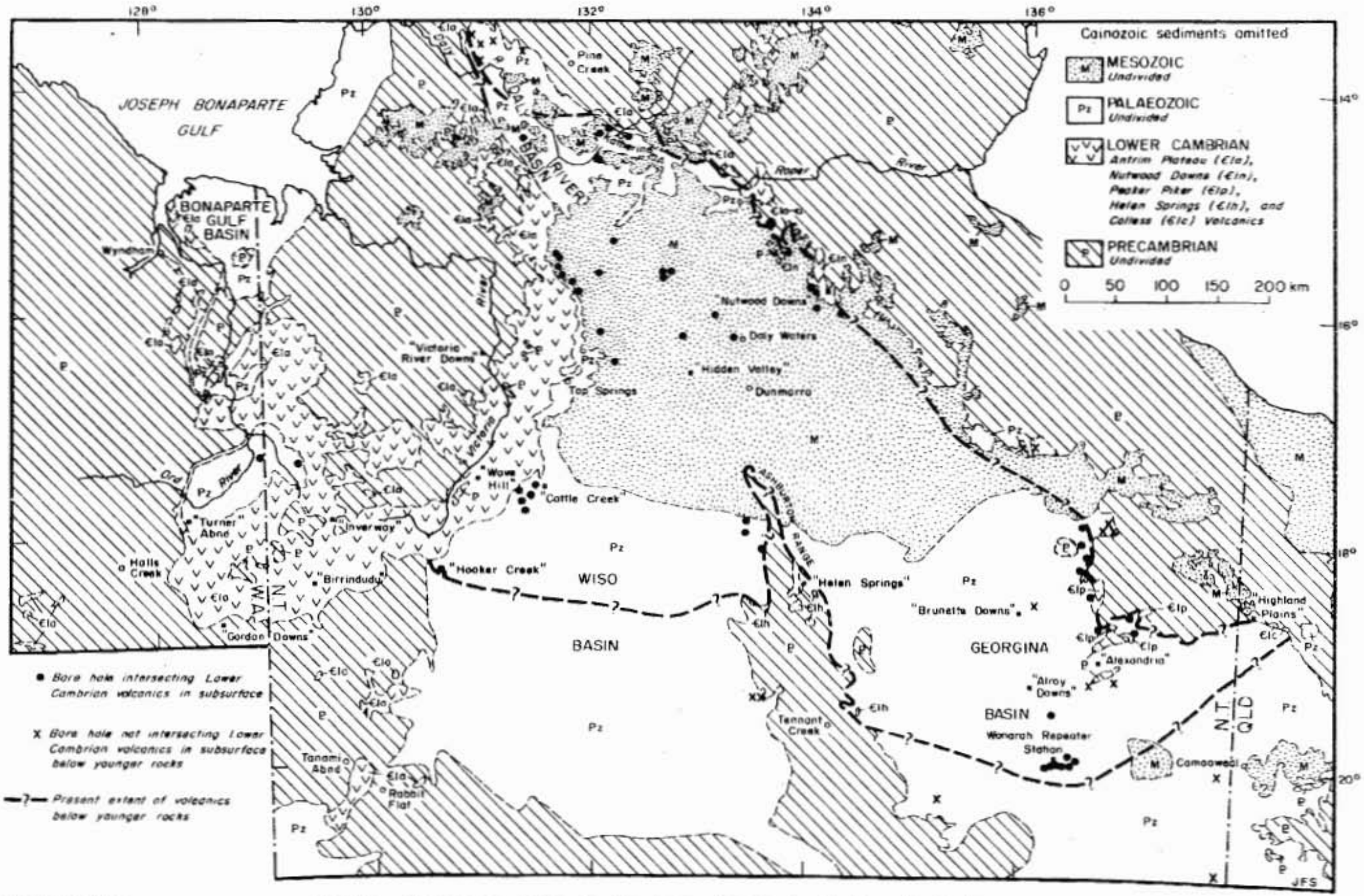
The Antrim Plateau Volcanics is a very widespread but hitherto little investigated sequence of basaltic lavas (flood basalts) and interbedded sediments, of probable Lower Cambrian age. Lavas in the formation are extensively exposed in the Ord River and Victoria River regions of northern Australia, and are known from drill hole intersections to underlie most Phanerozoic sediments of the northern Wiso and Daly River Basins (Fig. M5). Other isolated outcrops of basic volcanics correlated with the Antrim Plateau Volcanics have been mapped around the northern and western margins of the Georgina Basin (Colless, Peaker Piker, and Helen SpringsVolcanics) and the eastern margin of the Daly River Basin (Nutwood Downs Volcanics). Basic volcanics have also been intersected beneath lower Middle Cambrian sediments in the northern part of the Georgina Basin.

The formations consist predominantly of successions of flat-lying or gently dipping subaerial basaltic lava flows and thin sedimentary intercalations. The lavas are faulted and tilted in the western part of the Ord-Victoria region, but are little-disturbed elsewhere. Features of the areas investigated are the great scarcity of intrusive rocks and the lack of recognizable effusive centres.

The basalts are typical tholeiites, being made up essentially of labradorite, clinopyroxene, opaque oxides and a mesostasis consisting of devitrified glass or a quartzo-feldspathic residuum. Many flows contain pigeonite as well as augite, and pseudomorphs after olivine are present in a few flows. Accessory minerals are apatite, quartz, hornblende, and biotite.

Chemically the lavas form a fairly homogeneous group, most of those analysed containing quartz and hypersthene in the norm. However, they range in composition from under-saturated olivine tholeiites through tholeiites to quartz tholeiites and perhaps tholeiitic andesites. Specific chemical characteristics of these lavas are relatively high SiO_2 (about 52-53 percent) and low TiO_2 (about 1 percent) and total Fe (about 10 percent total iron as FeO) contents. They are not high-alumina types, a characteristic shared with most other flood basalt sequences. Parts of most flows have been affected by secondary alteration. Vesicles commonly contain zeolites, prehnite, pumpellyite, calcite, quartz, and chalcedony.

Some of the lavas contain native copper either as sparse interstitial disseminations of apparently primary origin in massive basalts or as secondary infillings of amygdales and geodes in vesicular flow tops. Malachite, azurite, chalcocite, and chrysocolla are commonly associated with the native copper in amygdales and geodes, and also occur in basal beds of overlying limestone. The formation has been examined for copper mineralization by several companies in recent years, but no significant concentrations of native copper or other copper minerals have been found.



Record 1974/127

Fig. M 5 Distribution of Lower Cambrian volcanics in Northern Australia

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PINE CREEK GEOSYNCLINE

DARWIN URANIUM GROUP by C.E. Prichard

STAFF: C.E. Prichard, P.G. Smart, P.G. Stuart-Smith, P. Fuchs (draftsman)

The Darwin Uranium Group provided administrative services for most BMR activities within the Territory. Wages hands and/or accounts were paid for fifteen field parties.

The Manton seismic station was operated throughout the year, and time signals were supplied to the ABC from the Crystal Clock. Geophysical staff provided advice to the public, and carried out field surveys (reported in the Summary of Activities of the Geophysical Branch). Geologists continued mapping the Alligator Rivers Uranium Field (report follows).

Sale of geological maps increased slightly, and there has been a marked increase in use of reference facilities throughout the year. It is apparent that there is a need for all Bureau publications to be available for reference in Darwin, and this service is being steadily improved.

Interest in the results of Bureau mapping in the Alligator Rivers Uranium Field remains high among those companies operating in the area. A general interest in the environment of uranium deposition and ideas on genesis of the ore bodies was shown by many representatives of exploration companies during the year.

More time and effort than previously were employed in liaison to facilitate Bureau operations in areas of aboriginal or environmental significance. Good relations have been established and maintained with the authorities administering Wildlife Sanctuaries and proposed National Parks. More problems have arisen from proposed work in Aboriginal Reserves: these stem from the need not only to liaise with the Department of Aboriginal Affairs, but also with the local groups of aborigines directly concerned. It is not always easy to identify all groups with interests in such areas, and to establish communication with them. In all cases agreement for Bureau operations was obtained, but unfortunately in one case not in time for the project to be carried out as planned.

ALLIGATOR RIVER PARTY by R.S. Needham and P.G. Smart

STAFF: R.S. Needham, P.G. Smart, A.L. Watchman (resigned 17/5/74), P.G. Stuart-Smith (commenced 2/9/74), I.H. Crick (August only)

INTRODUCTION

Field work for the party's program is almost complete, and only minor field checking and follow-up drilling are scheduled. Emphasis

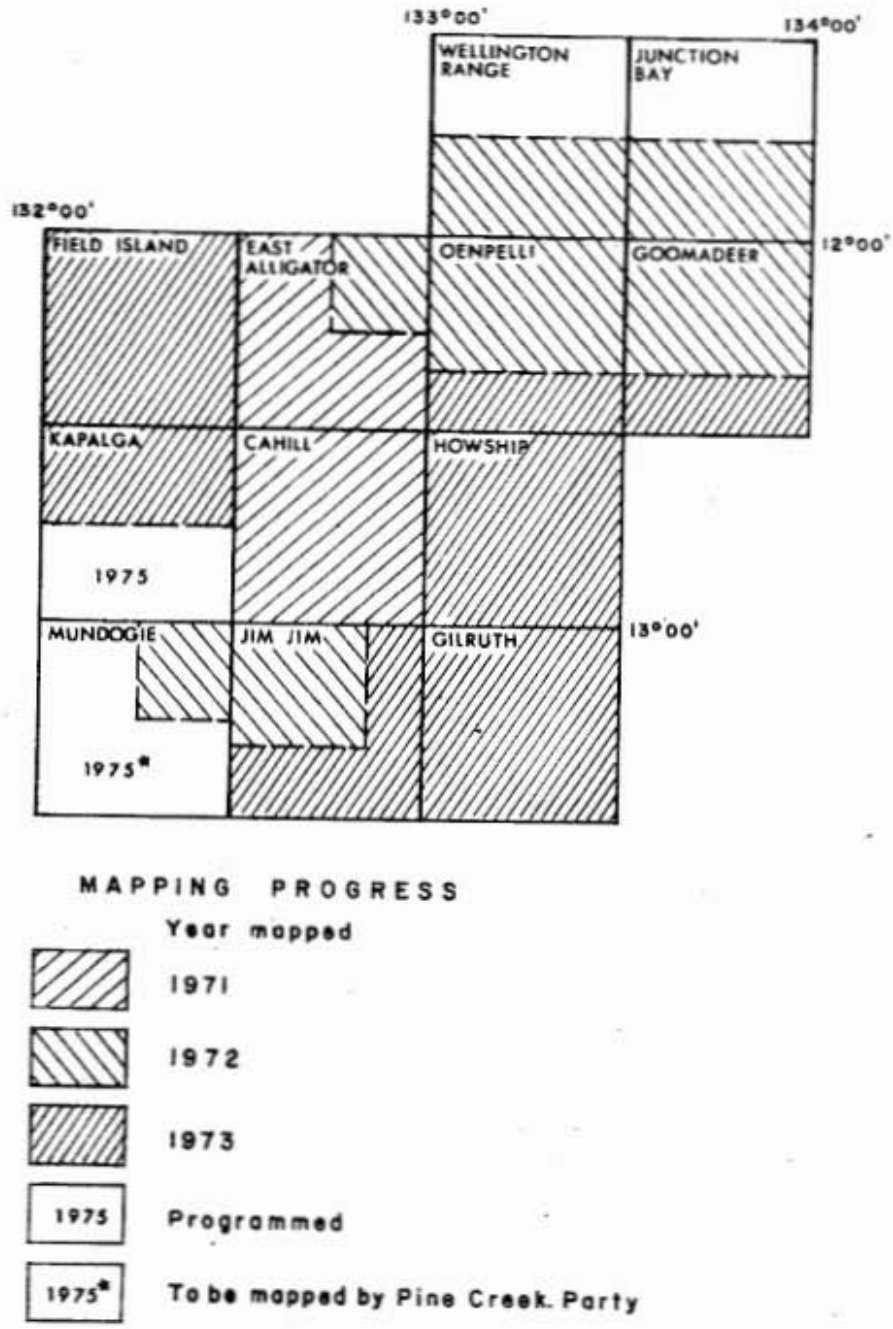


Fig. M 6 – Alligator River Party progress mapping

will be on map and report production after the end of the 1974 field season. Progress of mapping is shown in Fig. M6.

GENERAL GEOLOGY

Age determination by R.W. Page on several of the major rock units of the area has necessitated a partial reappraisal of the geological history of the area. Archaean ages from parts of the Nanambu Complex are evidence for an Archaean basement high during Lower Proterozoic sedimentation. The formation of the Nanambu (migmatite) Complex at about 1800 m.y. involved both Archaean and Lower Proterozoic rocks, rather than simply Lower Proterozoic material as we previously suggested. The genesis of the Nimbuwah Complex may differ from that of the Nanambu Complex. Dating of material from the Migmatite Zone has yielded ages of about 1800 m.y.. Material from the Granitoid Core was collected for dating in 1974, but as there is field evidence that granitic material intrudes Migmatite Zone rock types, it appears unlikely that an Archaean age will be determined for the Granitoid Core.

Dating of the phonolites and the Oenpelli Dolerite gave ages of about 1340 and 1720 m.y., respectively, dispelling ideas of a common parent magma for these rocks. The 1720 m.y. age also represents a maximum age for the Kombolgie Formation, as Oenpelli Dolerite forms basement highs unconformably overlain by the Carpentarian sandstone.

A small dolerite body measuring about 2000 m^2 at 12°12'S 133°45'E has apparent intrusive relationships with the Kombolgie Formation. It yielded an age of about 1200 m.y., and represents a minimum age for the Formation.

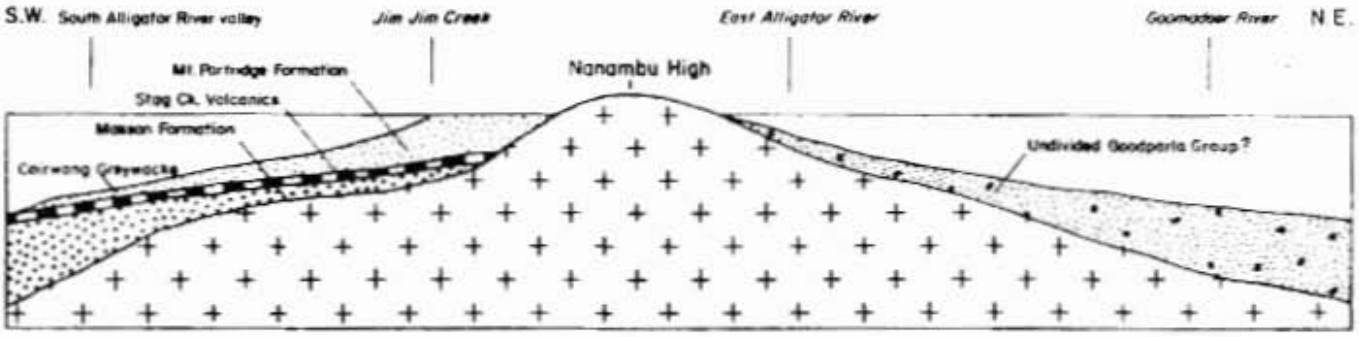
The geological history of the area is shown diagrammatically in Fig. M7.

Koolpin Formation equivalent

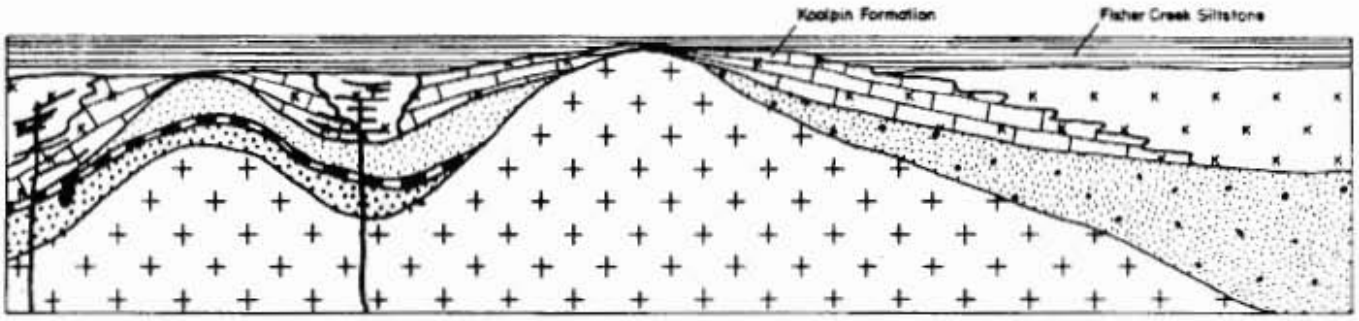
Mapping and subsequent detailed photointerpretation of metamorphosed and migmatized Lower Proterozoic sedimentary rocks in the Myra Falls Inlier have yielded a recognizable succession of strata possibly correlating with "Koolpin Formation equivalent" (or 'Mine Series') of the Cahill and East Alligator Sheet areas. The succession is as follows:-

C. Units above main quartzite

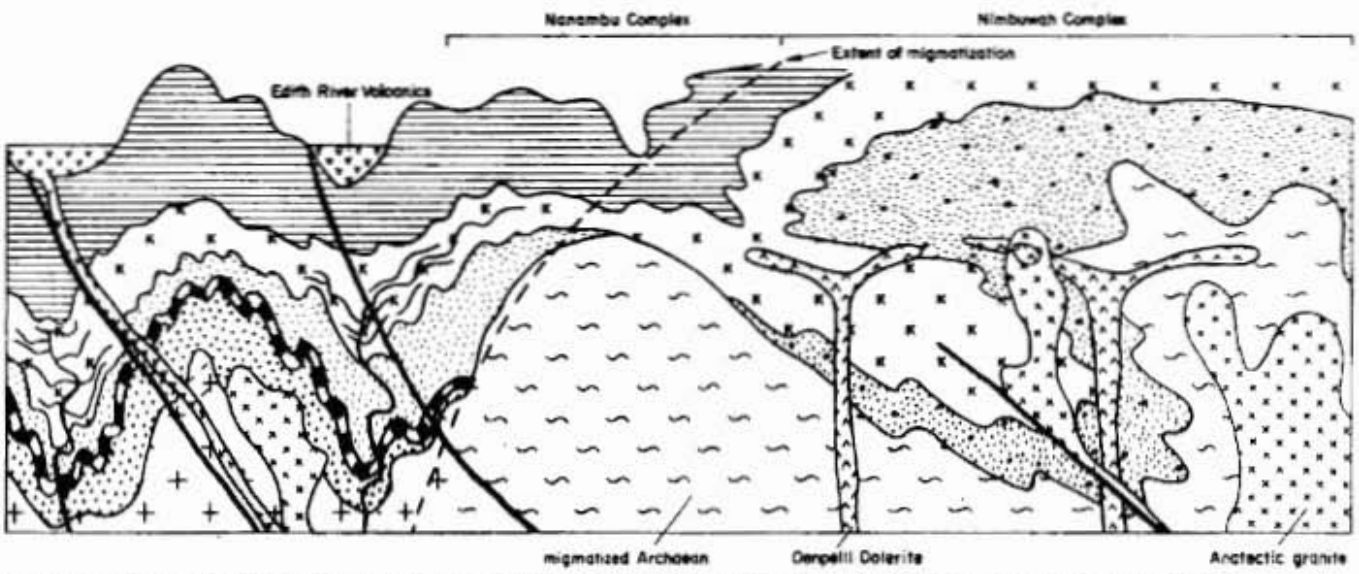
i) carbonaceous schist
ii) amphibolite
iii) psammitic gneiss, banded lit-par-lit gneiss
iv) garnet-hornblende-feldspar-quartz-muscovite-biotite gneiss, amphibolite, tremolite rock, lit-par-lit gneiss
v) garnet-hornblende-feldspar-quartz-muscovite-biotite gneiss
vi) (locally) marble and orange banded granular gneiss
vii) amphibolite, interbedded gneiss



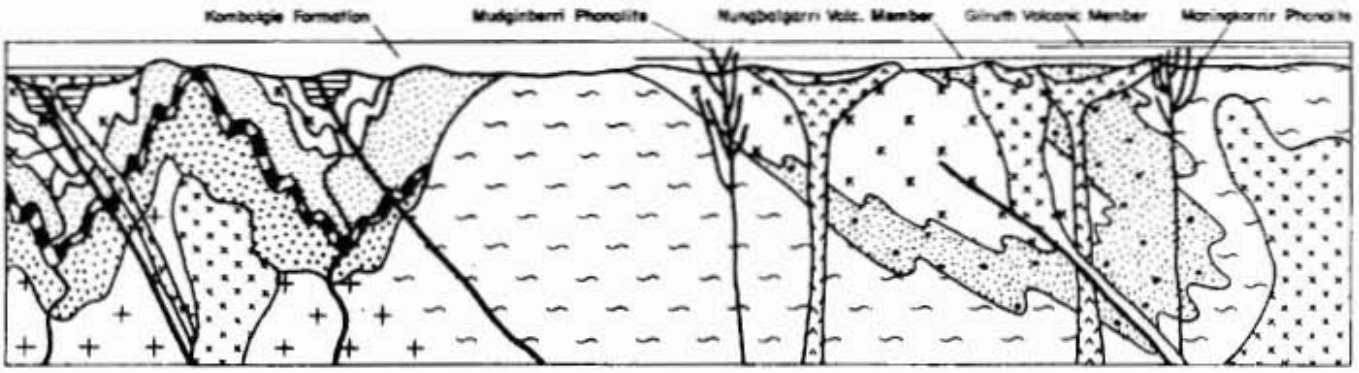
A. Deposition of Goodparla Group sediments in intracratonic basins. (2200 - 1840 m.y.?)



B. Open folding in southwest; deposition of South Alligator Group sediments; intrusion of Zamu Complex dolerites as sills (2200 - 1840 m.y.?)



C. Formation of Nimbuwah Complex by extensive migmatization; reactivation of Archaean basement to form Nanambu Complex mantled gneiss dome; associated overthrusting, folding and regional metamorphism; intrusion of Oenpelli Dolerite, formation and mobilization of anatectic granites and extrusion of (comagmatic?) Edith River Volcanics. (1840 - 1600 m.y.?).



D. Period of erosion. Deposition of Kombolgie Formation plateau sandstone, and extrusion of basaltic volcanic members; intrusion of phonolites. (1600 - 1320 m.y.?).

Fig. M 7 Geological history of the Alligator Rivers area, N.T.

B. Main quartzite	i)	interbedded fine to medium muscovite–feldspar quartzite and schist, minor amphibolite
	ii)	well-bedded coarse orthoquartzite, muscovite quartzite with some biotite, and gneissic in places
A. Units below main quartzite	i)	micaceous feldspar quartzite, minor amphibolite; grades to granular biotite–muscovite–quartz–feldspar banded gneiss
	ii)	(locally) hornblende muscovite quartzite
	iii)	amphibolite
	iv)	coarse muscovite–feldspar gneiss

This succession is probably overturned, units 'C' then correlating with Lower Mine Series at Ranger 1. Throughout the Alligator Rivers uranium field, carbonate rock within the "Koolpin Formation equivalent" lies at or near the bottom of the succession. Poor exposure and chloritization in the vicinity of Nabarlek make it impossible to trace these units by surface mapping, but discontinuous exposures of the 'main quartzite' about 15 km north and northwest of Nabarlek firmly place Nabarlek within the units grouped under 'C'.

The 1974 drilling programme was designed to collect information from the "Koolpin Formation equivalent" in the Jim Jim and Cahill Sheet areas. Results are presented under 'Drilling'.

1974 FIELDWORK

Field mapping was virtually completed in 1973, and consequently the 1974 field season involved field checking, drilling, and comparison of certain rock units with their possible stratigraphic equivalents farther south in the South Alligator Valley. Heavy August rains prevented the scheduled mapping of the southern half of the Kapalga Sheet area, and also curtailed the drilling programme.

Drilling

One hundred and thirty-three holes were drilled by two BMR "Mayhew 1000" rotary drilling rigs on three traverses (Fig. M8) in an attempt to correlate the lower amphibolite* facies metamorphic rocks of the "Koolpin Formation equivalent" with one or more of the Lower Proterozoic formations defined by Walpole et al. (1968).

On the Mount Basedow traverse (70 holes) no carbonate rock was found, but a band (100–150 m thick) of graphitic chlorite schist was intersected at the northwestern end of the traverse. This schist overlies meta-arkose (which forms Mount Basedow), and is overlain by about 400 m of feldspathic biotite schist with minor meta-arkose and feldspathic quartzite layers. The feldspathic rocks are probably metamorphic equivalents of either the top of the Mount Partridge Formation or part of

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*Indicated by the presence of kyanite in schist at Mount Basedow.

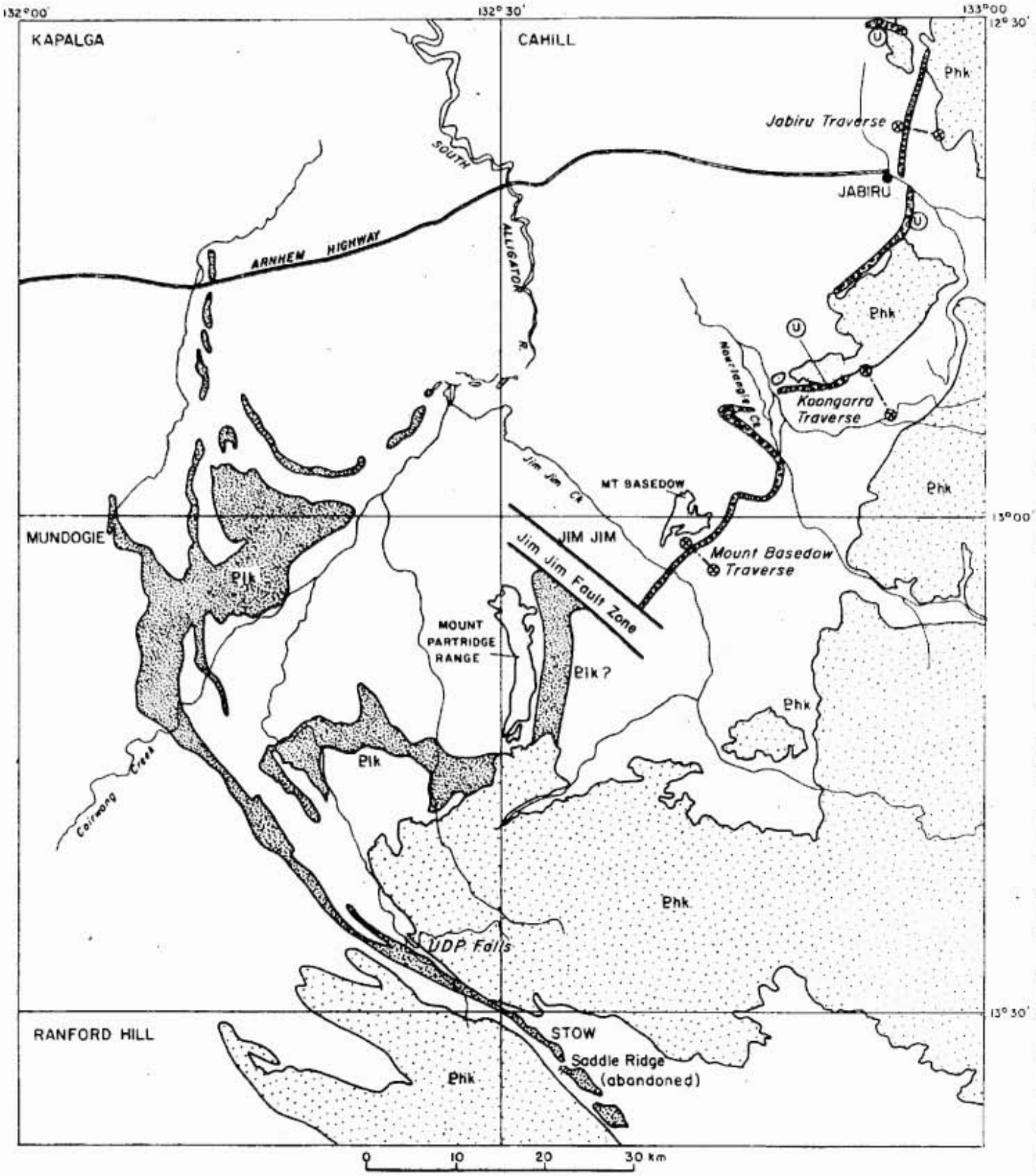

Fig. M 8 Area of Alligator River Party operations during 1974 Field Season.

Record 1974/127

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the Masson Formation. They are overlain by a sequence of non-magnetic and magnetic quartz-mica schists interlayered with amphibolite ("Koolpin Formation equivalent"). Garnet porphyroblasts are common in both the magnetic and non-magnetic schist, but are rare in the amphibolite. Kyanite porphyroblasts are found in only a few of the mica schists.

The Koongarra traverse (33 holes) intersected predominantly non-magnetic mica and quartz-mica schist interlayered with amphibolite. Only one hole intersected magnetic mica schist. Garnet porphyroblasts are far less common than at Mount Basedow, and were found only in rocks at the southeast end of the traverse. Rock types characteristic of "Koolpin Formation equivalent" were not intersected on this traverse, but probably lie to the northwest under the Kombolgie Formation, or may be truncated by the Koongarra thrust fault at the northwest end of the traverse. The traverse appears to lie entirely in metamorphosed Fisher Creek Siltstone.

The Jabiru traverse (30 holes) was completed in October. A sequence of non-magnetic chlorite and mica schist interlayered with amphibolite has been intersected at the eastern end of the traverse. "Koolpin Formation equivalent" rocks are expected to overlie gneiss of the Nanambu Complex at the western end of the traverse.

The rocks intersected on the Jabiru and Mount Basedow traverses appear to represent similar stratigraphic intervals of the "Koolpin Formation equivalent" at similar metamorphic grade. Lithological differences in the schist sequence and differences in the relative abundance of schist and amphibolite between the three traverses are attributed largely to differing amounts of Zamu Complex dolerite intruded into the sequence prior to metamorphism. Correlation of the three traverses is further complicated by tight, almost isoclinal folding, and faulting along and between drilling traverses.

Reconnaissance traversing of the Koolpin Formation

The Koolpin Formation, according to Walpole et al. (1968), is composed of two main members - an upper pyritic carbonaceous siltstone facies and a lower discontinuous dolomitic algal reef facies. During 1974, the carbonaceous siltstone facies was traversed in several places between Saddle Ridge and the U.D.P. Falls in the South Alligator Valley. It was found to comprise thinly laminated pyritic carbonaceous slate interlayered with an approximately equal quantity of a more resistant rock consisting of narrow bands, lenses, and ellipsoidal nodules of chert in a pyritic black slate (or meta-siltstone) matrix.

The pyritic carbonaceous slate ranges from a slightly metamorphosed siltstone and shale in some places to a foliated phyllite in zones of more intense deformation. Outcrop is generally poor and rubbly. The rock weathers to a heavily ferruginized and in places silicified red-brown laminated rock which is indistinguishable from weathered siltstone of the overlying Fisher Creek Siltstone.

The distinctive but variable chert and black shale, which weathers to a massive hematite-chert rock, is commonly brecciated and net-veined by quartz. This breccia closely resembles ferruginized and silicified carbonate rock, and Walpole et al. (1968) considered that the

chert bands, lenses, and nodules in the rock represent silicified dolomite. Brecciated varieties commonly develop boxworks, and form gossan-like outcrops.

Near Coirwong Gorge an exposure mapped as the dolomitic algal reef facies of Koolpin Formation by Walpole et al., was traversed. The exposure consists of siliceous chert breccia, finely banded chert, and some red, possibly carbonaceous, siliceous siltstone. No carbonate rock or algal structures were found; however, several of the rocks appear to have relict carbonate textures. The relationship of these rocks to the adjacent ones of the pyritic carbonaceous siltstone facies is not clear.

The Koolpin Formation traverses failed to reveal any useful marker beds. Neither the top nor the base of the formation has been satisfactorily identified as yet. At the base, the carbonaceous siltstone facies has been found only in faulted contact with meta-conglomerates of the Coirwong Greywacke. The top appears to grade transitionally into poorly exposed meta-siltstones of the Fisher Creek Siltstone.

The slightly metamorphosed rock types characteristic of the pyritic carbonaceous siltstone of the Koolpin Formation* have been traced discontinuously with the aid of a helicopter as far as the Arnhem Highway in the Kapalga 1:100 000 Sheet area. They have also been found to extend discontinuously to the southwest side of the Mount Partridge Range. A rotary drill traverse designed to test the presence of Koolpin Formation on the east side of the Mount Partridge Range was not drilled as the access track was boggy. East of Jim Jim Creek, Lower Proterozoic rocks are regionally metamorphosed to low amphibolite facies, and attempts to correlate these rocks with those to the south and west have not been satisfactory.

This metamorphosed sequence is considered by BMR geologists working in the area to be a metamorphosed time-equivalent of the Koolpin Formation, and has been informally named "Koolpin Formation equivalents". Company geologists have variously regarded it as a possible metamorphic equivalent of parts of the Koolpin, Masson, or Mount Partridge Formations, but some have temporarily overcome the difficulty by simply designating host rock to mineralization in their areas as 'Mine Series'. The "Koolpin Formation equivalent" is considered by us to be the host-rock for all major uranium mineralization in the Alligator Rivers region.

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*Note: The distinctive black slate containing bands, lenses, or nodules of chert is also found in the Golden Dyke Formation which crops out farther west. Few observations of the Golden Dyke Formation were made in 1974, but it appears that attempts to distinguish that formation and the Koolpin Formation as distinct mappable units in subsequent work will prove fruitless.

Ground magnetic and electrical traverses by the BMR Geophysical Branch (in 1974) have revealed a northwesterly-trending fault-zone several kilometres wide about 5 km west of Jim Jim Creek. The surface expression of one of these faults in the western part of the fault-zone extends for several kilometres as a gossanous quartz breccia. Others are merely expressed as photolinear features. The fault-zone possibly cuts off low amphibolite facies rocks which extend north and east of the fault-zone. Between the fault-zone and the Mount Partridge Range, slates, phyllites, and float of a banded hematite-chert rock similar to that in the carbonaceous siltstone facies of the Koolpin Formation have been found, and it therefore appears that the Koolpin Formation extends to the fault-zone. Little is known about displacement along the fault-zone, but it is possible that a deeper part of the Lower Proterozoic sedimentary pile is exposed east of the fault-zone.

RUM JUNGLE AND WESTERN PINE CREEK GEOSYNCLINE

STAFF: J.A. Ingram, K. Johnson, I.H. Crick

INTRODUCTION by J.A. Ingram and K. Johnson

Detailed geological mapping of the Rum Jungle district started in 1972. The work is part of a project, which will extend across the whole Pine Creek Geosyncline, to re-assess the previous geological mapping, and, with the aid of colour air photographs, stratigraphic drilling, and geophysical work to produce 1:100 000 geological maps of the region.

In 1972-73, mapping of the Rum Jungle Special 1:100 000 Sheet was carried out by K. Johnson. Ingram and Crick joined the party in 1974, and mapping was extended to cover the remainder of the Batchelor 1:100 000 Sheet area and the southeastern parts of the Noonamah and Reynolds River 1:100 000 Sheet areas.

Comments on certain features of the basement complexes (Rum Jungle and Waterhouse complexes) and the overlying sediments granite intrusions follow. The first of these, prepared by Johnson, refer almost entirely to formations represented within a proposed new Rum Jungle Special map, which will cover an area that is not quite identical with that covered by the original 1 inch to 1 mile Special sheet.

ARCHAEAN BASEMENT COMPLEXES AND LOWER PROTEROZOIC SEDIMENTS by K. Johnson

The validity of Rhodes' (1965) six-fold division of the Rum Jungle Complex was confirmed. In order of decreasing age the units are: schists and gneiss, metadiorite, coarse granite, large-feldspar granite, and leucocratic granite. Xenoliths of banded ironstone were found in the coarse granite phase, and this would favour their status as roof pendants rather than down-faulted blocks, as suggested by Rhodes.

Several different units have been distinguished in the Waterhouse Granite. Field work to date suggests that a possible breakdown of these units in order of decreasing age is: meta-sediments (acid volcanics, banded ironstone, and quartzite), schist (quartz-muscovite-feldspar schist, biotite-feldspar schist, biotite schist) and gneiss (quartz-feldspar gneiss and migmatite), granite gneiss, foliated leucocratic granite, foliated coarse and medium-grained granite and porphyritic granite, aplitic fine-grained granite, and garnetiferous granite. Aplite dykes, pegmatite veins, and quartz-tourmaline veins are also present. Both the granites and leucocratic granite contain schlieren and xenoliths of biotite-feldspar schist. The term 'Waterhouse Complex' is considered to be preferable to 'Waterhouse Granite'; the name has not yet been formalized.

Batchelor Group

Beestons Formation

The Beestons Formation around the Waterhouse Complex consists of ripple-marked and cross-bedded quartzite and magnetite-bearing sandstone, and has an average thickness of 20 metres. The equivalent formation around the Rum Jungle Complex has an identical basal quartzite and sandstone, but above this is up to 200 metres of arkose, arkosic conglomerate, siltstone, shale, and quartz-pebble conglomerate. After deposition of the basal quartzite there appears to have been a break, followed by deposition of clastic sediments around the Rum Jungle Complex only. Evidence for this hiatus is that hematitic shale and quartz-pebble conglomerate deposited above the basal quartzite around the Rum Jungle Complex contain scattered pebbles of quartzite identical to the basal quartzite. Banded ironstone pebbles derived from the basement complex are also included in the conglomerate. Along the margins of both complexes troughs of sheared quartzite and boudinaged quartz conglomerate extend into the complexes for up to 1200 metres. These sediments are believed to be basal Beestons Formation deposited in marginal basement troughs which were the centres of intense shearing during deformation of the cover and basement rocks.

There is evidence of repetition of the Beestons Formation and the Celia Dolomite by strike-faulting around the southern and eastern margins of the Waterhouse Complex and the southern part of the Rum Jungle Complex.

The basal quartzite around the eastern edge of the Waterhouse Complex is more extensive than is shown on the Rum Jungle Special map.

Field work indicates that rock shown as Beestons Formation immediately north of Eva Valley Homestead is in fact Crater Formation.

Celia Dolomite

The Celia Dolomite around the Rum Jungle Complex consists of magnesite marble, chert (in places retaining algal structures), and algal dolomite. Minor beds of amphibolite and ferruginous schist are interbedded with the marble. Drilling has shown that the Celia Dolomite is sheared in places.

Drilling of the Celia Dolomite around the Waterhouse Complex (Johnson, 1974) confirmed that the formation has been converted to calcareous amphibolite. However, only one example of recognizably calcareous amphibolite is shown in outcrop; amphibolite is exposed almost exclusively in breakaways, where it lies within a laterite profile, and is very intensely ferruginized.

Amphibolitization of the Celia Dolomite around the Waterhouse Complex may be due to low-grade greenschist facies metamorphism of impure dolomitic sediments, or metasomatism, or both. The absence of amphibolite stratigraphically equivalent to the Celia Dolomite around the Rum Jungle Complex could be due mainly to a facies change from impure dolomitic sediments to a pure calcium-magnesian carbonate. However, around the eastern margin of the Waterhouse Complex, metamorphic and metasomatic effects, probably associated with late granitic activity, can be recognized. These are scapolitization in the granite margins, tourmalinization of the Crater Formation, and phlogopite growth in the Celia Dolomite. Amphibolitization of the Celia Dolomite may be at least partly attributable to metasomatism. Chloritization of the Waterhouse Complex granites may be another effect of hydrothermal alteration related to a late granitic phase.

Crater Formation

Around the eastern margin of the Waterhouse Complex, bedded ferruginous chert, in places brecciated, superficially resembles the basal hematite-quartzite breccia of the Upper Proterozoic Depot Creek Sandstone Member. The chert is believed to represent a carbonate rock which was silicified and in places brecciated; the chert overlies about 100 m of pebble beds, quartz sandstone, and ferruginous sandstone, and is itself overlain by hematite boulder conglomerate. Field work showed that the hematite boulder conglomerate extends 3 km farther south on the western side of the complex that was shown on previous BMR geological maps. Using the hematite boulder conglomerate as a central marker in the Crater Formation, it was established that the lower part of the formation is thickest around the eastern margin of the Waterhouse Complex, and that the upper part is thickest around the Rum Jungle Complex.

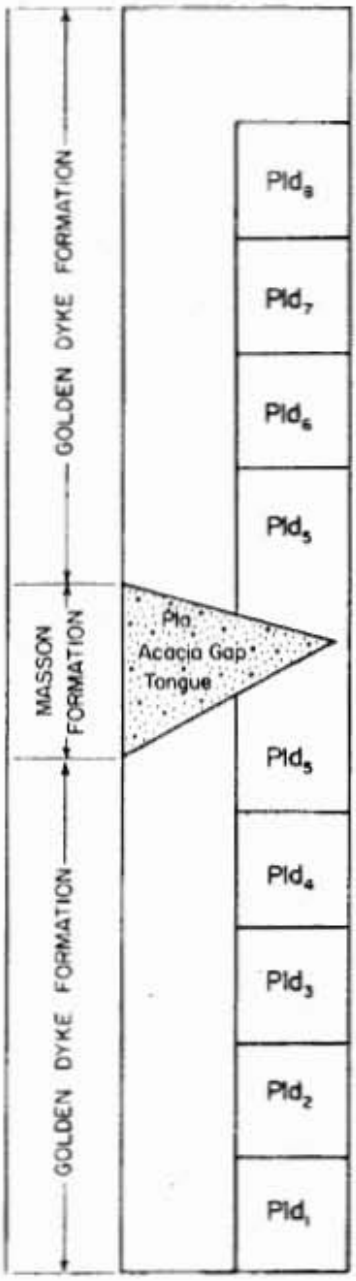
Coomalie Dolomite

The Coomalie Dolomite is composed mainly of dolomite and magnesite, but is locally lateritized, brecciated, and silicified; chert (in places retaining algal structures), siliceous siltstone, ferruginous quartzite, tremolite schist are also present. Tremolite appears to have been formed preferentially in a zone about 2.5 km long on either side of the Giant's Reef Fault.

Goodparla Group

Golden Dyke Formation and Masson Formation

The Golden Dyke Formation has been divided into eight lithological units (Fig. M9). The base is recognized by the appearance of pyritic carbonaceous calcareous shale (Johnson, 1974). The upper boundary is



Undifferentiated Golden Dyke Formation

Pld_8 Red siltstone, shale. Contorted quartz-hematite beds. Minor quartz-mica greywacke

Pld_7 Siliceous black-grey shale, purple-green siltstone, chert, chert nodules. Minor greywacke

Pld_6 Quartzite breccia in a cherty hematitic matrix and banded hematite-quartzite rock
Oolitic and stromatolitic in places - the "Mt Minza Type" ironstone.

Pld_5 Pyritic sandstone, siltstone. Chert interbeds. Intraformational slumping

Pld_5 Ferruginous porous buff coloured rock, weathered product of an oolitic chamositic calcareous sediment - the "Mt Deane type ironstone."

Pld_4 Pyritic siliceous ferruginized siltstone, sericitic siltstone.

Pld_3 Black pyritic shale, carbonaceous siltstone. Amphibolite.

Pld_2 Siliceous black shale (extensively quartz veined e brecciated), chert e chert concretions.
Quartz sandstone. Pyritic and tourmalinized in places.

Pld_1 Carbonaceous pyritic dololutite.

(Pla Pyritic quartz sandstone, quartzite)

Guide to stratigraphic thickness:

Total Section approx. 2500 metres thick.

Section Pld_5 to Pld_8 approx. 1100 metres thick.

Fig M 9 Goodparla Group

defined by consistent interbeds of greywacke which mark the incoming of the Burrell Creek Formation. The Masson Formation is represented by the Acacia Gap Tongue, a pyritic quartz sandstone and quartzite.

Important marker beds for correlating the Golden Dyke Formation within and outside the Rum Jungle Special Sheet area are the Mount Deane type ironstone (Pld_5) and Mount Minza type ironstone (Pld_6) (Johnson, 1974).

Finniss River Group

Burrell Creek Formation and Noltenius Formation

The previous division of this group into the predominantly siltstone Burrell Creek Formation, and the predominantly greywacke Noltenius Formation is over-simplified, as the two formations grade imperceptibly into each other and are interbedded in a complex manner. It is therefore proposed to refer only to the Burrell Creek Formation, and divide that into five units (see Fig. M10). The calcareous greywacke unit has been found to extend farther than formerly shown in the south-eastern part of the map area.

Stratigraphic Drilling by K. Johnson and J.A. Ingram

In 1974, 58 stratigraphic holes were drilled by BMR in the Rum Jungle Special Sheet area by two truck-mounted rotary percussion rigs. A total of 1892 metres was drilled, and 237 metres of core was taken.

The main purpose of the drilling was to aid mapping of the Lower Proterozoic Batchelor Group, particularly around the Waterhouse Granite Complex. Owing to poor outcrop in this area, previous mapping had not established the full extent and true nature of the carbonate units (Celia Dolomite, Coomalie Dolomite).

The 1974 drilling showed that the Celia Dolomite is represented by calcareous amphibolite around the Waterhouse Complex; the amphibolite was probably formed by metamorphic and/or metasomatic activity associated with probable late granitic activity within the Complex. In places, sulphides (pyrite and pyrrhotite) are fairly abundant in the amphibolite. Along the eastern side of the Complex drilling established the existence of a sandstone unit within the amphibolite.

Around the southern part of the Waterhouse Complex, the drilling showed that Coomalie Dolomite is present, although the unit had not previously been mapped in this area. The maximum thickness of the dolomite here is not less than 300 metres. Overlying the dolomite is a calcareous amphibolite, which is itself overlain by greywacke of the Burrell Creek Formation. This is therefore confirmation that the Burrell Creek Formation is, in part, a facies equivalent of the Golden Dyke Formation.

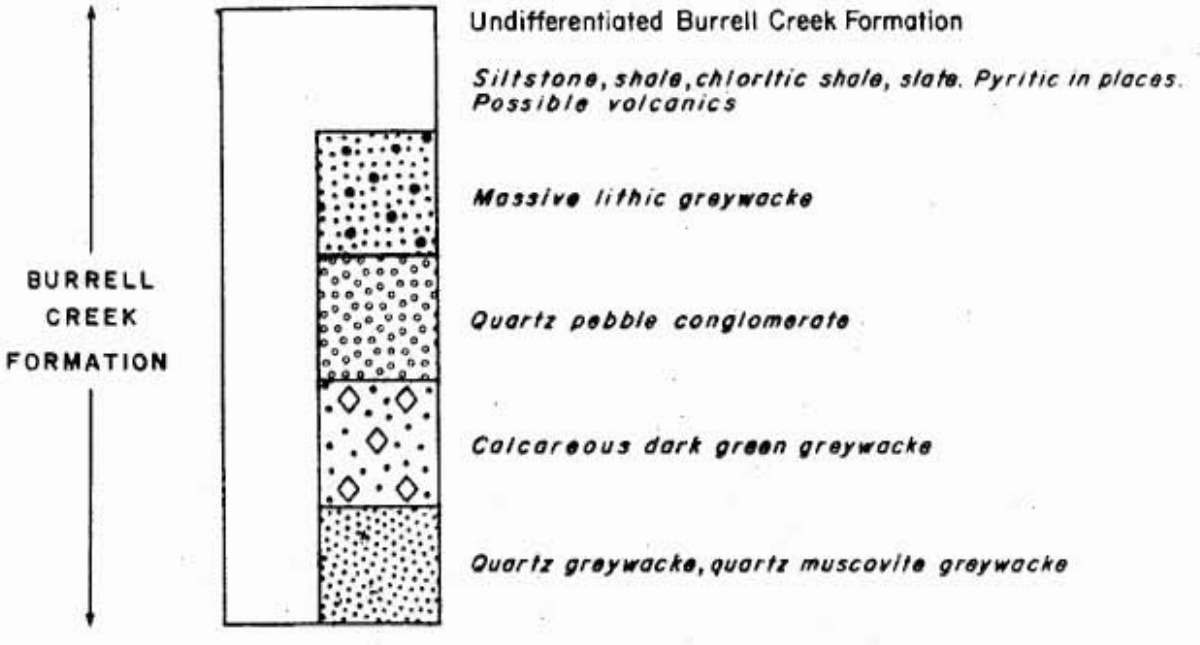


Fig. M10 - Finniss River Group

A further important purpose of the 1974 drilling has been to aid the mapping of the boundary between the Coomalie Dolomite and Golden Dyke Formation. In the Rum Jungle area, uranium and base metal deposits have been found to be associated closely with this boundary. Its location is therefore of particular importance. The drilling defined this boundary in several places, mainly in the area between the Waterhouse and Rum Jungle Complexes and in the area around the township of Batchelor.

BATCHELOR 1:100 000 SHEET AREA AND SOUTHEASTERN QUARTERS OF THE NOONAMAH AND THE REYNOLDS RIVER 1:100 000 SHEET AREAS: by J.A. Ingram, K. Johnson, and I.H. Crick

Golden Dyke Formation

Around the Burnside Granite, most of the Golden Dyke Formation lies within the metamorphic aureole of the granite. However, metamorphism is not so intense as to obscure the original rock compositions, and correlations can be made between the formation in this area and elsewhere. In places it was found to be underlain by pyritic, quartzose, and feldspathic sandstone, which is correlated with the Masson Formation (Fig. M 11). Towards the base of the Formation carbonate beds are interbedded with black, carbonaceous, pyritic shale. The carbonate appears as marble west of the granite, and in the north as calcareous amphibolite (previously mapped as dolerite). Tremolite rock is also present, and the calcareous amphibolite contains pyrite and pyrrhotite.

An ironstone, or in places a ferruginous, brecciated carbonate rock, extends right round the Burnside Granite. This is an important marker bed (Fig. M 11).

Only the upper part of the Golden Dyke Formation occurs in the Mount Bundey area, where it overlies interbedded quartz sandstone and siltstone of the Masson Formation. The base of the Golden Dyke Formation in this area is represented by a ferruginous dolomitic breccia containing stromatolites. This is overlain by predominantly cherty sequences of rock which underlie the Burrell Creek Formation (Fig. M 11). An identical sequence occurs around the northeastern part of the Rum Jungle Complex.

Burrell Creek-Noltenius Formation

The subdivision shown in Fig. M 10 has been adopted for the whole area. Structurally the area is complex, and the distribution of the various rock types may be the result of multiphase folding.

CORRELATIONS WITHIN THE GOODPARLA GROUP by J.A. Ingram

A tentative correlation of the Goodparla Group within the area mapped is presented in Fig. M 9 .

Identification of an ironstone-carbonate marker is an important factor in this correlation.

The carbonaceous pyritic shale and siltstone of the "lower" Golden Dyke Formation occur only in the relatively restricted environment of the northwest trending Central Trough. The ironstone-carbonate marker and the cherty sequence ('upper' Golden Dyke Formation) above it have a much wider distribution because they lap onto the marginal Mount Bundey and northeast Rum Jungle areas.

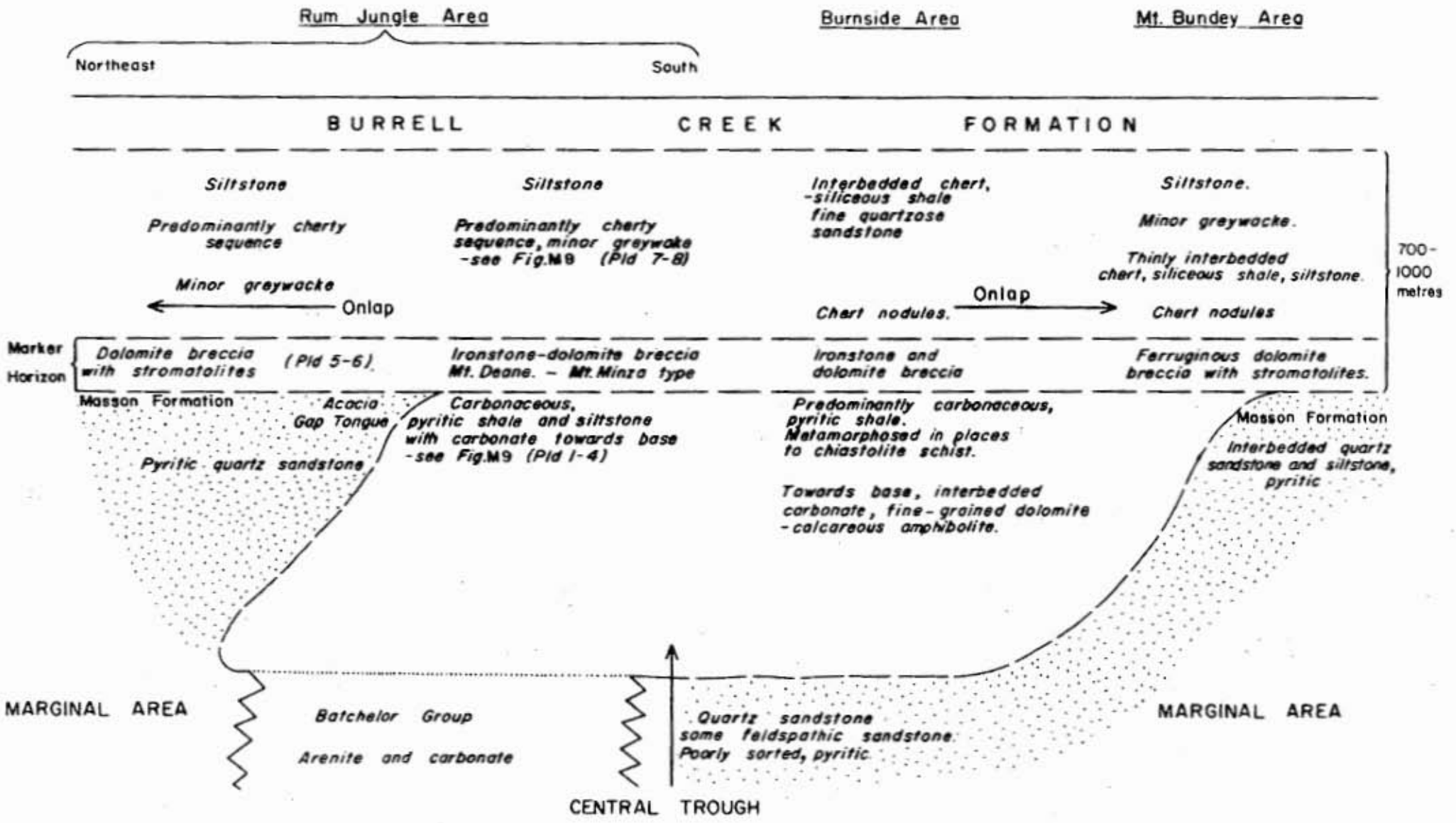


Fig. M II Correlation within the Goodparla Group.

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RHODES, J.M., 1965 - The Geological Relationships of the Rum Jungle Complex, Northern Territory. Bur. Miner. Resour. Aust. Rep. 89.

McARTHUR BASIN

CARPENTARIAN AGE DETERMINATION PROJECT by K.A. Plumb

The work was carried out in association with A.W. Webb of AMDEL.

Four additional total-rock samples from the Hobblechain Rhyolite Member, at the top of the Tawallah Group, have been analysed, and the results combined with those obtained from three samples reported in 1973 to give a final Rb-Sr isochron of 1575± 120 m.y.; the residual variance is probably due to loss or gain of Rb or Sr, or both, subsequent to the solidification of the rock.

Further attempts to date the shales of the Barney Creek Formation (McArthur Group) were unsuccessful, and no further work is to be carried out. The Nicholson Granite Complex has been resampled in detail in an attempt to resolve anomalies between the field relationships and age determination results; these samples will be analysed during 1975.

Reporting of Results

The regional significance of the ages so far determined in the project are discussed by Plumb & Sweet (1974). The full results and analytical data will be published by Webb and Plumb when problems associated with the Nicholson Granite Complex have been resolved.

REFERENCE

PLUMB, K.A., and SWEET, I.P., 1974 - Regional significance of recent correlations across the Murphy Tectonic Ridge, Westmoreland area. Aust. Inst. Min. Metall. N.W. Qld. Branch Reg. Meet. Pap., 199-206.

TENNANT CREEK

STAFF: J.R. Mendum, P.C. Tonkin (both ex-BMR)

During the year the final contributions to the maps and Record for the Tennant Creek area were received from the senior author. Contributions and suggestions for updating the maps and text have also been received from M.R. Daly, Geol. Survey of N.T. Drafting of the Preliminary editions of the Tennant Creek and Warrego Special maps is virtually complete; the Record and Explanatory Notes will be completed as soon as time and other factors permit. Progress on the geochemical project in the Tennant Creek area is reported in the section dealing with the work of the Geochemical Laboratory.

KIMBERLEY REGION

by

K.A. Plumb

STAFF: K.A. Plumb, G.M. Derrick

Preliminary editions of the Kimberley Basin and West Kimberley Region 1:500 000-scale geological maps were published as preliminary editions, and work is in progress on production of the respective coloured editions. Reports describing the geology of the Lansdowne (152), Lennard River (153), and Charnley (154) 1:250 000 Sheet areas were either published or are in press.

INTERNATIONAL GEOLOGICAL CONGRESS EXCURSIONS

by

K.A. Plumb

Plumb is organizing two excursions in northern Australia for the International Geological Congress: one through the Kimberley region (Excursion 44C) and one through the McArthur Basin (Excursion 46A). During the year an extensive field survey of the proposed routes of the excursions was undertaken, to enable the necessary detailed planning of the excursions to be carried out. Comprehensive excursion guide-books will be written during 1975.

ANTARCTICA

by

R.J. Tingey and R.N. England

STAFF: R.J. Tingey, A.P. Langworthy, R.N. England, J.W. Sheraton (part time)

INTRODUCTION

Geological mapping of the southern Prince Charles Mountains was continued in 1974, but was afforded a low priority for logistic support from ANARE because of precedence given to glaciologists this year. England and Langworthy were seconded to ANARE for the summer field season, and carried out detailed mapping in areas of interest selected as a result of previous work. Their program was curtailed because of the crash of a helicopter, and they were able to visit only four localities in the southern Prince Charles Mountains, and, for a short time only, a nunatak on the western edge of the Grove Mountains.

Laboratory work and office studies relating to the 1973 field season continued during the year. Long delays in the return of thin sections from the contractor have hampered petrographic studies, but these were largely completed by September. Geochemical and geochronological studies on rocks from the southern Prince Charles Mountains are continuing, but few results are as yet available. A preliminary report on the 1973 fieldwork has been prepared, but a full report has been delayed by the slow progress of petrographic studies.

Compilation of Preliminary Edition 1:250 000-scale geological maps of the southern Prince Charles Mountains was started during the year, and the Mount Menzies (5540-42/6) and Cumpston Massif (5540-42/7) sheets have been completed, and are awaiting fair drawing. The maps have been drawn on bases prepared by the Division of National Mapping from 1:250 000-scale enlargements of ERTS imagery. Field data and photogeological interpretation data resulting from studies of the 1:250 000-scale aerial photographs obtained in 1973 were transferred to the bases using the ERTS enlargements as a guide.

Tingey prepared a summary of the possible application of ERTS imagery in geological mapping and other Antarctic activities. As with air photographs, low-sun-angle imagery reveals many details of the ice surface that are invisible when the sun is higher. Tingey also wrote a paper for the Polar Record entitled 'Geological Mapping in the Prince Charles Mountains, Antarctica': the paper summarizes the results of mapping before 1973. A small exhibit that showed aspects of geological mapping in the Prince Charles Mountains was prepared for the BMR open days in May.

GEOLOGY

During the 1974 season the field party mapped, in semi-detail, parts of Mount Ruker, Mount Rubin, Mount Newton, the southern end of the Mawson Escarpment, and Austin Nunatak, a small nunatak on the western edge of the Grove Mountains. Localities are shown on the metamorphic map, Fig. M12.

Mount Ruker and Rubin and part of the southern end of the Mawson Escarpment belong to a comparatively young east-west belt characterized by a high-pressure facies series culminating in kyanite-staurolite grade metamorphism. Mount Newton, to the south of the east-west belt, consists of older basement rocks whose probable equivalents are exposed at Austin Nunatak.

A miogeosynclinal sequence overlying older granite at Mount Ruker contains banded ironstones, which are similar to both the Archaean and Proterozoic ironstones of Western Australia. The sequence includes quartzite, volcanics, dolomitic schist, black slate, and greywacke. The ironstones, which occur at a number of stratigraphic levels, are low-grade deposits: very few samples contain more than 35 percent iron. Although folding is not evident on a large scale, tight mesoscopic and microscopic folds are very common. The orientation of fold axes and axial planes is fairly constant, and only one phase of deformation is evident.

At Mount Rubin an unsuccessful search for Cambrian fossils was made, and some details of the structure were recorded. At Mount Newton upper amphibolite facies basement rocks have been partly retrogressed by the same metamorphism which has progressively metamorphosed the younger rocks. The structure is simple, and very little folding is associated with the retrogressive metamorphism.

Old high-grade metasediments and leucogneisses in the southern Mawson Escarpment have been strongly retrogressed by the low amphibolite facies metamorphism which affected the younger (east-west) belt. In many rocks overprinting masks almost all the features inherited from earlier high-grade metamorphism. Some rocks have no inherited features preserved, and may be related to the younger rocks of the east-west belt. At Austin Nunatak, quartz-rich rocks containing calc-silicates are probably related to the older high-grade rocks in the Prince Charles Mountains.

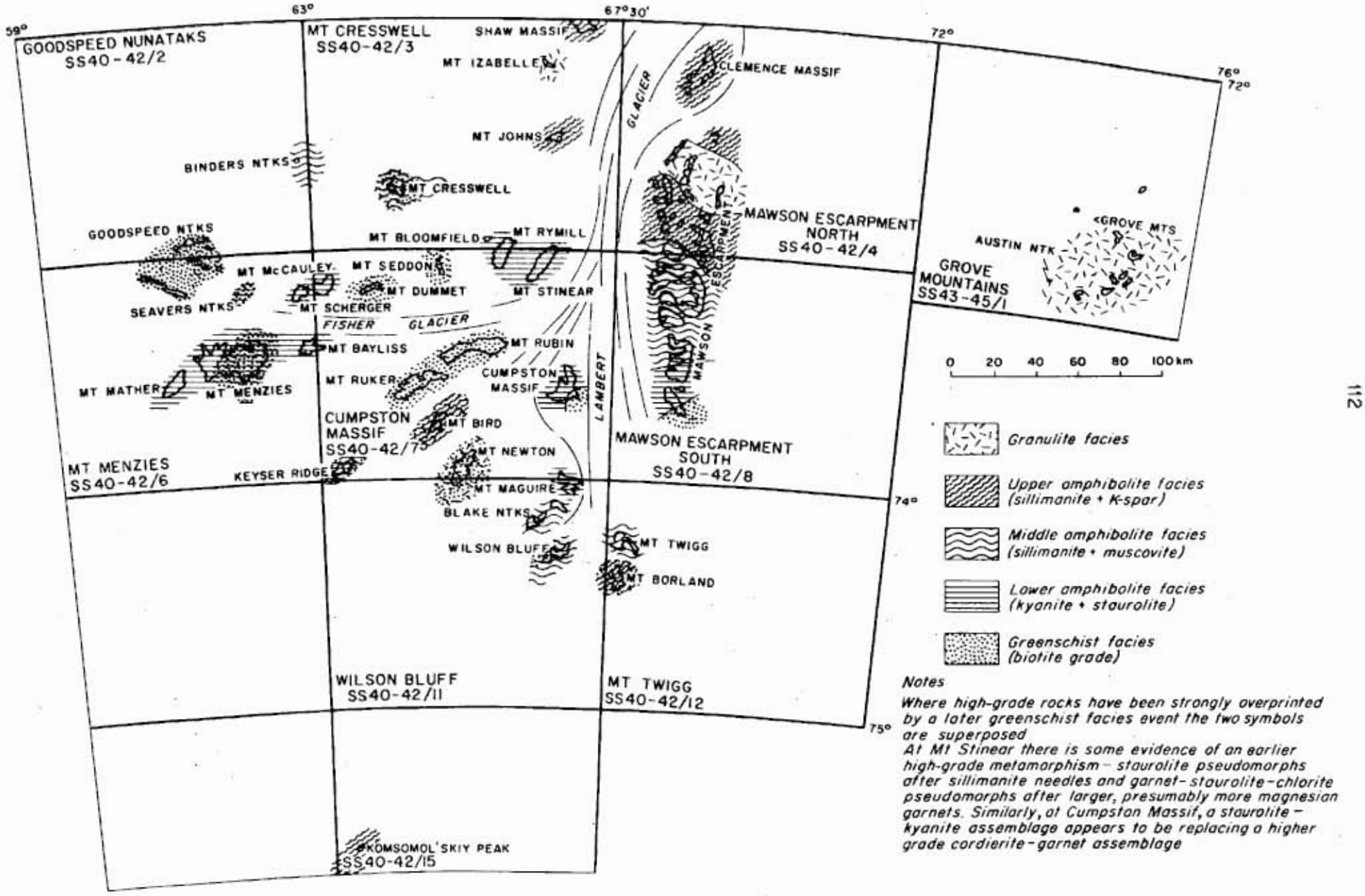

Fig. M12 Metamorphic map of southern Prince Charles Mountains

To accompany Record 1974/127

AN 2/119

GEOLOGICAL INVESTIGATIONS IN QUEENSLAND AND PAPUA NEW GUINEA

NORTHWEST QUEENSLAND PROVINCE

MOUNT ISA-CLONCURRY PROJECT by I.H. Wilson

STAFF: I.H. Wilson (GSQ), R.M. Hill, B.A. Duff, D.J. Ellis (part time), G.M. Derrick (part time); T.A. Noon (GSQ); M.R. Little (draftsman)

INTRODUCTION

The aim of the project is to systematically map the Precambrian rocks of the Cloncurry and Mount Isa 1:250 000 Sheet areas at a scale of 1:100 000, in order to better define areas which are potentially favourable for mineralisation. The four 1:100 000 Sheet areas in the strip between Cloncurry and Mount Isa were mapped during the period 1969-71, and work in the strip to the north started in the Prospector Sheet area in 1973 (Fig. M 13). During 1974, Kennedy Gap and Quamby, and the Precambrian outcrops in the Yelvertoft and Templeton Sheet areas, were mapped to complete the fieldwork for the first stage of the plan to map the whole northwest Queensland Precambrian province. Writing of a Bulletin on the results of the project will start during 1975. Specialist studies in geochemistry, geochronology, palaeomagnetism, and rock magnetism are being carried out in collaboration with the field party.

RESULTS OF FIELD WORK

The principal result of the detailed mapping program has been to delineate rock outcrops more accurately, and to subdivide the broad stratigraphic units previously mapped by Carter et al. (1961). This, in turn, has allowed detailed correlations to be made between sequences to which different nomenclatures were applied (Carter et al., 1961), and has made it possible to reliably trace potentially mineralized beds through the region. It is expected that the regional stratigraphic subdivision and nomenclature will be simplified by depicting many named units as extending over greater areas than previously.

General Geology

Rocks of the 'western succession' of the Mount Isa 'Geosyncline' are moderately to well exposed in the Kennedy Gap Sheet area, but weathering and younger sedimentary cover make phpto-interpretation less effective than in the previously mapped areas of the region, despite the availability of comparable high-quality 1:25 000 colour air-photographs. The Sheet area contains outcrops of the Leander Quartzite, Eastern Creek Volcanics, Judenan Beds, Gunpowder Creek Formation, and Paradise Creek Formation (of Carter et al., 1961), which have been subdivided and correlated with units in the Mount Isa area (Table M2). The Adelaidean(?) Pilpah Sandstone is not present; outcrops previously assigned to this unit belong to the Judenan Beds, Gunpowder Creek Formation, and Paradise Creek Formation.

The Yelvertoft and Templeton Sheet areas contain outcrops of Gunpowder Creek Formation, Paradise Creek Formation, and Pilpah Sandstone. The detailed mapping produced few changes to the previously published 4-mile Sheets.

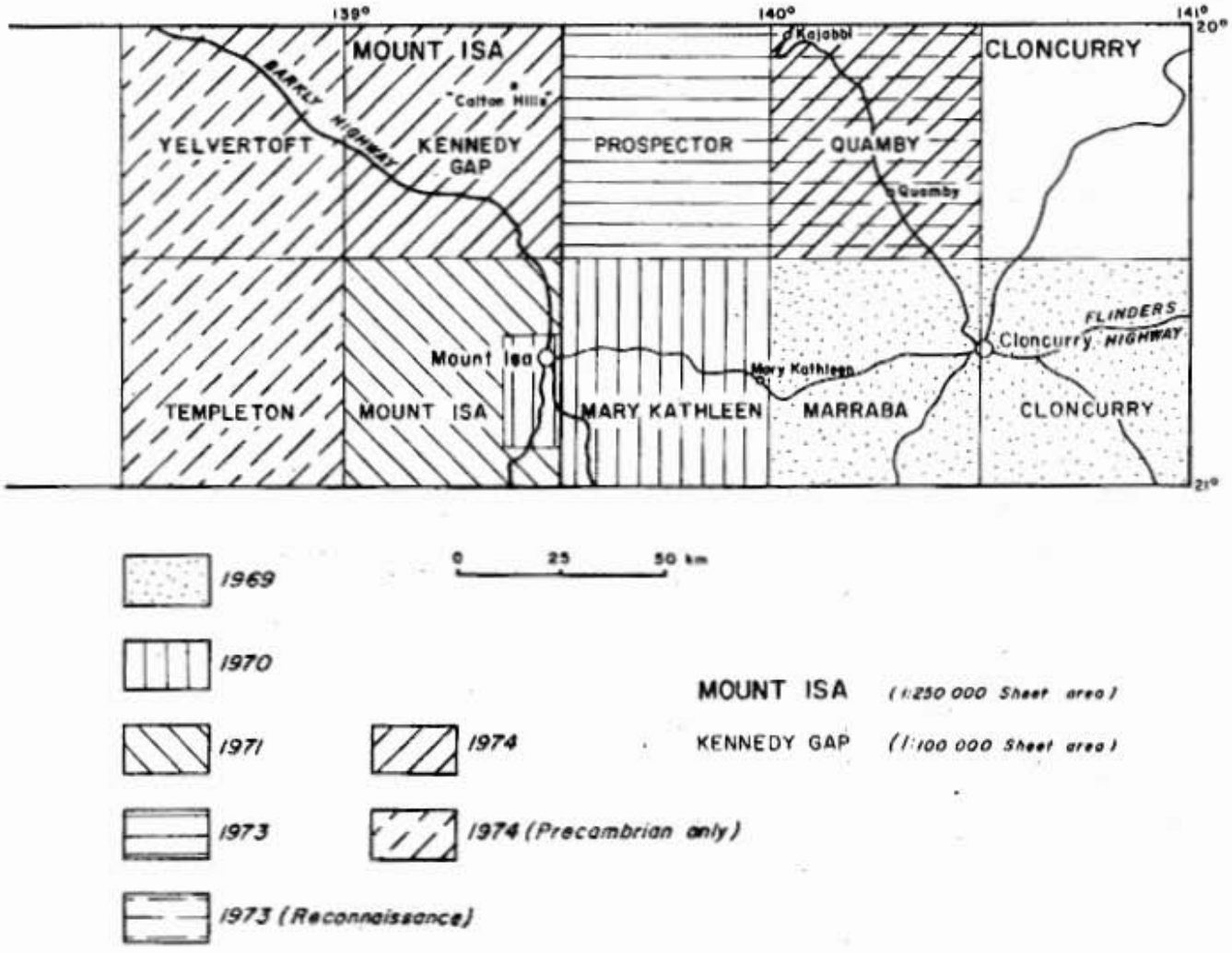

Fig. M13 Progress of mapping, Cloncurry – Mount Isa Project

TABLE M 2

Preliminary subdivisions and correlations of units in the Kennedy Gap Sheet area

Unit	Symbol	Rock types
Pilpah Sst.	Pui	Cgl., pebbly sst.
unconformity		
Paradise Cr. Fm.	Px_3	Sst., dol., sltst., chert, strom.
	Px_2	Dol., slst., chert, strom.
	Px_1	Chert marker bed
Gunpowder Cr. Fm. (cf. Mingera Beds)	Pv_4	Qtzite, dol. sltst.
	Pv_3	Shale, pyritic shale
	Pv_2	Sltst., micaceous sltst.
	Pv_1	Cgl., qtzite
unconformity		
Sybella Gr.	Pgs_3	Even m.g. gr.
	Pgs_{1a}	Aplite
	PgS_1	Porph. m.g. gr.
Carters Bore Rhy.	Phr	Porph. f. to m.g. rhy.
Judenan Beds	Phj_3	Qtzite, sltst., strom.
	Phj_2	Lam. sltst.
	Phj_1	Qtzite
Eastern Cr. Volc.	Php	Metabasalt, sltst., qtzite
	Phl	Qtzite, shale
	Pho	Metabasalt, sltst., qtzite
Leander Qtzite	Phq_2	Orthoqtzite
	Phq_1	Labile sst., sltst.

Unit	Symbol	Rock types
Mount Isa Group: Native Bee Sltst.	Pin	Chert, sltst., dol. sltst.
Mount Isa Group: Breakaway Sh.	Pib	Shale
Mount Isa Group: Moondarra Sltst.	Pim	Sltst.
Mount Isa Group: Karrina Park Qtzite	Pik	Cgl., qtzite
Myally Beds	Phm_5	
	Phm_4	Not exposed in Kennedy Gap Sheet area
	Phm_3	
	Phm_2	
	Phm_1	Qtzite
Mount Guide Qtzite	Phg	(Not in Kennedy Gap Sheet area)

The Quamby Sheet area contains mainly Corella Formation, Knapdale Quartzite, and Naraku Granite, of the 'eastern succession'. Despite the high grade of metamorphism (amphibolite facies), the subdivisions of the Corella Formation previously mapped in the Mary Kathleen Sheet could still be recognised (Table M 3). The Wonga and Naraku Granites are multi-phase batholiths which intrude units at least as high as the Corella Formation; considerable difficulty exists in distinguishing between the Naraku Granite and highly feldspathic metamorphosed arenaceous units of the Corella Formation.

Stratigraphic Correlations

In the Kennedy Gap Sheet area the Leander Quartzite-Eastern Creek Volcanics-Judenan Beds succession may be correlated in detail with the Mount Guide Quartzite - Eastern Creek Volcanics-Myally Beds succession (Table M 3), although the upper two divisions of the Myally Beds in the Prospector Sheet area become progressively less significant to the west, and the base of the Leander Quartzite is not exposed. The Carters Bore Rhyolite, above the Judenan Beds, may correlate with acid volcanics in the upper Myally Beds.

The Sybella Granite intrudes the Eastern Creek Volcanics and the Judenan Beds. Its northwestern porphyritic phase is similar in composition and texture to the Carters Bore Rhyolite; the granite and rhyolite may be co-magmatic.

In different places the Gunpowder Creek Formation lies unconformably on the Carters Bore Rhyolite, the Judenan Beds, or the Eastern Creek Volcanics, similarly to its correlative, the Mount Isa Group. The succession in the Gunpowder Creek Formation is very similar to that made up of the Warrina Park Quartzite, the Moondarra Siltstone, and Breakaway Shale in the lower Mount Isa Group. A chert marker bed at the base of the Paradise Creek Formation can be correlated with a similar marker at the base of the Native Bee Siltstone. Broad similarities exist between the overlying carbonate-lutite successions of the Paradise Creek Formation and the Native Bee Siltstone, although the abundant stromatolitic dolomites in the Paradise Creek Formation represent a significant lateral facies change.

In the Quamby Sheet area the arenaceous beds and basalts in the middle of the predominant carbonates and lutites of the Corella Formation provide a key for correlation with the sequence in the Marrabu Sheet area. Pyrrhotitic shales near the top of the Corella Formation, just below the Knapdale Quartzite, resemble the beds below the Deighton Quartzite in the Mary Kathleen Sheet area.

Structure

The usual north-trending regional structures are evident in the northeastern part of the Kennedy Gap Sheet area, but in the south they are deformed into an east-trending north-dipping sequence by the intrusion of the Sybella Granite. The intensity of folding decreases towards the west, where open basin-and-dome structures predominate.

Major north- to northwest-trending faults displace folds sinistrally, but also probably have a considerable vertical component of movement, such as in the vicinity of Carlton Hills, where the northern extension of the

Mount Isa Fault has caused a repetition of the Leander Quartzite by east-block-down movement. Easterly-trending faults typically have a south-block-down vertical displacement.

REPORTING OF RESULTS

The results of the 1974 fieldwork will be presented in a Record, and Preliminary and First Editions of the Kennedy Gap, Prospector, and Quamby 1:100 000 Sheets prepared, during 1975. Now that 1:100 000 mapping of the Mount Isa and Cloncurry 1:250 000 Sheets is complete, a Bulletin on the Geology of the Mount Isa-Cloncurry Region, and second editions of the Mount Isa and Cloncurry 1:250 000 Sheets will be prepared.

REFERENCE

CARTER, E.K., BROOKS, J.H., & WALKER, K.R., 1961 - The Precambrian mineral belt of north-western Queensland. Bur. Miner. Resour. Aust. Bull. 51

TABLE M 3

Preliminary subdivisions of the 'eastern succession'

in the Quamby Sheet area

Unit	Symbol	Description
Knapdale Qtzite	Bpk	F.g. qtzite, sltst.
unconformity		
	BkC_{3t}	Sltst.
	BkC_{3s}	Pyrrhotitic shale
	BkC_{3y}	Staurolite schist
Corella Fm.	BkC_{3}	Cal. shale, sltst., lst.
	BkC_{2b}	Metabasalt
	BkC_{2a}	Banded para-amphibolite
	BkC_{2}	Feld. qtzite
	BkC_{1}	Grey lam. sltst., sandy schist
Ballara Qtzite	Bkb	Qtzite

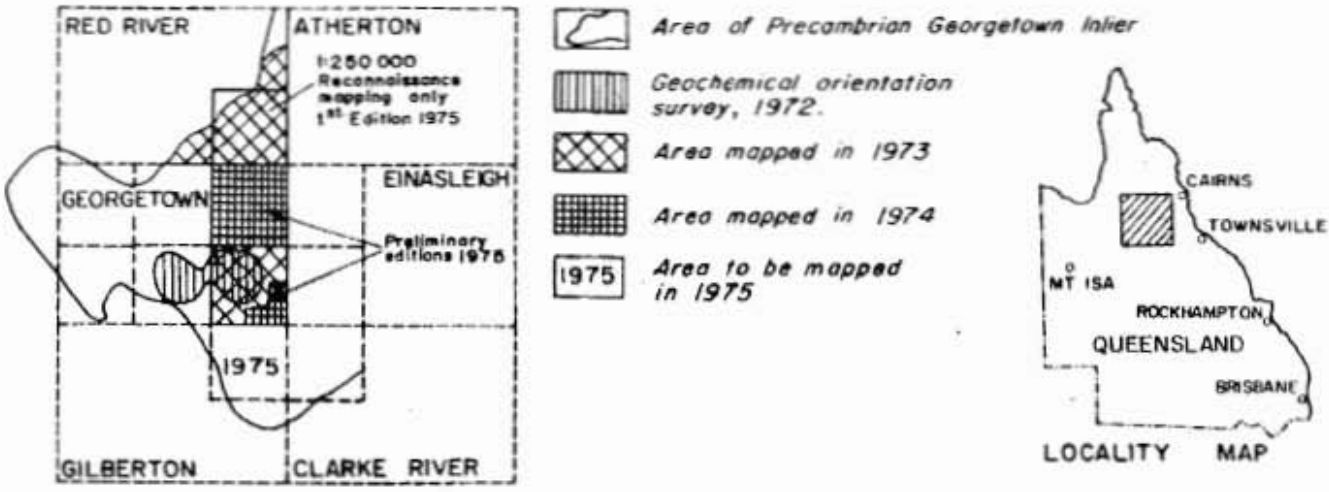

Fig.M14 Geological mapping, Georgetown project.

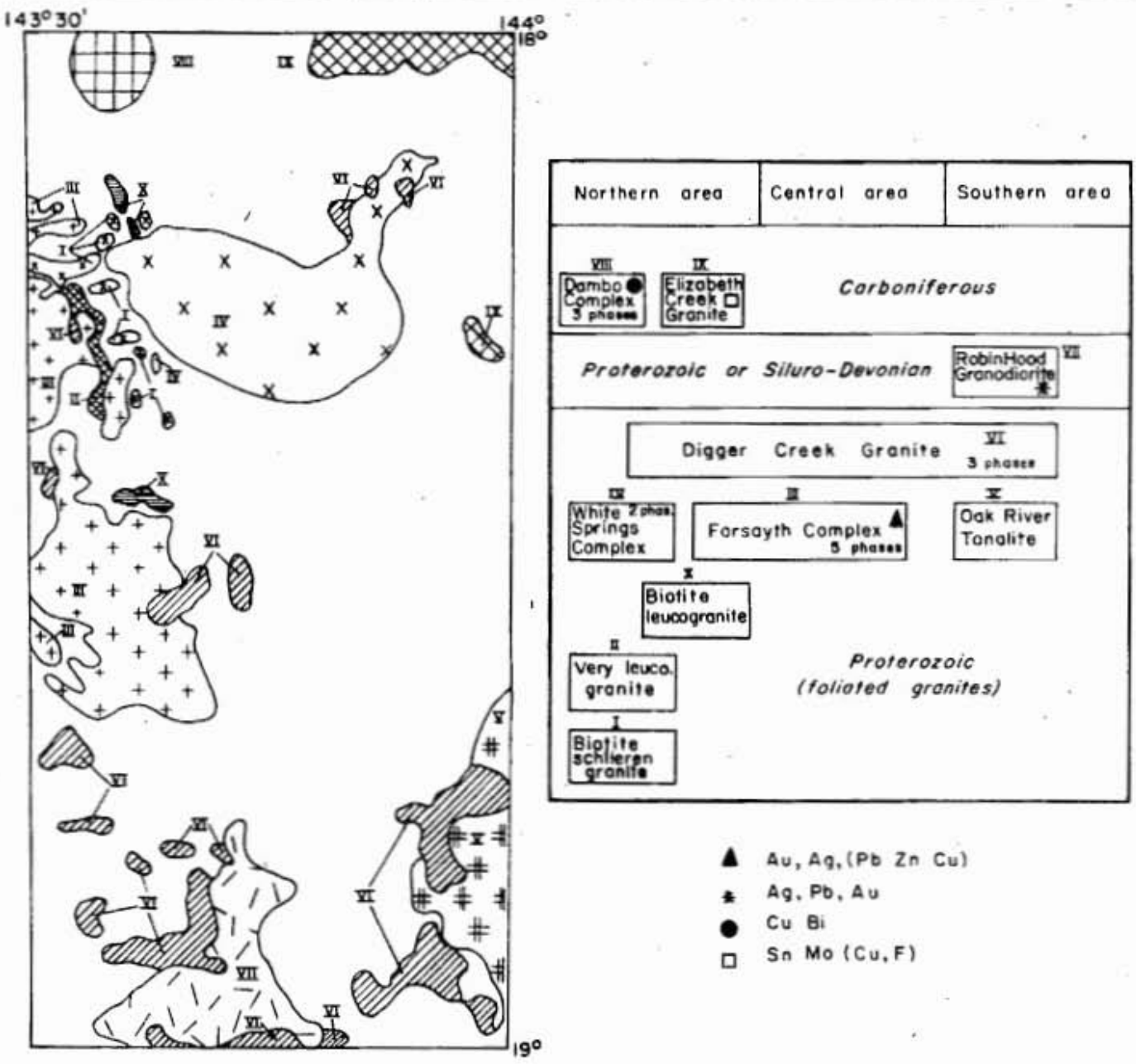

Fig. M15 Geographical distribution, sequence of intrusion and main metallogenic associations of the granites, Georgetown and Forsayth 1:100 000 Sheet areas.

WESTMORELAND PROJECT by I.P. Sweet

STAFF: I.P. Sweet, J.E. Mitchell, C.M. Gardner, P.J. Slater (GSQ; resigned February), J. Mifsud (draftsman)

The Westmoreland area was mapped at 1:100 000 scale in 1972-73 as part of a systematic programme to remap the Precambrian rocks of the Carpentaria Province, and the only field work carried out during 1974 was by Gardner, who revisited the Seigal 1:100 000 Sheet area to sample granites for isotopic dating. Sweet and Mitchell continued with preparation of maps and reports. Sweet, in conjunction with K.A. Plumb, prepared a paper (on the geology of the Westmoreland area) which was presented at an AIMM Regional Conference at Mount Isa in August.

The Hedleys Creek and Seigal 1:100 000 Sheets have been compiled, and should be issued as Preliminary Editions early in 1975. In addition, data on Hedleys Creek have been generalized for a Second Edition of the Westmoreland 1:250 000 Sheet. A Preliminary Edition of this Sheet should also be available in 1975.

A Record by Sweet, Mitchell, Gardner, and Slater on the Precambrian geology of the two 1:100 000 Sheet areas is being prepared.

GEORGETOWN INLIER

GEORGETOWN PROJECT by J.H.C. Bain, B.S. Oversby, and I.W. Withnall.

STAFF: J.H.C. Bain, B.S. Oversby, I.W. Withnall (GSQ), P.L. Blythe (draftsman).

INTRODUCTION

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. M 14). The immediate objective is to map the Forsayth, Georgetown, and Gilberton 1:100 000 Sheet areas specifically to determine the geological relationships of the main rock units of the Inlier. Particular attention is being paid to the locating and cataloguing of all mines, prospects, and mineral occurrences. Regional and detailed geochemical and geophysical surveys are being coordinated with the geological mapping.

Fieldwork:

Base camp facilities were shared with the Geochemical Party sampling in the Forsayth Sheet area. The Georgetown 1:100 000 Sheet area and the southeastern corner of the Forsayth 1:100 000 Sheet area were mapped between May 30th and September 23rd using 4-wheel drive vehicles. A helicopter was used to map the more rugged parts of the Newcastle Range, and for rapid access in reappraising some critical areas mapped the previous year.

Progress:

The 1:100 000-scale mapping (using colour photos at 1:25 000 scale) has resulted in subdivision of the Precambrian Forsayth Granite, the metamorphic rocks, and the Carboniferous Newcastle Range Volcanics. Further advances include the mapping of metamorphic isograds, the determining of the deformational history of the metamorphics, and the location of numerous previously unrecorded mines and prospects.

QUATERNARY

McBRIDE BASALT	Q	Vesicular olivine basalt

MESOZOIC

GILBERT RIVER FORMATION	M	Sandstone, siltstone, conglomerate

CARBONIFEROUS

		main range	eastern range
NEWCASTLE RANGE VOLCANICS	Cvn_{VI}	Grey-purple porphyritic (quartz-feldspar) rhyolite	
	Cvn_{V}	Fine grey-purple porphyritic (q-fels) rhyolite; buff-red porphyritic (feldspar) rhyolite	
	Cvn_{IV}	Coarse buff purple porphyritic (quartz-feldspar) rhyolite	
	Cvn_{III}	Andesite?	
	Cvn_{II}	Banded grey slightly porphyritic (feldspar) rhyolite; agglomerate	
	Cvn_{I}	Coarse-medium buff purple porphyritic (q-fels) rhyolite; green porphyritic rhyolite	
	Cvn_{5}		Coarse grey porphyritic (quartz-feldspar) rhyolite
	Cvn_{4}		Purple porphyritic (quartz-feldspar) rhyolite
	Cvn_{3}		Buff-purple porphyritic (quartz-feldspar) rhyolite
	Cvn_{2}		Buff grey aphanitic slightly porphyritic (q-fels) rhyolite
	Cvn_{1}		Coarse-medium buff-purple porphyritic (q-fels) rhyolite; slightly porphyritic rhyolite
	Cvns	Litho-feldspathic and volcanogenic sandstone, siltstone and conglomerate	
	Cvni	Intrusive rhyolite	
"CUMBANA VOLCANICS"	Cvc_{I}	Porphyritic (quartz-feldspar) rhyolite; agglomerate; crystal lithic tuff	
	Cvc_{II}	Volcanogenic sandstone	
ELIZABETH CREEK GRANITE	Cgz	Medium even grained biotite leuco adamellite; porphyritic fine grained biotite microgranite; pink aplite; greisen	
"DAMBO COMPLEX"	Cgd	Hornblende biotite granodiorite; biotite leuco adamellite; pink aplite	

PROTEROZOIC

DIGGER CREEK GRANITE	Pgd	Grey-pink muscovite and biotite-muscovite leucogranite, aplite & pegmatite (± garnet & sillimanite)
"WHITE SPRINGS COMPLEX"	Pgw	Fine-medium even grained biotite granodiorite; Porphyroblastic biotite muscovite leuco adamellite
"FORSAYTH COMPLEX"	Pgf	Coarsely porphyroblastic foliated biotite granite/adamellite . medium porphyritic muscovite biotite granite
	Pgt	Biotite leucogranite
	Pgr	Very leucocratic biotite (muscovite) granite (foliated)
	Pgm	Biotite schlieren granite (foliated)
ROBERTSON RIVER METAMORPHICS	Pmr_{I}	Schist, quartzite, gneiss, meta dolerite & amphibolite
	Pmr_{II}	Quartzite, schist, metadolerite & amphibolite
EINASLEIGH METAMORPHICS	Pme	Gneiss, migmatite, schist, quartzite, amphibolite

Fig. M16A Generalised geology of the Georgetown 1:100 000 Sheet area.

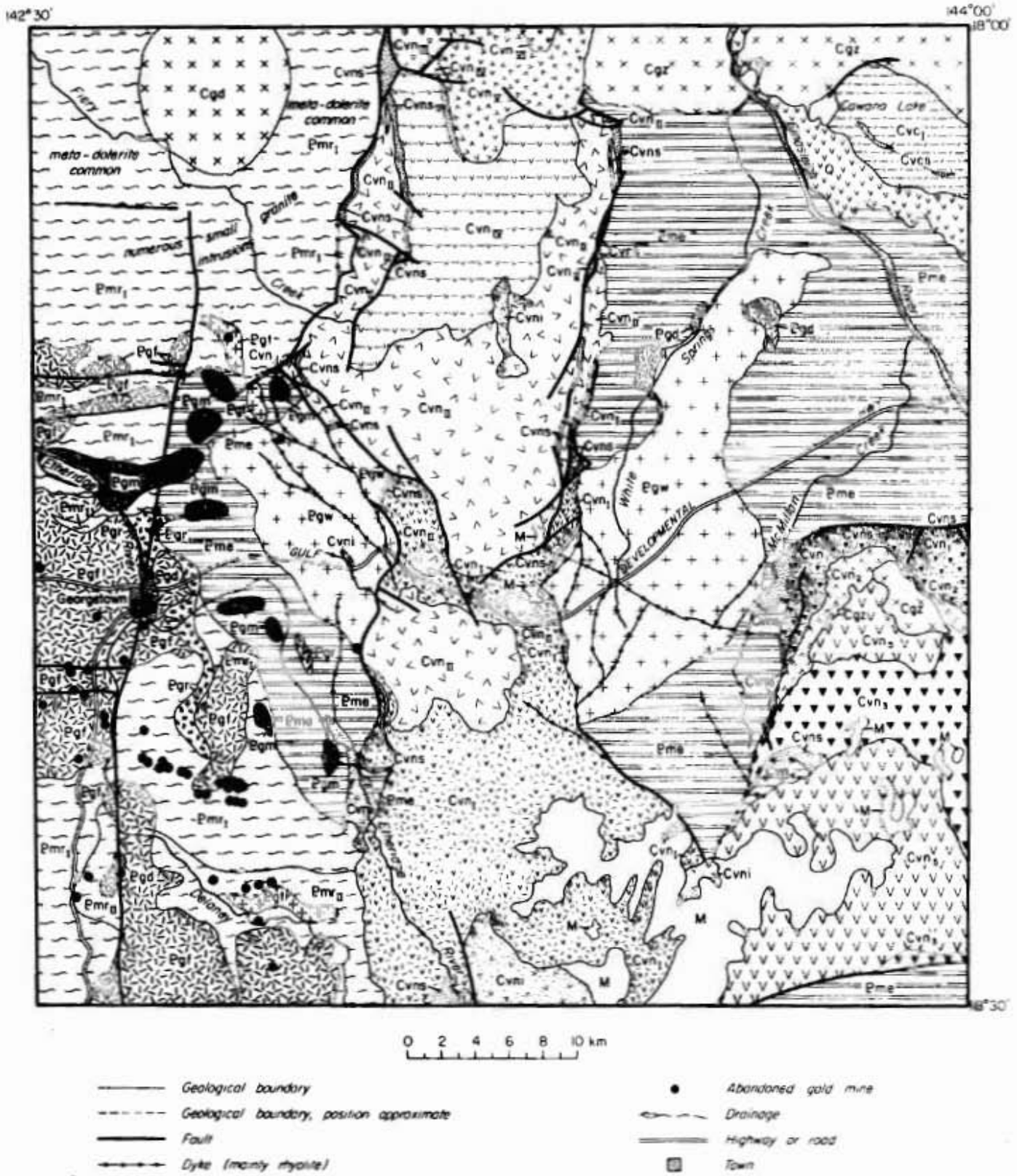

Fig M16B Generalised geological map of the Georgetown 1:100 000 Sheet area

GENERAL GEOLOGY

Granites.

Within the Georgetown and Forsayth Sheet areas there are ten intrusive granitic complexes and a number of small discrete plutons of unknown affiliation. Two of the complexes are highly differentiated sub-volcanic intrusive equivalents of the Carboniferous acid extrusives, and the others are syn- or late kinematic deep-level Proterozoic complexes in which at least three separate parent magmas have been involved. Hitherto the Proterozoic granites had not been subdivided, and only the Carboniferous Elizabeth Creek Granite was distinguished from them.

One of the main problems in mapping the granites lies in the diversity of rock types and the complexity of their interrelationships. The lack of a characteristic photo-pattern for each rock type is a further handicap. Consequently rather than map each different rock type, we mapped intrusive complexes in which we were able to recognise several distinct phases, and in most cases to determine their sequence of intrusion. Scintillometers were used to aid the mapping, the various distinct groups of readings obtained being generally coincident with the broad groupings of rock types into complexes. The lithology, sequence of intrusion, and distribution of the complexes is shown in Figs. M 15 and 16. The relationships between the "Forsayth Complex", "Oak River Tonalite" and "White Springs Complex" are not known, as the complexes are not in contact. However, they may be regarded as roughtly equivalent in age - all are intruded by the Digger Creek Granite, and have similar petrographic properties.

Metamorphics

The Einasleigh Metamorphics consist of gneiss, schist, amphibolite, and minor calc-granofels (calc-silicate gneisses are common in the southeast corner of the Forsayth Sheet area). In addition, pegmatite dykes, probably produced during metamorphism, intrude the rocks. The rocks have been deformed by at least three, and probably four, phases of folding, and have been metamorphosed to middle to upper amphibolite facies. Later retrogression has affected the rocks, particularly the metasediments.

The Robertson River Metamorphics are mainly schist, quartzite, and amphibolite of lower middle and possibly upper amphibolite facies which grade into low greenschist facies rocks of the Etheridge Formation. The boundary is difficult to place accurately because of the lack of key minerals in critical areas. Key minerals in the amphibolite grade rocks include staurolite, andalusite, cordierite, and sillimanite, but lack of key minerals in critical areas causes difficulties in mapping the boundary with the low-grade Etheridge Formation. The Robertson River Metamorphics are thought to have been deformed by at least three phases of folding; the metamorphism appears to have accompanied the first phase.

The 1974 mapping did not resolve the problem of the relationship between the Einasleigh and Robertson River Metamorphics. However, in the headwaters of the Percy River, on the southern edge of the Forsayth Sheet area, the two formations appear to grade into each other - e.g., quartzite and schist characteristic of the Robertson River Metamorphics are interlayered with biotite gneiss characteristic of the Einasleigh Metamorphics. Thus the formations may be equivalent, the differences in character merely reflecting a combination of variations in metamorphic grade, style of deformation, and lithofacies.

PAPUA NEW GUINEA

NORTH SEPIK PROJECT by M.A. Norvick

STAFF: M.A. Norvick, D.B. Dow, D.S. Hutchison

The mapping of the North Sepik Region, comprising the Wewak, Aitape, Vanimo, and Sepik 1:250 000 Sheet areas, during 1972 and 1973 marked the completion of regional mapping by BMR in Papua New Guinea. No further fieldwork was done in 1974, and the year was spent compiling the four geological sheets and preparing reports.

The completion of isotopic age determinations (by R.W. Page and A.W. Webb (AMDEL)), palaeontological sample dating (by D.J. Belford), chemical analyses (by AMDEL) and preliminary petrography confirmed the main points reported in the 1973 Annual Summary of Activities.

Additional data from the Border Mountains, southwest of Amanab, confirmed the presence of Permian intrusive rocks in that area (age 257 $\pm$ 7 to 242 $\pm$ 5 m.y. for seven samples). Results from the Bewani and Torricelli basement areas suggest that the Torricelli Intrusive Complex was probably comagmatic with the Late Cretaceous to Early Miocene basic volcanism of the Bliri volcanics. However, some of the intrusive rocks associated with the Prince Alexander crush-zone are significantly older (163 $\pm$ 3 to 106 $\pm$ 1.5 m.y., or Middle Jurassic to Early Cretaceous). In addition, late-stage porphyry dykes in the Prince Alexander basement have yielded dates (24.5 $\pm$ 1.0 to 19.9 $\pm$ 0.8 m.y.), some of which are slightly younger than the onset of basal Miocene (zone N4) non-volcanic cover sedimentation in the western parts of the Aitape and Lumi troughs. This lends support to the hypothesis of eastward onlap of cover sedimentation, and the corresponding longevity of basement igneous activity in the Prince Alexander Mountains.

Papers were read by the three project members at the BMR Wednesday seminar series and at the BMR symposium for industry.

The Wewak and Vanimo and most of Aitape 1:250 000 Sheets have been compiled, and should be issued as Preliminary Editions early in 1975. The Sepik 1:250 000 Sheet, which contains only a very small land area, should also appear in Preliminary Edition in 1975. Hutchison has prepared a Record on the basement geology of the North Sepik Region, and work has started on the Record, Bulletin, and Explanatory Notes covering all aspects of the geology of the area.

WEST SEPIK PROJECT by M.A. Norvick

STAFF: H.L. Davies (GSPNG), M.A. Norvick, D.S. Hutchison (BMR), R.J. Ryburn (on study leave at University of Auckland, NZ).

Explanatory Notes for the Blucher Range 1:250 000 Sheet are in press. Compilation was completed for the May River 1:250 000 Sheet. Work on the Ambunti and Wabag 1:250 000 Sheets was delayed for some time by lack of base maps, but compilation of the former has now begun.

VOLCANOLOGY AND ORE GENESIS by R.W. Johnson

STAFF: R.W. Johnson (at Imperial College, London, until 11 February), D.E. Mackenzie (at University of Melbourne), W.D. Palfreyman (part time)

Johnson returned to Canberra at the beginning of February, and much of the first part of the year was spent writing a report on the distribution and major element chemistry of volcanoes of the southern margin of the Bismarck Sea. He spent several weeks examining the files, and re-organising the reprint collection, of the late G.A.M. Taylor. Assisted by C.J. Pigram, and using the data in one of Mr Taylor's files, he wrote a report on the 1967 gas emissions from Koranga Open Cut, near Wau, and arranged with G.M. Lukaszewski (CSIRO, Melbourne) for follow-up work to be undertaken on the application of recent developments in mineral chemistry to an interpretation of the 1967 Koranga phenomena.

Preliminary enquiries showed that the publication of a volume of papers dedicated to Mr Taylor would be well supported. Negotiations were therefore undertaken to find a possible publisher, and to find likely contributors.

Arrangements were made for a 3-year programme of co-operative research with ANU on the trace-element geochemistry of volcanic rocks from Papua New Guinea.

Johnson visited Papua New Guinea in April, and discussed future work with the staff of the Geological Survey of Papua New Guinea, then returned in July to write a report, in conjunction with D.A. Wallace, on the geology and petrology of the volcanic islands off-shore from New Ireland, and to undertake field work.

Mackenzie continued his study of rocks from the Quaternary volcanoes of the Papua New Guinea Highlands at the University of Melbourne.

Palfreyman continued his study of the past volcanic activity of Manam volcano.

Late Cainozoic volcanoes at the southern margin of the Bismarck Sea can be divided into "western" and "eastern" arcs. The volcanoes of the western arc form a narrow zone which is associated with the boundary between the South Bismarck and Indo-Australian plates. This boundary is thought to have been vertical throughout the Late Cainozoic, and to have been characterised by generally higher rates of subduction nearer its eastern end. Most of the volcanoes of the eastern arc overlie a northward-dipping Benioff zone which in part represents the boundary between the South Bismarck and Solomon Sea plates.

The volcanic rocks of both arcs are hypersthene-normative and highly porphyritic, especially in plagioclase. Other phenocrysts are olivine, clino-pyroxene, pleochroic orthopyroxene, amphibole, iron-titanium oxides, quartz, and minor apatite and biotite. Basalts (53 percent SiO_2) and low-silica andesites (53 SiO_2 57 percent) are common in the western arc, high-silica andesites (57 SiO_2 62 percent) are less common, dacites (62 SiO_2 70 percent) are rare, and rhyolites (70 percent SiO_2) have not been found. The volcanoes of the Schouten Islands, at the western end of the western arc, are unusual because basalts appear to be absent from them. The range of rock types in the eastern arc is wider: andesites are common, basalts and dacites are less common, and rhyolites are rare. Basalts in both arcs are either quartz- or olivine-normative. Rocks showing high $Mg/(Mg + Fe^{2+})$ values are also present in each arc, and could represent approximations to primary magmas that were in equilibrium with the olivine of upper mantle peridotite.

A comparison of the compositions of rocks containing the same amounts of silica demonstrates pronounced changes (1) along the western arc - in a direction parallel to the plate boundary, and (2) across the eastern arc - in a direction more-or-less at right angles to the plate boundaries. The compositional changes in the eastern arc appear to be related to depth to the present-day Benioff zone. A favoured model for petrogenesis in both arcs is partial melting of upper mantle peridotite under hydrous conditions, producing mafic primary magmas, which rise and fractionate, and give rise to magmas of lower magnesia, and higher silica, contents. However, anatexis of young crustal rocks in the South Bismarck plate cannot yet be ruled out as a possible process for the derivation of at least some acid rocks.

PETROLOGICAL, GEOCHEMICAL, AND GEOCHRONOLOGICAL LABORATORIES

STAFF:

Professional Staff: K.R. Walker, A.D. Haldane, R.W. Page, A.Y. Glikson, S.E. Smith, L.P. Black, J.W. Sheraton, R.N. England, B.I. Cruikshank, A.G. Rossiter, Misses C.M. Gardner and M.S. Shackleton (transferred to laboratory, January; resigned October), and Mrs C. Giddings (Graduate Clerk - April to August).

Technical Staff: M.W. Mahon, T.I. Slezak, T.K. Zapasnik, J.G. Pyke (commenced January), J.C.W. Weekes, K.J. Armstrong (part time), G.W.R. Barnes (commenced January), A. Maenner (transferred CCAE, December), R. Flossman (commenced April), G.C. Willcocks (transferred to Housing and Construction Department, June), P.J. Swan (transferred to laboratory, June), R.J. Lucerne (commenced April, resigned August), J.L. Duggan (commenced July), C.R. Robison (transferred to Marine/Phosphate, December).

Trainee Technical Officers: G.F. Sparksman (transferred from laboratory, February), B.E. West (transferred from laboratory, February), R.W. de Mardi (commenced February), Miss J.E. Price (commenced February), I.M. Donald (transferred to laboratory, April), G.B. Price (transferred to laboratory, May), and H. Schiretz (transferred to laboratory, July).

Sheraton was on extended leave throughout May and June, and Mahon was absent for eleven weeks following a road accident in May.

INTRODUCTION

by

K.R. Walker

Notable changes have been taking place in the Chemical Group with alterations and reorganization of laboratory space. With the arrival and progressive installation of major new pieces of analytical equipment mentioned in last year's report, and the updating of other pieces, so that automatic sample changers and on-line outputs to computer facilities are in general use, the Chemical and Petrological Groups have obtained new potential for analytical work. The new automatic XRF equipment, Philips model PW/1450, will be installed in remodelled laboratory space with its own adjacent sample preparation area. The chemical laboratory now has a separate atomic absorption laboratory housing its two spectrophotometers and their ancilliary equipment. The conventional wet chemistry laboratory has been remodelled.

Slow progress is being made with the installation of the on-line output of the Direct Reading Optical Spectrograph, owing to equipment supply problems. Similar difficulties delayed installation of an energy dispersive X-ray analysis system for the electron probe microanalyser until the end of the year. The basement sample preparation and mineral separation laboratory area is due for remodelling next year, and this will then cater for all such requirements needed by the Geochronology and Geochemistry groups.

The X-ray diffraction laboratory will be updated in the near future with the installation of an automatic sample changer and data acquisition equipment. In the Geochronology laboratory a new Dynavac degassing unit has much improved the efficiency of the facilities in the mass spectrometer area. Remodelling of the chemical separation laboratory is in progress.

The Geochronology Group has had a particularly productive year, eclipsing the output of isotopic data for any previous year. The Nuclide, the original mass spectrometer, installed in 1963, made its 10,000th run in June, typifying the success of this joint BMR-ANU operation. The laboratory is hoping to extend its traditional Rb-Sr and K-Ar dating facilities to include U-Pb on zircon next year, so enabling more conclusive dating of some Precambrian rock units whose ages are complicated by one or more metamorphic events. Recent refinements in U-Pb dating on zircon provide a means of penetrating these events to measure original ages. Progress on geochronology projects is reported below; undoubtedly the most significant result has been the recognition by Page of basement Archaean in the Nanambu Complex in the Alligator Rivers area, indicating the likelihood that this and the Rum Jungle area are parts of the same uranium province.

Geochemical survey work proceeded on a limited scale according to the availability of staff and contract finance. The main effort this year by Rossiter and Shackleton has been devoted to completing stream sediment sampling of the Forsayth Sheet area, and thus obtaining sufficient geochemical data in part of the Georgetown Inlier to make an initial assessment of the value of conducting such geochemical work in the area. Analysis and evaluation of the data obtained are in progress. Planning is also in progress for exploring improvements in field sampling efficiency, possibly with the aid of a mobile sample preparation laboratory. The laboratory's exhibit in the BMR Open Days held in May depicted geochemical survey work from field sampling to interpretation, and included the demonstration of the Direct Reading Optical Spectrograph as an analytical instrument for this type of work. Shackleton completed her report on the results of geochemical survey work in the Tantangara area of the A.C.T.

Work on pollution studies and monitoring trace elements in the Molonglo River is expected to be at a reduced level following the completion of a report issued in June by members of the working group on "Mine waste Pollution of the Molonglo River".

In lithogeochemical and petrological studies the major work by Sheraton on the North Queensland acid igneous rocks and their relationship to mineralization has been completed. Work on the Tennant Creek geochemical project by Haldane and Smith is nearing completion after having been interrupted somewhat through the reorganization of laboratory space and equipment; however, with the completion of analytical work this year, it is hoped to be able to report the results next year.

Project work undertaken by the Petrological Group has been mainly continuing studies on igneous and metamorphic rocks from the Arunta Complex Mount Isa/Cloncurry, Westmoreland, and Antarctica. As a result of extensive enquiries in Australia and overseas Glikson has made good progress towards having IGCP accept "Geochemistry of Archaean Rocks" as a project, and he is investigating the formation of a working group to participate in this.

As for last year, laboratory workers continued to actively pursue field work as part of their investigations, and contributed to mapping where their project demanded it. Seven members of staff spent an aggregate of 56 man-weeks in the field. In addition, England joined ANARE for 13 weeks in the summer to continue field work in the Southern Prince Charles Mountains, and do collecting to further, in collaboration with Sheraton, the metamorphic studies undertaken during the previous seasons. Dr P.A. Arriens, of ANU, is conducting the geochronological investigation of these rocks.

Another successful geochemical field season of 13 weeks was completed in the Georgetown area by Rossiter and Shackleton.

Glikson spent 8 weeks mapping the complex successions of basic granulites in the Mount Chapple, Mount Hay, and Redbank Hill areas in the Arunta Complex, and Black spent two weeks making a further collection of specimens for isotopic dating of rock units in the region.

Later in the season Black accompanied D.H. Blake on a 3-week visit to the Herberton-Mount Garnet area of northeastern Queensland to collect specimens to determine age relationships between granite and different types of mineralized and unmineralized greisens.

Northwestern Queensland received particular laboratory attention in that Ellis spent nine weeks making a further collection of the basic igneous rocks, and Gardner also visited there to compare granites with those being studied by her in the Westmoreland area. She collected additional specimens from Westmoreland for age determination. Page returned to the Mount Isa area to collect further specimens from the basement acid volcanic sequence upon which he hopes to initiate U-Pb work on zircon. He also did a good deal of further collecting in the Alligator Rivers area, and started collecting in the Rum Jungle area.

The laboratory had another productive year for publication, originating 32 manuscripts of various types. Two Bulletins and one Report are with the editors. Members of staff completed four Records and have another 6 in preparation, apart from those prepared as drafts of external publications. Nine papers have been published in outside journals, and another 4 are in press. In addition, 2 papers have been submitted for external publication, and another 3 are in preparation.

Various members of staff attended and contributed papers to scientific meetings. Five lectures were presented to the BMR Wednesday morning lecture series, and Page participated in the BMR symposium, drawing attention to the discovery of Archaean basement in the Nanambu Complex. Glikson spoke to a divisional meeting of GSA on relations between granite and metamorphic rocks in the Reynolds Range area. Laboratory staff held regular meetings throughout the year, which in part acted as a forum to discuss progressive results of projects.

Haldane this year again presented a course and practical classes at CCAE on atomic absorption spectrophotometry in applied geochemistry. Smith continued to be responsible for Trainee Technical Officer practical training in the Geological Branch, and has advised on the content of CTC courses through committee discussions. Six Trainees worked on various facets of laboratory work during different periods.

The laboratory co-operated with CSIRO in providing the Direct Reading Optical Spectrograph facilities for R.E. Smith in January and February to make about 500 analyses for a geochemical investigation in the vicinity of Freddies Well, in Western Australia.

Colombo Plan student, J. Castaneda, from the Philippines, received two weeks' instruction on geochemical exploration techniques and data interpretation in the laboratory, and then joined the geochemical survey party at Georgetown for two weeks to assist with sampling in the field.

Some staff members attended various training courses. Rossiter participated in the AMF 10-day course on Geochemical Exploration in November, and Ellis undertook a 2-week course on Mineragraphy in February. The CCAE conducted a 10-day Fortran course in June for the Department, and Cruikshank attended this. A 3-day ADP course run by the Training Section in September was attended by Haldane.

Page and Black undertook a Shot Firer's certificate course conducted by the PMG for three weeks in April, qualifying them to use explosives while sampling in the field anywhere in Australia.

Various conferences and symposia were attended by staff. Haldane went to the GSA Specialist Meeting on Exploration Geochemistry held in Brisbane in July, and to a Symposium in Canberra in August on Water Sampling and Analysis Techniques. He continued his interest in pollution and water quality control, and attended various IDC sub-committee meetings on these matters.

Ellis represented BMR at a meeting of electron probe microanalysts convened at the BHP Central Laboratory, Melbourne, in May.

Walker, Cruikshank, and Haldane made a day visit to AAEC in March to discuss and inspect work and facilities of mutual interest. From this a general agreement was reached on BMR's using AAEC's service for U analysis.

Glikson made overseas visits in May and October to participate in a symposium on Plate Tectonics and Metallogeny at St Johns, Newfoundland, and assist with the organization of a meeting on 'Geology and Geochemistry of the oldest Precambrian Rocks' at Redwood, Minnesota.

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

PETROLOGY OF HIGH-GRADE ARUNTA COMPLEX ROCKS, N.T., by A.Y. Glikson

Basic granulites of the Mount Hay-Mount Chapple-Redbank Hill areas, Hermannsburg 1:250 000 Sheet area

The Mount Hay massif consist mainly of fine-grained basic granulite and amphibolite, with which widespread fine-scale acid segregations are associated. The latter consist mainly of plagioclase, but also contain rapakivi-like porphyroblasts. It is suggested that these segregations are the products

of partial melting of the basic rocks in situ or subautochthonously, rather than allochthonous intrusions. Minor garnet gneiss and aplite form bands in the granulites. Garnet is a common minor constituent of the basic granulites, indicating very high pressure conditions of metamorphism. The anorthosites are exposed along the northern flanks of the Mount Hay massif; they are medium-grained, consist of over 80 percent calcic plagioclase, and display fine-scale rhythmic banding, grading, and spotting, which express variations in the proportions of amphibole and/or pyroxene.

The Mount Chapple massif contains a much higher proportion of biotite gneiss and amphibole gneiss than the Mount Hay massif, and includes large discrete bodies of granitic to intermediate gneiss. Mixed gneiss-granulite rock bodies are common, but the fine scale of lithological alternations makes mapping difficult. Partially mobilized gneiss intrudes the granulites, and abounds in inclusions and schlieren of the latter. Garnetiferous gneiss is common. However, no garnetiferous basic granulites were observed.

The Redbank Hill massif includes relict bodies of granulite and amphibolite abundantly intruded by porphyroblastic acid and rapakivi intermediate gneiss. All stages of anatexis from basic granulite, through porphyroblastic melanocratic biotite gneiss, to garnet-quartz-orthoclase-plagioclase gneiss are represented. Mylonitic zones are abundant, alternating with little-sheared zones of gneiss and basic rocks.

It is tentatively considered that the Mount Hay massif represents an upfaulted deep crustal segment, and that the Mount Chapple and Redbank Hill bodies represent the progressive segregation of granitic melts within this segment. A large number of specimens was collected for petrological work to elucidate the high-pressure nature and anatectic history of the granulites.

Metamorphic geology and structure in the Aileron and Tea Tree 1:100 000 Sheet areas, Napperby 1:250 000 Sheet area

Petrographic work has been carried out on about 200 specimens of spinel-cordierite-sillimanite-perthite granulites, pyroxene and amphibole granulites, granitic gneiss, calc-silicate rocks, and mica schists representing retrogressed granulites. Two major metamorphic-igneous complexes were recognized:

(1) The Reynolds Range belt, stratigraphically divided into six units, and consisting of greenschist facies to low-pressure hornblende-granulite facies metapelites, quartzites, and calc-silicate rocks intruded by medium-grained granitic gneiss.

(2) The Aileron granulite-Boothby granite association, consisting of small-scale interlayered granulite and augen porphyroblastic gneiss of upper amphibolite to hornblende granulite facies. This complex is considered to be of a deeper-seated origin, and possibly older, than complex (1). The two complexes are separated from each other by the Aileron Shear and related faults. Retrograde metamorphism, schist zones, major shears,

and structure within the basement are considered to be the results of southward thrusting of the basement over the Ngalia Basin during the Alice Springs orogeny, an event that reset isotopic ages. A report has been submitted for incorporation in the Napperby Record by Stewart et al. (in prep.).

PETROLOGICAL AND GEOCHEMICAL STUDY OF BASIC IGNEOUS ROCKS, MOUNT ISA-CLONCURRY AREA, QLD, by D.J. Ellis

Collection of basic volcanics and dolerite dykes was completed this year. Specimens were collected from the outcrop area of the Proterozoic terrain between Gunpowder Creek in the north and Dajarra in the southwest, and McKinlay River (Soldiers Gap Formation) in the southeast. Five different volcanic units and several generations of dolerite dykes have been sampled. Two broad generations of dolerite dykes have been recognized in each of the three tectonic units - the eastern and western geosynclinal successions and the older basement terrain. First-generation dolerites are folded, faulted, and metamorphosed. Later-generation dolerites consist of several distinct petrographic types, and are discordant to folding, though often faulted, and are not metamorphosed.

The regional metamorphic grade of the older dolerites ranges from lower greenschist facies to upper amphibolite facies, with a later amphibolite facies contact metamorphism. Regional metamorphism appears to have reached a higher temperature in the eastern succession than in the western succession. Metasomatism (K_2O, S, Cl) has played an important part in several areas, leading to the development of biotite schist in the basement and eastern successions, and scapolite amphibolite in the Marraba area of the eastern succession.

Several traverses were made across the Wonga Granite - Corella Formation contacts in the Prospector Sheet area to the east of Mount Isa. Specimens were collected for a mineragraphic study with the aim of explaining several of the aeromagnetic anomalies found during the 1973 geophysical survey in the Mount Isa region. A gossanous zone was crossed during these traverses.

VOLCANICS FROM THE TABAR, LIHIR, TANGA, AND FENI GROUP ISLANDS OFF THE COAST OF NEW IRELAND, P.N.G., by D.J. Ellis

A petrological study has commenced on the volcanic rocks from the Tabar to Feni group of islands. Analcite, hauyne, and leucite basalts, picritic basalts, hauyne and analcite trachytes, and rhyodacites are present.

Electron-probe study of the pyroxenes shows that they are augites with pronounced compositional zoning (including hour-glass structure) due to differences in Si-Al content. Hauyne also shows chemical zoning (K_2O especially). All the lavas examined are characterised by the absence of titaniferous minerals; magnetite is the only iron oxide present.

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

Acid igneous rocks of northeast Queensland range in age from Precambrian to Permian. Four main groups are recognized.

The Proterozoic Esmeralda Granite and associated Croydon Volcanics are characterized by high Fe/Mg and K/Na ratios, as well as relatively high U, Th, Rb, Sn, Pb, Zn, Y, and Zr contents compared to average granites. The geochemical features of this suite suggest derivation from potash-rich, sialic crustal rocks, a series of arenaceous sediments and carbonaceous shales being a suitable parent material. The data preclude an origin by fractionation of basic magma. The Esmeralda Granite magma crystallized under conditions of low water pressure (less than 1000 bars), consistent with the observed shallow depth of emplacement.

The other (mainly) Precambrian granitic rocks are the relatively deep-level intrusions of the Forsayth batholith, and include the Forsayth and Robin Hood Granites. At least three separate parent magmas appear to have been involved in the formation of the Forsayth Granite. The Forsayth granodiorites are probably not genetically related to the granites and adamellites of the Forsayth area. The compositions of these rocks have been significantly modified by metasomatic processes during metamorphism, which brought about extensive redistribution of U, Th, and alkalis. The Forsayth Granite is particularly low in Cu.

The Siluro-Devonian Dumbano Granite and Dido Granodiorite form a geochemically rather heterogeneous group. The majority of the rocks making up the Dumbano Granite, together with the tonalites of the Dido Granodiorite, probably represent a single magmatic differentiation series, derived by anatexis of sedimentary material, and bearing some resemblance to the Forsayth granodiorites. The Dumbano trondhjemites and Dido quartz diorites are probably not genetically related to this suite, or to one another, and represent separate magma types.

The extensive Upper Palaeozoic igneous rocks comprise both intrusive (predominantly adamellite, but including granite, granodiorite, and more basic varieties) and extrusive (mainly rhyodacite welded tuff sheets, with subordinate rhyolite, dacite, andesite, and basalt) types. Both intrusive and volcanic rocks show similar variation trends and abundances of major and trace elements, although the volcanics exhibit a greater variation of alkali ratios, probably attributable to post-consolidational metasomatism. The more highly fractionated rocks (e.g., Elizabeth Creek, Mareeba, and Finlayson Granites) are low in Fe, Mn, Mg, Ca, Ti, Sr, Cr, Ni, Co, and Cu, and enriched in Si, K, Pb, Li, Rb, Th, and U, and have low K/Rb and Mg/Li ratios. Isotopic and chemical data are consistent with an origin for the acid magmas by anatexis of Rb-poor deep crustal material, possibly caused by rising basaltic or andesitic magmas derived by melting of subducted oceanic crust. Water pressures during crystallization were probably less than about 1000 bars. The unexposed lower parts of the intrusions are likely to have a less fractionated composition than most of the presently exposed rocks, and may be comparable with the Hammonds Creek Granodiorite which is relatively low in Rb, Th, and U, and has a high K/Rb ratio.

Granites and adamellites which have associated tin mineralization (e.g., Esmeralda, Elizabeth Creek, Mareeba, and Finlayson Granites) are enriched in volatile elements, such as Li, Be, B, and F. Tin contents are significantly higher than those of non-stanniferous granites, but lower than values reported for many tin granites elsewhere. A distribution of tin in which a high proportion of samples have tin contents significantly higher than background values, appears to be a useful criterion for potential tin mineralization. An uneven distribution of tin in the crust (or possibly the upper mantle) would explain the differences in tin contents of granites with associated tin mineralization, compared with granites from areas which do not contain tin deposits.

No correlation of granite geochemistry with lead/zinc or copper mineralization was found. In particular, granites associated with such mineralization do not show anomalous abundances of Pb, Zn, or Cu. If mineralization is regarded as an independent by-product of magma generation rather than the direct result of magmatic differentiation processes, then this lack of correlation is explicable.

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

Petrographic and geochemical study of the Westmoreland granites (Norris and Nicholson Granites) was nearly completed, and reporting was in progress. Field evidence, as well as petrographic and geochemical evidence, does not support the major division into Nicholson and Norris Granites, and the granites have been mapped as phases of a single complex in the Seigal 1:100 000 Sheet area. Phases in the complex range from a porphyritic adamellite rich in hornblende and biotite in the eastern part of the Murphy Tectonic Ridge through successively more acid granite in the central and northern parts (characterized by finer grainsize, lower mafic content, lower plagioclase/potash feldspar ratio, etc.) to a fine-grained muscovite granite in the western part of the ridge. These petrographic trends are closely paralleled by smooth geochemical trends from east to west as follows: increasing SiO_2, K_2O, K/Rb, $K_2O/K_2O + Na_2O$, decreasing CaO, MgO, etc. These trends are interpreted as indicating that the granite is younger to the west, rather than to the north, and that granite previously mapped as Norris is older than the western part of the Nicholson Granite. This interpretation is supported by the fact that Murphy Metamorphics intruded by the muscovite granite in the west are less deformed than the metamorphics intruded by granite farther east; there is also some evidence that the only observed contact between the older part of the Nicholson granite and the Cliffdale Volcanics (comagmatic with the northern part of the complex) may be intrusive. A short field trip was aimed at collecting samples, particularly from the west, for further isotopic dating.

Nearly all phases of the granite have been affected by late potash and silica alteration, as evidenced by metasomatic overgrowth of potash feldspar, quartz veining, greisen zones, etc.

The generally low abundances of trace elements such as U, W, Sn, and Li, and the virtual absence of mineralization are surprising for such a high-level granite, but it may be that the uppermost mineralized part of the granite and the rocks which it has intruded have been eroded.

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

Routine descriptions of rocks from the Southern Prince Charles Mountains have been made to supplement the mapping carried out in this area during the past three years. In addition to this, more detailed studies have been made of a number of distinctive rock types from both the Prince Charles Mountains and the Mawson Coast area. These include basic granulites from the North Mawson Escarpment, garnet-cordierite pelites from the Mawson area,

sapphirine-bearing rocks from Mawson, and rocks selected for geochemical investigation (acid and basic granulites, garnet gneisses and pelites from the Mawson area; granites, acid gneisses, quartzites, and basic rocks from the Southern Prince Charles Mountains). Of particular interest are the garnet-cordierite rocks from the Mawson Coast, which it is hoped will prove useful indicators of PT conditions during metamorphism. The basic granulites of the North Mawson Escarpment provide an unusual opportunity to study the transition from the amphibolite to the granulite facies, and the associated chemical and mineralogical changes. Here, the presence of quartz appears to be a necessary and sufficient condition for the complete breakdown of hornblende. The prograde transition from amphibolite to granulite facies seems to be unexpectedly sharp. The distinctive ferrohastingsite gneisses of the southern Prince Charles Mountains may represent the variously metamorphosed and deformed remnants of a suite of granitic rocks which intruded what is now the basement on which younger sediments were deposited.

STUDIES OF ARCHAEAN ROCKS, by A.Y. Glikson

A four weeks' visit was made to Canada and the U.S.A., and talks were given at the Geological Survey Canada, Geological Survey of Manitoba, University of Toronto, Columbia University, University of New York at Albany, and Massachusets Institute of Technology.

An invited paper entitled "Archaean to Early Proterozoic Shield Structures: Relevance of plate tectonics" was read at the NATO-sponsored symposium on Plate Tectonics and Metallogeny held at St Johns, Newfoundland (19/5-5/6/74).

A geochemical study of Archaean rocks from South Africa, in collaboration with Dr S.R. Taylor, A.N.U., continued, and the results will be published within the framework of the IGCP project on Archaean Igneous Geochemistry.

IGCP-ARCHAEAN IGNEOUS GEOCHEMISTRY, by A.Y. Glikson

This project proposal, forwarded by the Australian National Committee for the IGCP to the IGCP Board early in the year, has been recommended by the International Scientific Committee, and accepted by the IGCP Board under category B, defined as "a project offering promise as a nucleus for development into an international project on a major problem." Glikson was invited to form a Project Working Group, and to organize a preliminary meeting. This meeting took place during the conference on "Geology and Geochemistry of the Oldest Precambrian Rocks" at Redwood Falls, Minnesota (29/9-4/10/74). Glikson was invited by the organizers of this conference (Profs S.R. Hart, S.S. Goldich) to take part in preparations for it.

A circular has been sent to about 50 workers on Archaean rocks in 9 countries, inviting them to take part in the project, and correspondence concerning the formation of the Project Working Group was prepared. To date 31 workers have indicated their interest in taking part in the project.

ROCK AND MINERAL REFERENCE COLLECTION, by C.M. Gardner

Work continued on the establishment of a type petrological and mineralogical reference collection; a further 70 samples were added. These include a range of granites, granodiorites, tonalites, trondhjemites, syenites, etc; rhyolites, rhyodacites, tuffs, ignimbrites; amphibolites, granulites, granite gneisses, and retrogressed granites; lamprophyres, a peridotite, and an eclogite. Cataloguing of the collection continued.

INSTRUMENT LABORATORIES AND SUPPORTING FACILITIES, by D.J. Ellis and G.W.R. Barnes

The electron probe microanalyser laboratory

New sets of natural and synethetic oxides, silicates, and sulphides have been obtained as probe standards (rutile, sanidine, nepheline, kaersutite, periclase, apatite, chromite, troilite, anandite, and nickel silicide). Two computer programs for data reduction have also been obtained. These programs have been modified for use in the BMR HP2100 computer, and work is well under way for the automation of the probe and automatic on-line data reduction and interpretation. Late delivery of the new Si(Li) solid state detector, which is to be attached to the probe, delayed the program of modifying and updating the microprobe laboratory until all the equipment arrived in October.

Two main projects were carried out with the electron probe this year - a mineralogical study of the basic amphibolites and unaltered dolerite dykes in the Mount Isa region, and a study of the feldspathoid-bearing lavas from islands off the coast of New Ireland.

An examination of the biotites from the basic rocks of the Mount Isa region (and elsewhere) indicates that the amount of octahedrally and tetrahedrally coordinated aluminium in biotite can be used as a geothermometer for both metamorphic and igneous rocks.

The X-ray diffraction laboratory

860 minerals were identified, and 66 powder photographs were taken. These services were required mainly by the Museum, Baas Becking Mineralogical Group, and our own Petrological Group. Owing to staff changes, the laboratory was out of operation for the first quarter of the reporting year.

Other activity in the laboratory included the establishment of a reference collection of powder pattern photographs and a set of clay reference standards. There has been increasing demand for clay identification from the Baas Becking, sedimentology, and engineering geology groups.

Film templates for different size Debye-Scherrer films for Cu, Fe, Co, and Cr radiation have been obtained, and a camera has been modified to take X-ray photographs of the internal structure of micro-fossils.

The Thin Section laboratory

720 thin sections and 20 polished thin sections were prepared, and about 40 rocks slabbed and polished. This laboratory was not operated for half of the year owing to resignation of the operator.

GEOCHEMISTRY

POLLUTION STUDIES IN THE MOLONGLO RIVER, N.S.W. AND A.C.T., by A.D. Haldane

A meeting of Ministers of the Governments of New South Wales and Australia, held in January, recognised the urgent need to achieve a permanent solution to the problem of mine waste pollution of the Molonglo River at Captain's Flat. As a result a Joint Government Technical Committee of officers from New South Wales and Australian Government departments was established. This Committee replaced the previous joint working group, examined the working group's findings, and proceeded to prepare a final report on remedial measures for the permanent abatement of pollution from mine waste at Captain's Flat.

As the Bureau, in conjunction with the Department of Housing and Construction, has been responsible for the systematic sampling, chemical analyses, compilation, and interpretation of the analytical results, a substantial portion of the work load was carried by officers of these two organizations.

The final report was prepared by the Department of the Capital Territory, and was issued in June. It follows and expands on the report of the earlier working group. The preferred remedial treatment is the control of leaching and erosion by sealing the dumps with a rock-soil cover, together with the diversion of water from Forsters Creek away from the mine workings. The estimated cost, which includes five years' maintenance, is $2,700,000.

The Bureau continues to provide analytical facilities for monitoring the pollution level in the river at Burbong, and in Lake Burley Griffin, and will be involved further when remedial work on the dumps commences.

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

This project continues from the previous year, and jointly involves the Northern Territory Geological Survey, Australian Development Ltd, Geopeko Ltd, and the Bureau. Its aims are set out in the Annual Summary for 1973.

All analytical work on the collection of 600 silicate rocks is complete, and the results have been compiled and checked ready for statistical analysis by computer. Statistical evaluation of the data has been delayed, however, by limitations of available staff following elevated priorities for other work, laboratory alterations, and difficulties experienced with computer services while new facilities are being introduced at CSIRO. The position improved for a short period when the services of a graduate clerk (Mrs C. Giddings) were available to carry out minor program modifications and computing work.

The additional silicate analyses that became available during the year, particularly those of granites and porphyries, are consistent with the broad model of a hydrothermal origin of the mineralisation as proposed in the 1973 Annual Summary.

The analytical work on the ironstone collection was held over early in the year to make way for the analysis of stream sediments from the Forsayth 1:100 000 Sheet area. As a result, the analysis of the ironstones was not completed until the latter half of the year; consequently there will be a corresponding delay in the compilation and interpretation of this phase of the project.

All silicate rock samples were examined by gamma-ray spectrograph for radioactivity. As a group, the lamprophyres consistently show a significantly higher total count than any other rock unit. A few granite and porphyry samples show above background results; otherwise there is little of note in the gamma-ray results. Uranium will be determined on all samples showing above background activity.

GEOCHEMICAL SURVEYS IN THE TANTANGARA AND BRINDABELLA 1:100 000 SHEET AREAS, A.C.T., by M.S. Shackleton

The Tantangara 1:100 000 Sheet area stream sediment survey was written up as a Record. The samples had been collected during the 1972-73 field season, and were analysed by AMDEL in 1973. No significant new anomalies were found other than anomalies detected in stream sediments associated with known mineralisation. The main conclusions reached from this survey were that the analytical precision of emission spectroscopy (used for 2/3 of the element determinations) was inadequate, and that the sampling density (1 sample per 12 sq. km) was not high enough for a survey of this type.

Stream sediments from the western half of the Brindabella 1:100 000 Sheet area were collected during the 1973-74 field season. The sampling density was increased to 1 sample per 4 sq km, and samples were analysed by AMDEL using X-ray fluorescence and atomic absorption methods for 16 of the more common trace elements. Background results were generally low, but several anomalies were found, the most interesting being a tin-tungsten-thorium anomaly in the Tumorrama Swamp area. The results have been written up as a Record.

Stream sediment sampling in the Tantangara-Brindabella area is handicapped by two important factors - first, the coarseness of the stream sediments necessitates the collection of minus 40 mesh material instead of the more usual minus 80 mesh; and secondly, the vast majority of streams are flowing so samples were wet-sieved; thus the finest fraction is lost.

GEOCHEMICAL SURVEY, GEORGETOWN, QUEENSLAND, by A.G. Rossiter

During 1973 orientation sampling was carried out as the forerunner to a regional stream sediment survey in the Georgetown 1:250 000 Sheet area. Studies during 1972 had indicated that the fraction minus 85 mesh BSS was the optimum grainsize to collect, and all stream sediments were sampled on this

	A		B		C	
No. of Samples	4		10		9	
AAS	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Ag	-	-	1.4	0.5	5	1
Be	1.4	0.1	2.3	0.4	2.3	0.3
Cd	-	-	-	-	-	-
Co	11	1	10	3	13	1
Cr	91	2	49	4	70	19
Cu	16	1	13	3	24	3
Li	8	1	5	1	10	2
Mn	778	44	964	682	598	140
Ni	17	1	15	4	18	2
Pb	16	2	31	2	28	2
Zn	40	1	49	7	60	7
XRF						
As	-	-	-	-	-	-
Ba	372	81	903	67	617	47
Ce	44	8	57	11	122	47
Rb	97	2	125	7	122	19
S	352	46	410	52	372	42
Sn	-	-	-	-	-	-
Th	20	3	17	3	28	15
U	5	0.5	-	-	5	2
W	-	-	-	-	-	-

Table M4: Results of replicate stream sediment sampling at three localities A, B, and C. In those cases where a particular element was below the detection limit in some of the samples at the one site, the means and standard deviations could not be calculated. These cases are indicated by a dash.

basis. Soils (sieved to minus 30 mesh BSS) and heavy mineral concentrates were also collected. The stream sediment and soil samples were analysed for Ag, Be, Cd, Co, Cr, Cu, Li, Mn, Ni, Pb, and Zn by atomic absorption spectrophotometry (AAS), and for As, Ba, Ce, Ni, Pb, Rb, S, Sn, Th, U, and W by X-ray fluorescence spectrometry (XRF). The heavy minerals (S.G. 2.8) were examined microscopically, and analysed by semi-quantitative emission spectroscopy for Ag, Bi, Ce, Co, Cr, Cu, La, Mo, Nb, Ni, Pb, Sn, Ta, W, Y, Zn, and Zr. The sampling and analytical procedures followed have been reported in a Record.

Some of the more important results to emerge from the study are discussed below.

At a number of sites several samples were collected from various parts of the stream channels, and analysis of these gave a measure of the combined sampling and analytical errors. With the exception of Mn, the elements determined by AAS showed little site variation (see standard deviations, Table M4). Data obtained by XRF were less precise but quite acceptable. From these observations it was concluded that duplicate sampling will not be necessary for later work.

The position in the stream from which a sample was taken proved to matter little. Bank samples closely reflected values obtained in more active channel sediment, and might even be a more useful sampling medium in areas affected by recent mining contamination.

Most elements in the sediments shared fairly homogeneous distribution over the survey area; for example, samples collected on granite and sedimentary rocks were very similar geochemically. Samples from the Newcastle Range Volcanics were relatively low in Co, Cr, Cu, and Ni, whereas those associated with the Cobbold Dolerite were relatively high in Cu, Co, Ni, and lower in Pb, although data for this rock-type are limited owing to restricted outcrop. Threshold values for the different elements in both stream sediments and soils have been defined using cumulative frequency plots on arithmetic and logarithmic probability paper, and these will appear in the Record being prepared.

Dispersion trains occurred up to 5 km downstream from copper, lead, zinc, tin, and uranium mineralization. Cu, Pb, and Zn proved useful indicators of sulphide-rich gold deposits, although the dispersion trains were less extensive. Sulphur showed anomalous values in the vicinity of lead deposits, probably due to the presence of detrital anglesite ($PbSO_4$). Interpretation of the U results was difficult because the sediments in some granitic terrains were rich in monazite in areas remote from mineralization. The distinction between high U levels (up to 81 ppm U) due to monazite and those associated with uranium mineralization could be made by studying the appropriate heavy mineral concentrates or by using the Ce plus Th values as an indication of monazite content. Arsenic also proved useful, as high values for this element (to 57 ppm) were characteristic of the uranium occurrences.

Soil anomalies were generally similar to those in the stream sediments; however, the soils showed higher metal contents, and the anomalies in them covered smaller areas than did stream sediment anomalies.

The heavy mineral studies were very successful. Minerals of economic significance found in the concentrates were anglesite, cerussite, cassiterite, malachite, fluorite, and gold, together with rare pyrite, chalcopyrite, sphalerite, and carnotite. The heavy mineral concentrate was especially sensitive in picking up lead and copper mineralization. Values exceeding 6000 ppm Pb were common in the vicinity of lead deposits. Although Cu contents seldom exceeded 200 ppm, malachite was very conspicuous in the concentrates, and in a number of instances the heavy minerals detected copper mineralization that had no anomalous expression in the corresponding sieved samples. As expected, gold and tin deposits showed up well by this method, but uranium minerals were very rare in the concentrates, and the major application of the technique to uranium exploration appears to be in the interpretation suggested above. The heavy mineral samples could also be used to study the distribution of certain rock-types - hornblende indicated dolerite in a particular catchment area, epidote indicated basalt, and so on.

During the 1974 field season regional stream sediment sampling of the Forsayth 1:100 000 Sheet area was completed. Using a helicopter over 1100 samples were taken- an average of approximately one sample per 2.5 square kilometres. At each site a 10 kg bag of sediment was collected. The minus 85 mesh fraction as well as a heavy mineral sample was later extracted at the base camp. The analytical work has not yet begun but will be similar to that outlined above. An extensive soil sampling program was carried out along a number of mineralized shear zones in the Forsayth area to ascertain whether base metal anomalies could be used to trace gold deposits with no outcrop. No results are available as yet.

A Record covering the 1973 work is being prepared.

GEOCHEMICAL SURVEY, WESTMORELAND, N.T. AND QLD, by A.G. Rossiter

Sampling in the Westmoreland area (Seigal and Hedleys Creek 1:100 000 Sheet areas) during 1973 was directed mainly towards assessing the usefulness of stream sediment geochemistry in prospecting for uranium. Sampling and analytical techniques employed there were similar to those used during the Georgetown project (see above).

The minus 85 mesh BSS stream sediments showed U anomalies persisting for about 3 km downstream from mineralization. Hence the stream sediment technique appears to have considerable potential for uranium exploration in this area. Arsenic, Cu, Sn, and W anomalies were associated with the various uranium deposits, but not all of these elements were present in every instance. In contrast to the Georgetown area, monazite was not a problem in interpretation; U values greater than 12 ppm invariably mean U mineralization.

The most interesting feature to emerge from the heavy mineral studies was the presence of gold in several samples collected from near uranium deposits. This mineral deserves closer attention in the Westmoreland area, both as a part of uranium exploration programs and also in its own right.

Interpretation of the results is continuing, and a Record will be completed towards the end of the year.

GEOCHEMICAL INVESTIGATION, BMR CLONCURRY NO. 8 AREA, QLD. by A.G. Rossiter

A substantial soil anomaly with copper values as high as 950 ppm has been delineated 12 km west-north-west of Mary Kathleen.

Soil samples were collected on a grid pattern, and the minus 85 mesh fraction analysed at AMDEL for Co, Cu, Fe, Mn, Ni, Pb, and Zn by atomic absorption spectrophotometry. Of these elements, only Cu gave interesting results.

A cumulative frequency plot of Cu values on log probability paper gave a value of 60 ppm Cu as the upper limit for background, and this was used to distinguish anomalous from background samples. An anomalous zone some 600 m long and up to 100 m wide was outlined; within this an area, about 150 x 50 m showed copper values above 200 ppm.

The anomaly is within the Corella Formation, which is known to contain copper mineralization; its apparent association with the intersection of faults is also encouraging. Turam, induced polarization, and to a lesser degree transient E.M. anomalies coincide with the geochemical anomaly. A drill hole put down in 1973 intersected disseminated sulphides, but it is doubtful if the most favourable zone for mineralization was intersected, and further drilling is warranted.

A Record dealing with this investigation is being prepared.

ANALYTICAL LABORATORIES AND SUPPORTING FACILITIES, by S.E. Smith

During the year laboratory facilities were re-designed to improve conditions in the sample preparation, atomic absorption, and X-ray fluorescence areas, as most of the analytical work in the next few years is expected to involve these areas.

Work carried out in the laboratory was associated mainly with four projects:

(i) Geochemistry of the Tennant Creek Goldfield

(ii) Georgetown Geochemical Survey

(iii) Westmoreland Geochemical Survey

(iv) Pollution studies of the Molonglo River

A summary of the work carried out follows:

The atomic absorption laboratory - 2200 samples were analysed (22 000 element determinations). This included 1000 samples for the Tennant Creek project, 700 for the Georgetown project, and 400 for the Westmoreland project.

The X-ray fluorescence laboratory - 3150 samples were analysed (16 000 element determinations. This included 1100 samples for the Tennant Creek project, 300 for the Georgetown project, and 130 for the Westmoreland project.

The laboratory also analysed 200 samples by optical emission spectroscopy (4000 element determinations), 800 water samples (mainly from the Molonglo River), and 600 samples using the gamma-ray spectrometer.

GEOCHRONOLOGY

INTRODUCTION, by R.W. Page

During the past year, systematic geochronological investigations in six separate 1:100 000 mapping areas in the Northern Territory, Queensland, and Western Australia have continued. Field work and concurrent analytical efforts were focused on the Precambrian rocks in the Arunta and Tennant Creek areas, Alligator Rivers region, Granites-Tanami region, Mount Isa-Cloncurry region, and the Georgetown Inlier. Minor activities also continued in Papua New Guinea. Our endeavours to date the important geological events in these regions, and to characterize and distinguish likely source materials of igneous and metamorphic rocks, have provided a sound base on which to interpret and build their geological history. A brief summary of the major topics covered and results achieved during the year is given below.

Over 900 solid source (on Nuclide and MS-X) and 15 gas source (on MS-10) mass spectrometer runs were carried out, and virtually all the data were reduced with the aid of the on-line computer facilities referred to in last year's report. This output represents a slight increase on last year's, despite a 3-month partial cessation in analytical activities due to staff illness. A notable point in the history of the laboratory was marked in June, when the 10 000th sample analysis was performed on the Nuclide mass spectrometer; as far as is known, this is considerably more than have been carried out on any other instrument in the world.

The Geochronology Group continued to use the joint isotope laboratory facilities in the Research School of Earth Sciences, ANU. It is a pleasure to acknowledge continued cooperation and assistance of the Director and staff of the School.

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

A total of 181 separate isotopic analyses for Rb and for Sr were made on both whole rock and mineral samples during the past year. The results generally confirm the conclusions presented in last year's report. For example, the 1800 m.y. old granulite-facies metamorphism is now well documented in widely scattered areas of the Arunta Block. The reality of the lower-grade metamorphic event at about 1700 m.y. has also been further confirmed. Other results indicate perhaps as many as half a dozen additional metamorphic and/or intrusive events during the Proterozoic. These may provide a possible alternative explanation for some of the K-Ar ages ranging between 1700 m.y. and the Devonian-Carboniferous Alice Springs Orogeny, reported by A.J. Stewart (J. Geol. Soc. Aust., 17, pp. 205-211). Perhaps some of these dates may indicate real events, rather than retention of excess Ar, or partial resetting by the Alice Springs Orogeny. Consequently, future work will be aimed at investigating the authenticity of these "intermediate" events.

Investigations in the Jervois Range, which are now almost complete, indicate intrusion at 1800, 1700, and 1500 m.y.; the area seems to have been completely unaffected by the Alice Springs Orogeny.

Additional samples from the Georgina Range area were collected during 1974. Both the ultramafic rocks and the surrounding gneisses were sampled. The latter could yield the oldest total-rock isochron so far found in the Arunta Complex. The tentative lowermost Proterozoic age could not be precisely determined from the previously collected samples.

TENNANT CREEK AREA, N.T., by L.P. Black

Twenty-nine isotoptic analyses for Rb and for Sr have been made on rocks and minerals from the Tennant Creek Area. Dating of mineral concentrates hasnot proved completely successful; work on total-rock systems, which will be undertaken in late 1974-early 1975, will be required to decipher the chronology of most rock types. The only unequivocal mineral results indicate an age of about 1800 m.y. for phases of the Tennant Creek Granite.

GEORGETOWN-HERBERTON-MOUNT GARNET AREA QLD, by L.P. Black

In all, 40 mass-spectrometric determinations of Rb and Sr were made during the year. Perhaps the most interesting of these are of mica concentrates from several ore-bearing rocks. Previously there was only one date of this kind from the area, and that was determined by the K-Ar method. The results show a correlation between the time of formation of the gangue minerals (and presumably the associated tin and tungsten minerals) and the main pulse of Elizabeth Creek Granite emplacement about 320 m.y. ago.

Several analyses further confirm that the Featherbed Volcanics are geochronologically complex, and are made up of components of at least three, and probably more, distinct ages.

Isotopic considerations appear to preclude the derivation of the Upper Palaeozoic igneous rocks from either the Hodgkinson Formation or the Precambrian rocks of the Georgetown Inlier.

Sampling during 1974 was chiefly aimed at establishing the chronology of mineralised and unmineralised greisens in the Herberton-Mount Garnet area.

ALLIGATOR RIVERS PROJECT, N.T., by R.W. Page

In the last Annual Summary, K-Ar and Rb-Sr mineral ages of around 1800 m.y. were reported from schists, gneisses, and migmatites of the Nanambu and Nimbuwah Complexes. This 1800 m.y. age was recorded from both within and outside of the areas of known uranium mineralization, and was interpreted as the age of the last major regional metamorphism.

During the past year the Rb-Sr total rock isochron approach has been employed to look for further evidence on the history of these Complexes. The most significant result is that an Archaean age of 2.5 b.y. has been identified amongst the leucocratic alkaline granites of the Nanambu Complex. The antiquity of these bodies, together with the low initial Sr^{87}/Sr^{86} ratio (0.704), strongly suggests that the granitic rocks of the Complex are true

basement on which the Goodparla and South Alligator Groups were deposited in the Lower Proterozoic. This situation presents an important analogy with the environment of the Archaean Rum Jungle Complex. The Rb-Sr total rock system in other parts of the Nanambu Complex has partly or wholly responded to the 1800 m.y. metamorphism. Where this is the case, very high initial Sr^{87}/Sr^{86} ratios (up to 0.79) are preserved, and indicate that such rocks had an undoubted Archaean pre-history. An important outcome of the Rb-Sr work on the so-called "basement Nanambu Complex" beneath the "Mine Series" at Ranger 1 is that, although these rocks also have a metamorphic age close to 1800 m.y., their extrapolated maximum estimated age is 2150 m.y. This is clearly younger than the age of the confirmed Archaean Nanambu basement, and implies that the rocks underlying the "Mine Series" are probably meta-arkoses, etc., belonging to the Lower Proterozoic sedimentary succession.

The geochronological work so far carried out on gneisses and migmatites of the Nimbuwah Complex suggests an age (1840 m.y.) and origin which are quite distinct from the partly Archaean Nanambu Complex. Further sampling and examination of the Nimbuwah rocks in September, 1974, was aimed at elucidating these initial findings.

The large differentiated sill of Oenpelli Dolerite yields concordant Rb-Sr total rock isochron and mineral ages of around 1720 m.y. This result provides an important marker in the geological history, and is consistent with structural and petrographic evidence which indicates that the Dolerite was emplaced after the 1800 m.y. metamorphism. The Oenpelli Dolerite age can be regarded as a maximum for the age of deposition of the Kombolgie Formation which unconformably overlies the Dolerite. A small dolerite body east of the Goomadeer River intrudes the Kombolgie Formation, and its preliminary K-Ar age of 1200 m.y. provides the only known younger limit for the Kombolgie Formation.

Internal Rb-Sr mineral isochrons from phonolite dykes which intrude the metamorphic complexes have clarified the aberrant total-rock K-Ar ages reported in the previous Annual Summary. Separate Rb-Sr isochrons set an age of about 1350 m.y. (in agreement with K-Ar biotite ages) for the phonolite dykes.

MOUNT ISA-CLONCURRY PROJECT, QLD, by R.W. Page

The past year was devoted largely to the further appraisal of data reported in last year's Annual Summary. Further sampling of the meta-igneous rocks in the central basement area (Leichhardt Metamorphics, Magna Lynn Basalt, Argylla Formation, Kalkadoon Granite) was undertaken in an attempt to resolve uncertainties and discrepancies in the present Rb-Sr data. It is possible that a new approach involving U-Pb zircon geochronology will be employed to clarify ages and geological history within the Mount Isa basement succession.

Still other aspects of geochronology in this area are also being investigated; these include detailed Rb-Sr dating of the Tuff Marker Beds in the Urquhart Shale (Mount Isa Group), and internal Rb-Sr mineral isochron work on the Kuta Gabbro and Lakeview Dolerite.

GRANITES-TANAMI PROJECT, W.A. AND N.T., by R.W. Page

This past year saw the completion of planned geochronological work on the several granitic and volcanic suites from the Granites-Tanami Block. The 1800 m.y. Rb-Sr total rock isochrons reported in the 1973 Annual Summary for the Winnecke Granophyre and the Mount Winnecke Formation volcanics, are consistent with Rb-Sr mica and feldspar ages that have now been determined. It is concluded that the 1800 m.y. results represent the approximate age of igneous activity, and that the Palaeozoic metamorphic effects known farther south in the Arunta Block have not extended to the Granites-Tanami Block.

Rb-Sr ages were measured on glauconites from the Gardiner Formation which unconformably overlies the 1800 m.y. igneous rocks. Their pooled Rb-Sr age of about 1500 m.y. confirms earlier-determined K-Ar ages on the same samples, and thus appears to give a fair minimum estimate for the age of the Formation.

Acid lavas from the Pollock Hills Formation and intrusives from the Mount Webb Adamellite, considered to be comagmatic with the volcanic rocks, have each defined Rb-Sr isochrons of a little over 1500 m.y. The indicated initial Sr^{87}/Sr^{86} ratios are only poorly defined because of the high Rb/Sr ratios. The 1500 m.y. igneous event had not been suspected previously, and may be more akin to tectonic episodes of this age in the Arunta Block.

BANGEMALL BASIN GLAUCONITES, W.A., by R.W. Page

This minor project was initiated (with M.J. Jackson) to obtain an age estimate for the oldest sediments of the Bangemall Basin which directly overlie the Archaean Yilgarn Block. Five of the six glauconite samples that were dated at around 1700 m.y. by the K-Ar method (AMDL Report AN3473/73) were purified and analysed by the Rb-Sr method. The ages obtained range between 1500 and 1620 m.y. - significantly younger than the K-Ar ages. This difference is possibly due to the impure nature (resulting in excess argon problems) of the glauconite separates used in the K-Ar analyses. The isotopic data are clearly insufficient, and can only be interpreted to indicate that the sediments are between 1500 and 1700 m.y. old - i.e., of Carpentarian age. This conclusion is consistent with the fact that the sequence higher up is intruded by a 1200 m.y. dolerite (Compston, W., 1974, J. Geol. Soc. Aust.), but is at variance with unpublished stromatolite data which suggests that the sequence is much younger, viz., late Precambrian.

PAPUA NEW GUINEA, by R.W. Page

Only a minor amount of K-Ar analytical work was undertaken as a check on earlier-obtained ages on the mineralized porphyries in the Star Mountains of Papua New Guinea and Irian Jaya. The whole-rock and mineral K-Ar ages indicate that most of the intrusions were emplaced between 7 m.y. and 1 m.y. ago.

The discordant ages found within some intrusive bodies suggest that these are in fact multiple intrusions of more than one age. For example, new data from the monzonites and diorites in the vicinity of the Ok Tedi porphyry copper deposit demonstrate a gap of 1.5 m.y. between initial magmatic emplacement (at 2.6 m.y.) and subsequent copper mineralization associated with the Fubilan porphyries (at 1.1 m.y.).

ORE GENESIS INVESTIGATIONS

STAFF: W.M.B. Roberts, K. Johnson, J. Ferguson, and D.A. Fitzsimmons (T.A.)

RUM JUNGLE SPECIAL SHEET MAPPING, by K. Johnson

Preliminary results for the 1974 field season have been presented in the report on work in the Rum Jungle area. In this section emphasis is placed on those field observations which appear to be significant for understanding the controls of base-metal and uranium mineralization.

Metasomatism is widespread, and has resulted in the formation of quartz-tourmaline veins and in tourmalinization of sediments; the rock units affected are the Rum Jungle Complex, Waterhouse Complex, Batchelor Group, and the lower parts of the Golden Dyke Formation. Other possible metasomatic effects listed below are localised around the eastern margin of the Waterhouse Complex:-

(i) Extensive tourmalinization of sandstone of the Crater Formation.

(ii) Amphibolitization of the Celia Dolomite

(iii) Development of pyrrhotite and phlogopite within the Celia Dolomite.

(iv) Scapolitization and amphibolitization of the marginal granitic rocks of the Waterhouse Complex.

Williams (1963) believed that the "area was subjected to four generations of deformation which were responsible for folding the basement into dome and basin structures". According to Williams, this multiple-phase folding explains the steep dips of the Batchelor Group away from the complexes, but we believe that it does not explain deformation in conglomerates within the Crater Formation and Beestons Formation. Maximum deformation of quartz pebbles occurs within conglomerate which has an incompetant hematitic matrix. In conglomerate so deformed, maximum axial pebble ratios of 9:2:1 are developed. The orientation of the long axes of the conglomerate pebbles around both complexes is sub-vertical, except between the complexes where there is a shallowing in dips of the long axes. This type of deformation appears to require an intense upward push of the basement, and a minimum stress-strain field would be expected to develop between the two basement domes. Diapiric doming of the rocks forming the Rum Jungle and Waterhouse Complexes by a younger granite (which may also have locally pierced the complexes) could have caused the observed stretching of the conglomerate pebbles.

Isotopic dating of both complexes, and an evaluation of a regional gravity survey completed this year by the Bureau, will add further information in support of, or opposition to, the concept of diapiric upthrusting of the basement complexes.

The geological history of the Rum Jungle area can be summarized as follows:-

1. Deposition of the Batchelor Group as a marginal shelf facies around Archaean basement islands.

2. Deposition of the Goodparla Group in basins surrounding and onlapping the shelf areas. Shale containing Pb, Zn, and Cu, as well as uranium-bearing shale, was deposited during this basinal sedimentation cycle - i.e., syngenetic protore was formed.

3. Intrusion of basic sills into the sediments.

4. Deposition of the Finniss River Group in troughs marginal to and onlapping the basin areas.

5. Folding of the sedimentary rocks about north-trending axes, and development of isoclinal folds within the troughs; these pass into monoclinal folds on the shelf and in the marginal basins. The intensity and style of folding are controlled by the thickness of the cover-rocks over the basement.

6. Upthrusting of the basement complexes and the consequent doming of the Batchelor Group and lower Goodparla Group. It was during this period that extensive metasomatism occurred, and syngenetic uranium and base-metal protore was mobilized, and was concentrated in structural traps. The Giants Reef Fault was active during this time.

7. Extensive erosion of the Lower Proterozoic sequence.

8. Deposition of the Depot Creek Sandstone Member during the Upper Proterozoic.

REFERENCE

Williams, P.F., 1963 - Geology of the Rum Jungle district, Northern Territory. Territory Enterprises Pty Ltd Report (unpubl.)

MINERALIZATION, RUM JUNGLE AREA, by W.M.B. Roberts

Over the past year, investigations have been centred on the study of the mineralogy and petrology of rocks in the Rum Jungle area, and in particular Brown's copper-lead-zinc deposit. The formations studied are the Beestons Formation, Celia Dolomite, Crater Formation, and, most extensively, the Golden Dyke Formation.

Both dolomites have been strongly recrystallized, and in places metasomatized; sections of the Celia Dolomite showed strong development of phlogopite and pyrrhotite, and bear a remarkable resemblance to the metasomatized Coomalie Dolomite at Brown's deposit. It is probable that the ore components were derived from the sediments; the orebodies themselves were formed from low-temperature hydrothermal solutions, and are located in suitable structural situations. The ore fluids were probably connate waters originally trapped in pore spaces during diagnesis. The ore-forming processes took place at low temperature, and probably in response to the tectonism which has affected the area. Although up to the present time there is no direct evidence of any intrusive granite in the Rum Jungle area, subsurface activity related to the Burnside and Cullen Granites could have played a part in the mobilization of the ore fluids. The solution of this problem will depend partly on detailed dating of the Rum Jungle and Waterhouse Complexes.

EXPERIMENTAL INVESTIGATIONS, by J. Ferguson

Geochemical analysis: (Fitzsimmons)

Geochemical analysis of the Rum Jungle rocks commenced in June, but to date there are not enough data available to reach any conclusions.

Simulated Sedimentary Systems: (Ferguson in co-operation with P.J. Davies (BMR) and B. Bubela (Baas Becking))

Experiments showed that lead and zinc could be concentrated 200 to 300 times during precipitation from a sulphide-deficient brine, and incorporated into sediments in association with carbonate phases and iron oxides.

Metallo-organic complexes: (Ferguson in co-operation with R.O. Hallberg (Sweden) and B. Bubela (Baas Becking))

Experiments have shown that organic matter is implicated in the prevention of copper sulphide formation through forming an organic complex which prevents precipitation of the sulphide.

Atomic Absorption Investigation: (Ferguson in co-operation with T.H. Donnelly (Baas Becking))

A new method of background correction for flameless methods of atomizing samples for atomic absorption spectrophotometry has been tested and proved to be accurate and precise (R.S.D. 8-10%), and to have sufficient sensitivity for the determination of Zn and Fe over the total range of concentrations reported for seawater. Cu, Pb, and Cd could be determined only at higher concentrations. The method is particularly useful where sample volumes are small - e.g., for determining trace elements in interstitial waters of marine sediments.

MISCELLANEOUS

OVERSEA VISITS

D.B. Dow attended a symposium on Methods of Mineral Exploration in Developing Countries held at Orleans, France, from 22 to 24 November 1973. The main purpose of the symposium, which was sponsored by O.E.C.D., was to identify inadequacies of research programs, and to suggest ways in which available exploration methods could be better applied in developing countries. As most of the developing countries are situated in the tropics, much of the discussion was concerned with the special problems of climate, deep weathering, jungle cover, and difficult access posed by these regions.

While in Orleans Dow took the opportunity to tour the establishment of Bureau de Recherches Geologiques et Minieres.

Between 26 and 31 August, Dow attended the Circum-Pacific Energy and Mineral Resources Conference in Honolulu, Hawaii. The conference was sponsored jointly by the American Association of Petroleum Geologists, the Committee for Co-ordination of Joint Prospecting and Mineral Resources in Asian Offshore Areas, and the Pacific Science Association, and was intended to discuss economic, environmental, geological, and geophysical aspects of exploration and development of energy and mineral resources of the Pacific and surrounding land areas.

Some outstanding papers were presented, but because no discussion of papers was allowed, the aims of the conference were not realized as successfully as might have been expected.

During the conference arrangements were made to produce a series of maps of the Circum-Pacific region portraying the geology, tectonics, and mineral and energy resources.

Following the Honolulu conference Dow attended the Tenth Commonwealth Mining and Metallurgical Congress held in Canada from September 2 to 28. In addition to the two days of Plenary Sessions, he took part in a tour of the Sudbury Nickel Province and the Elliot Lake uranium deposits, as well as a tour which covered the coal deposits of Ontario and British Columbia.

R.G. Dodson attended the International Atomic Energy Agency Symposium on the Formation of Uranium Deposits, held in Athens from 6 to 10 May, and presented a paper entitled "Uranium Mineralization In the Rum Jungle-Alligator Rivers Province, Northern Territory, Australia". Dodson was chairman for the session, "Sedimentary basins and sandstone type deposits", and joined working group No.IV for discussion on "Vein and similar type deposits".

The Symposium was one of a series arranged from time to time by the International Atomic Energy Agency with the object of promoting exploration for uranium, and study of the most modern methods of uranium exploration. The tenor of the symposium was one of urgency for the expansion of uranium exploration throughout the world, because predictions based on present known reserves point to a serious shortage of uranium within twenty years for fuelling nuclear reactor power stations. In addition to detailed descriptions of the latest developments in exploration methods, papers presented at the symposium covered a wide range of types of uranium deposits, including those which are not at present economically viable, but will undoubtedly become exploitable in the near future as treatment techniques improve, and the price for uranium oxide increases.

Proceedings of the symposium will be published in December.

A.Y. Glikson made two overseas visits during the year. On the first, sponsored mainly by NATO, and partly by BMR, he delivered a series of lectures on Precambrian geology at North American geological surveys and universities. The purpose of the second visit, sponsored by the Carnegie Institution and I.U.G.S., was to attend a conference in Minnesota on the "Geology and Geochemistry of the Oldest Precambrian Rocks". Some further information on these visits is given in the report on the Petrological Laboratory.

TRAINING COURSES

A course of lectures on mineral exploration was given by Professor W.C. Lacy, of James Cook University of North Queensland, at BMR from 25 to 29 March; the lectures were well attended by BMR staff as well as staff and students from the ANU and CCAE.

Professor Lacy's course on porphyry copper deposits was attended by R.W. Johnson in Panguna, and by R.J. Bultitude at AMF.

D.B. Dow attended a course on Economic Evaluation and Investment Decision Methods given by Professor F. Stermole in Canberra from 5 to 9 August. The course provided a valuable insight into economic and financial aspects of the mineral industry.

A.G. Rossiter and D.J. Ellis took part in AMF courses in geochemistry and mineragraphy, respectively, and B.I. Cruikshank attended a Fortran course at CCAE.

BAAS BECKING GEOBIOLOGICAL RESEARCH LABORATORY

Sulphur Biology and Isotope Geochemistry (L.A. Chambers, T.H. Donnelly, H.E. Jones, G.W. Skyring, P.A. Trudinger).

Physiological and biochemical characteristics of the sulphate-reducing bacteria pertinent to the biogeochemical activities of these bacteria have been examined. Particular emphasis has been placed on the use of isotopic data and other criteria to determine the role of sulphate-reducing bacteria in sulphide ore genesis.

A. Previous studies, in the Laboratory and overseas, have established that the green protein, desulfoviridin, is an essential catalyst in the pathway of sulphate reduction by Desulfovibrio. The chromophore of desulfoviridin is a tetrapyrolle which is related chemically to porphyrins found in both modern and ancient sediments.

It has now been found that the chromophore, released from the protein by mild heat treatment, still possesses at least part of the catalytic activity of intact desulfoviridin, namely the production of sulphide from dithionite ($S_2O_4^{2-}$). Scientifically this is a very significant finding since it opens up the prospect of a chemical and physical chemical investigation of the mechanism of catalysis of sulphite reduction.

The finding also has possible biogeochemical implications in view of the often-expressed notion that the development of biological sulphate reduction may have been an early event in biochemical evolution. Tetrapyrolles are known to form abiologically under conditions simulating those predicted for the primordial terrestrial environment. Chemical reduction of sulphur compounds catalysed by tetrapyrolles may, therefore, represent the precursor of the biochemically-mediated reaction.

B. In the last summary we described the formation of thiosulphate and trithionate during reduction of sulphite by desulfoviridin. In order to explain bacterial isotopic fractionation effects it became necessary to establish what roles, if any, thiosulphate and trithionate play in sulphate reduction since it is the various transformations which sulphur undergoes which determines the overall isotopic effect.

C. Interpretation of isotopic data on ancient sediments relies, to a large extent, on results of studies on experimental systems and on modern sediments where various concurrent chemical and biological processes may be followed.

We have collaborated with Dr P.J. Cook of BMR on an analysis of a core from the Timor Trough collected during the Joides deep sea drilling programme. The core is characterized by an extreme deficiency of sulphate in interstitial waters from about 1 - 350 metres depth. This is accompanied by decreasing alkalinity over the same depth. Since bacterial sulphate reduction generates alkalinity it was suspected that the sulphate and alkalinity anomalies might be caused by such a process. Pyrite was present in samples from various depths, and was all in framboidal form. Isotopic analyses on the pyrite revealed a general trend from light (relatively rich in ^{32}S) to heavy from 310 metres to 1 metre. This result is consistent with the notion that extensive bacterial sulphate reduction took place in recent sediments but a full interpretation of the chemical and biochemical events depends on further data becoming available.

Examination of pyrite and pyrrhotite from black shale samples from six localities in the Yilgarn Block, Western Australia, indicate that the sulphide was not formed at the same time as the shales. The sulphur isotope ratio values indicate a magmatic origin for the mineralization. Other sediment sulphides from the Yilgarn Block will be examined, where the mineralization indicates primary origin, to try and establish the source of the sulphur.

In conjunction with Dr R.R. Keays and Mr A.H. Green, of the University of Melbourne, sulphur isotopes have been examined from individual dykes of the Wood's Point dyke swarm which contain economic mineralization. The middle Devonian dykes intrude the Silurian shales. A sample from the Morning Star dyke has produced a Rb/Sr date of 380 m.y. The dyke affords an opportunity to study the redistribution of sulphur in a system which apparently remained closed. Preliminary results indicate S^{34} values +1‰ for sulphides in unaltered rock (hornblende type; mineralization includes pyrite, pyrrhotite, pentlandite, and chalcopyrite). A minimum temperature from fluid inclusions in quartz and calcite from the Shamrock dyke is 200-250°C (Dr R.W.T. Wilkins). So far separated sulphide pairs (pyrrhotite/chalcopyrite and pyrite/chalcopyrite) have not shown equilibration, and could not be used for geothermometry.

Precambrian Life (D.Z. Oehler, J.H. Oehler in collaboration with M.D. Muir, Imperial College, London, M.R. Walter and K.A. Plumb, BMR, and J.D. Saxby and J.W. Smith, CSIRO, North Ryde).

These studies are designed

to assess the relationships between Precambrian biological activity and economic mineralization

to obtain direct evidence of metal-organic associations, through microscopic and chemical studies of carbonaceous materials preserved in mineralized sediments of Precambrian age,

and to investigate the utility of Precambrian fossils for biostratigraphy and for reconstructing ancient basin environments.

A. Two field trips were undertaken to collect fossiliferous and organic-rich sediments from the Mount Isa area, the McArthur River area, the Amadeus Basin, and the Adelaide Geosyncline. Particular emphasis was placed on unmetamorphosed sediments from the McArthur Group where previous studies had revealed spatial associations between well preserved microfossils and base-metal sulphides. Galena-rich sediments from the HYC Pyritic Shale Member contain algal microfossils almost completely filled with cubic sulphide crystals. The Cooley Dolomite (?) equivalent of the HYC contains microfossils, interpreted as manganese-oxidizing bacteria, which are encrusted with manganese and are rich in zinc and copper. Silicified dolomitic shales from the Amelia Dolomite, underlying the Barney Creek Formation, contain a diverse microflora which includes distinctive fossils of colonial organisms in which each cell contains a single cube of (?)pyrite. Adjacent to the sulphide-containing fossils are other microfossil types which do not contain intracellular sulphides. This suggests that, within the McArthur Basin, some species were capable of precipitating sulphides whereas other, coexisting species were not. Also within the Amelia Dolomite are

spheroidal microfossils that contain minute pyrite crystals within their cell walls. Several other potentially fossiliferous horizons within the HYC are under investigation, and attempts are being made to recognise population distributions that could lead to a biostratigraphic zonation of the McArthur Group.

B. Techniques have been perfected for studying metal-organic relationships in Precambrian fossils by transmission electron microscopy coupled with energy dispersive X-ray microanalysis. At magnifications of 100,000 and higher, algal microfossils from the Bitter Springs Formation were found to contain opaque, ultramicroscopic particles within the organic sheaths surrounding their cells. X-ray analysis showed that the particles are rich in calcium, and it appears that these particles were precipitated within the sheaths of the living algae. This approach is now being extended to study microfossils from metalliferous horizons in the McArthur Group to determine whether metals could also have been precipitated in a similar fashion by ancient microorganisms.

Using optical microscopy, sulphide-rich algal microfossils were also detected in stromatolitic cherts from the Paradise Creek Formation. These fossils, however, cannot be studied by electron microscopy because they are too poorly preserved to be dissolved intact from the rock matrix.

C. Metal-organic relationships were studied by emission spectroscopy, using the insoluble particulate organic matter (kerogen) extracted from orebody sediments at Mount Isa, Hilton, McArthur River, and the Woodcutters Prospect at Rum Jungle. Results suggest that at least some of the vanadium, nickel and cobalt present in these rocks may have been deposited as metal-chelated porphyrins (degradation products of biological pigments). In addition, the work by J. Ferguson (BMR) suggests that some of the zinc and copper (but not the lead) in these rocks is present as organo-metallic complexes. This would be consistent with the observation (noted in part A) that manganiferous, bacterium-like fossils in the Cooley Dolomite contain zinc and copper, but not lead. To date, studies conducted in this Laboratory have shown no positive indications of organic-lead complexes in Precambrian metalliferous sediments.

D. Carbon isotope studies on Precambrian kerogens are designed to elucidate the origins of Archaean organic matter. These studies were prompted by earlier findings of an isotopic discontinuity near the base of the Onverwacht Group in South Africa which suggested a major geological event or fundamental biological event at about 3.4×10^9 years B.P. To determine whether the isotopic discontinuity in rocks of this age is local or cosmopolitan in extent, a suite of carbonaceous rocks was obtained from the Archaean of Western Australia and Greenland. Analysis of the Australian samples showed that most contain carbon that can be attributed to the activity of photosynthetic organisms; however, one sample did give an unusually heavy value similar to that from the lowest Onverwacht. Moreover, the Greenland sample, which is from the oldest known sedimentary sequence on earth, also has a heavy value like that of the lowest Onverwacht sediments. These data not only suggest that the early Archaean isotopic discontinuity is widespread, but they also suggest that detection of this discontinuity in structurally complex Archaean strata from Western Australia may be a useful means of differentiating between very early Archaean formations and those that are somewhat younger. It is also possible that intercontinental biostratigraphic

correlation of early Archaean sediments may be feasible through analyses of this kind. In view of the potential significance of these results, as well as the yet unexplained origin of this type of carbon, additional samples from Western Australia and from South Africa are being collected for further study.

Irreversible contamination of Precambrian kerogen by younger Organic compounds (J. Oehler).

We are testing the hypothesis that the insoluble, particulate "kerogen" fraction of sedimentary organic matter is immune to contamination by younger organic compounds, and is therefore a true representation of the organic matter originally deposited in the rock.

Kerogen extracted from a late Precambrian (ca. 1500 m.y. old) chert of the Paradise Creek Formation was refluxed for 48 hours in the presence of universally labelled (C^{14}) serine, and then was extracted 5 times with organic solvents to remove all extractable organic compounds. Results showed that, under these experimental conditions, 1 gm of kerogen could incorporate 5×10^{-5} gm of serine, which could not be removed by standard techniques. This indicates that kerogen can be irreversibly contaminated by younger organic compounds. However, the level of contamination observed is insufficient to have an appreciable effect on organic geochemical analyses (including carbon isotopic studies) of Precambrian kerogen. Experiments are continuing to determin whether higher levels of contamination can occur under different experimental conditions or with different organic compounds.

Sources of Metals for Ore Genesis (B. Bubela, in collaboration with P.J. Davies, J. Ferguson, BMR, and R.O. Hallberg, University of Stockholm).

The objective is to evaluate the role of organic matter, brines, and carbonates in the transport, accumulation, and fixation of metals in sediments.

A. An experiment using a simulated sedimentary environment was designed to study the interaction of sulphide, metals (Pb, Zn, and Cu), and organic matter at the sediment-water interface. The results indicated that metal concentration in interstitial waters was proportional to the organic carbon content. No base-metal sulphides were detected, even though H_2S was present. We conclude that though organic matter may be an important factor in metal accumulation in sediments it may, at least in certain circumstances, prevent subsequent sulphidization of metals, probably by forming relatively stable organo-metallic complexes. Studies on the nature of important metal-organic complexes are in progress, and a simple, rapid thin-layer chromatographic method has been developed for this purpose.

B. W.M.B. Roberts (BMR) has suggested that carbonates may be involved in the fixation of metals which are released to form soluble organo-metallic complexes during dolomitization. Previous studies in the experimental sedimentary system showed that metals do indeed accumulate in metastable carbonates. Studies are now directed towards the mechanism of dolomite formation.

Based on results of laboratory studies, we proposed in previous reports that the metastable magnesium carbonate, nesquehonite, might participate in the formation of dolomite. Nesquehonite has now been detected in the sediments of the Coorong Lake which has a high dolomite content. The genetic relationship between the two minerals in the field, however, cannot, as yet, be evaluated.

Geochemical and Mineralogical Investigations of Rocks Around the Woodlawn Deposit, NSW (I.B. Lambert, M.D. Petersen)

This project is aimed at defining mineralogical and chemical dispersion haloes and assessing ore genesis.

Chemical analyses for 35 elements in an initial batch of 105 rocks have been completed; X-ray diffraction analyses of the same samples have been completed and interpreted. Current work involves microscopic examination of thin sections of these samples, and preparation of an additional 61 samples for chemical, X-ray, and microscopic analyses.

Abiologic sulphate reduction by petroleum (L.A. Chambers, P.A. Trudinger with D.T. Rickard, University of Stockholm).

Thermodynamically, sulphate should be readily reduced to sulphide by petroleum. This reaction is potentially a major sulphide source for sulphide ore formation (especially of the Mississippi Valley type), and also has implications for the genesis of sulphur deposits and sulphur distribution in petroleum reservoirs. Studies by other workers have shown that petroleum-linked sulphate reduction takes place rapidly at temperatures greater than 300° in the presence of a suitable catalyst such as H_2S.

We have carried out a series of experiments in which samples containing various combinations of petroleum, ^{35}S-sulphate-rich brine, sulphur, and sulphide were incubated for up to 5 weeks at temperatures ranging from ambient to 200°C. Reduction of sulphate was determined by assaying radioactivity in H_2S.

No massive reduction was observed. However, in samples incubated at 80°C, up to 0.02% of the original ^{35}S was recovered in a "volatile" form. Tests are under way to determine whether this "volatile" radioactivity was, in fact the result of sulphate reduction.

Brines as Ore-forming Solutions (C.J. Downes)

In last year's report experimental results on the behaviour of base-metal ions in brines were discussed in terms of the separation and transport of Pb and Zn. Further work has concentrated on determining the nature of lead and zinc species in highly saline brines. This has involved writing computer programs to evaluate equilibrium constants for the formation of chloro-complexes of these elements. Consideration has also been given to the simultaneous transport of reduced sulphur species in these brines. A search has been made for possible ways in which chemical reduction of sulphate may proceed under geologically feasible conditions. The most promising results have been obtained using hydrogen, a major component of the "active gas" fraction of at least some present-day geothermal exhalations.

GEOLOGICAL SERVICES SECTION

GENERAL

by

E.K. Carter

The Section contributed to the Bureau's Open Days at the end of April and beginning of May.

Close co-operation was maintained throughout the year with the Engineering Geophysics group which provide valuable data and interpretations to many projects which the Engineering Geology group carried out. With extended fieldwork in the Darwin East development area, NT and involvement in the Albury Wodonga studies, the Engineering Geology's areas of activities increased, despite the lack of active participation in PNG projects.

Staff matters, stratigraphic nomenclature, Branch finance, field inspections and planning for urban development areas, including Albury-Wodonga, Darwin East and Holsworthy were attended to. He participated in two inter-departmental committees, three conferences of inter-governmental officials and several departmental and BMR committees.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

FUNCTIONS AND GENERAL ACTIVITIES

STAFF: Supervising Geologist: E.G. Wilson; Senior Geologists: G. Jacobson (fron January), D.C. Purcell; A.T. Laws (until May); Geologists: G.A.M. Henderson, P.D. Hohnen, P.H. Vanden Brock, G.B. Simpson, P.A. Lang, G. Anderson (from April), G. Briscoe (from August), R. Holdsmith (from September); Technical Officer: J.R. Kellett; Technical Assistant: A.W. Schuett.

The Engineering Geology and Hydrology Sub-section is essentially a service group, but, in the course of its activities contributes to an understanding of the geology and hydrology of the areas in which it works, and makes the information gained generally available. It provides geological services to government authorities concerned with urban development planning and the investigation, design and construction of engineering works. In the ACT and its environs investigations are done mainly for the National Capital Development Commission (NCDC), the Department of Housing and Construction (DHC), and the Department of the Capital Territory (DCT). During 1974 a co-ordinating role was also undertaken in geological investigations for urban planning at several other growth centres on behalf of the Cities Commission (CC), and the Albury Wodonga Development Corporation; field investigations were also carried out in the Darwin East area.

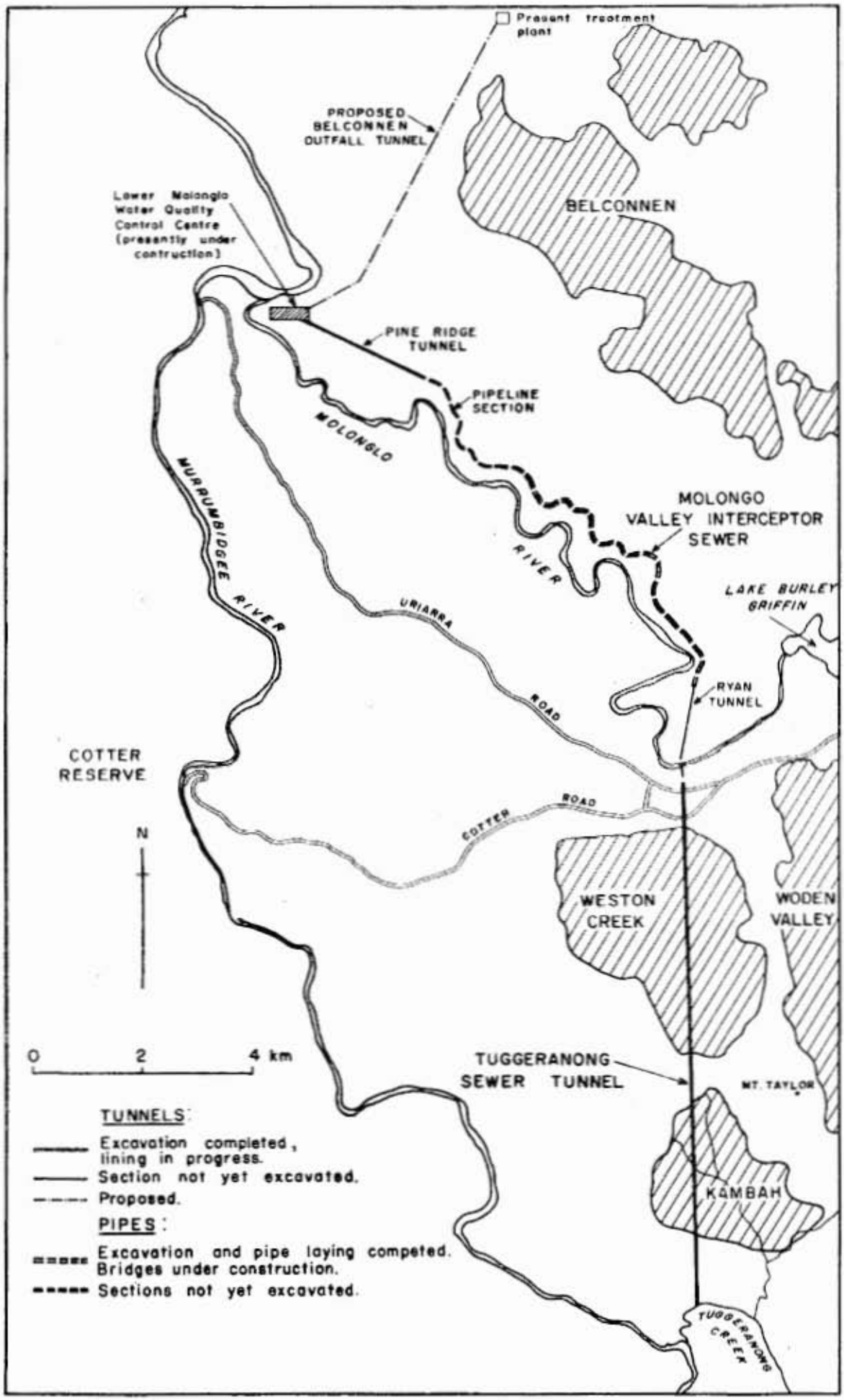

Fig. GS 1 Canberra Sewerage. Tuggeranong Tunnel and Molonglo Valley Interceptor Sewer

Record 1974/127

R.F. 155/A16/1237

The group continued its surveillance and advisory role in groundwater hydrology in the ACT, the Federal Territory of Jervis Bay, and at Lake George, in NSW.

Compilation of engineering geological data on to 1:10 000 base maps of the ACT began in 1974 and publication of a series of engineering geological maps at this scale is planned.

A request by DHC for the secondment of BMR engineering geologists to their Sydney and Melbourne divisions is being arranged, but early staffing is not expected.

ENGINEERING GEOLOGY

SEWER LINES by D.C. Purcell and P.A. Lang

Engineering geological services were provided to the Department of Housing & Construction for the investigation and construction of the ACT sewerage system. The locations of the sewerage works are shown in Fig. GS1.

TUGGERANONG SEWER TUNNEL

Construction of the tunnel and appurtenant works continued throughout the year. Excavation of the tunnel and five shafts were completed in April and August respectively. Cleaning up operations and concrete lining (including grouting) commenced at the south portal after tunnel break-through in April.

Full geological assistance was given to DHC during tunnel and shaft excavation and, as required, during lining and grouting operations.

Excavation from the south portal was generally in sound rock with few major defects. However, during excavations from the north portal, numerous sheared and fractured zones were intersected, including a weathered contact zone between blue dacite and purple rhyodacite. Excavation conditions and support requirements closely matched predictions. Water inflows into the north heading have been as high as 2600 m^3 per day.

A summary of pertinent features is shown in Table GS1.

MOLONGLO VALLEY INTERCEPTOR SEWER

Construction of the Pine Ridge Tunnel, the buried pipeline and bridges to carry the pipe continued throughout the year, and construction of Ryan Tunnel commenced in July. Full geological assistance was given to DHC.

Pine Ridge Tunnel

Excavation of the east heading for 1069 m was completed, and excavation from the west portal commenced in April. Tunnel break-through took place on 10 October, 1974.

TABLE GS1

SUMMARY OF TUNNELLING CONDITIONS

	TUGGERANONG SEWER TUNNEL	PINE RIDGE TUNNEL	
		EAST HEADING	WEST HEADING
Commencement of excavation	June 1972	September 1973	April 1974
Completion of excavation	August 1974	April 1974	October 1974
Total length of tunnel excavated	9007 m	1079 m	939 m
Total length of shafts excavated	300 m (approx)	nil	nil
Length of tunnel needing steel support	1715 m (19 percent)*	297 m (27%)	46 m (4.9%)
Water inflows	Total 900 000 m^3 (June 1972 - August 1974)	av. 9 m^3/hour	av. 9 m^3/hour
Rock types excavated	Northern half; rhyodacite, some rhyolite Southern half: blue grey dacite	Agglomerate, shale and welded dacite tuffs	Welded dacite tuffs
Commencement of concrete lining operations	April 1974	July 1974	-
Concrete lining progress	1630 m	435 m	-

* only 230 m (or 2.5 percent) occurred in the southern half of the tunnel

Cleaning up of the east end started in April and the first concrete pour was made in July. Approximately 435 m of concrete lining had been poured by 28 October, 1974.

Excavation from the east portal for the first 289 m was through variably weathered volcanic agglomerate, and fractured and sheared black tuffaceous shale. The shale is faulted against welded dacitic tuffs and its poor condition results from the fault. Continuous steel support was required for the 189 m from the portal. The remainder of the east heading, and all the west heading has been excavated in blue-grey to green-grey welded dacitic tuffs with some zones of purple staining (hydrothermally deposited hematite). The dacite is very hard but generally closely jointed.

Water inflows have been constant at about 9 m^3/hour at each end.

A summary of pertinent features is given in Table GS1.

Some additional seismic refraction traverses were done by the BMR Engineering Geophysics group* to help predict tunnelling conditions ahead of the face. The correlation between rock condition and the seismic results has been good.

Excavation and lining of the Pine Ridge Tunnel is 4 months behind schedule on the original program, and the program has had to be revised.

Ryan Tunnel

Tunnelling from the north portal commenced in July and approximately 50 m had been excavated by 19 October.

Excavation of an open cut at the south portal has been completed ready for tunnelling.

Additional seismic traverses and resistivity surveys have been done by the BMR Engineering Geophysics group along the route of the tunnel. The results indicate that Ryan Tunnel will need more support than was originally envisaged and that tunnelling conditions are likely to be more varied than in Pine Ridge and Tuggeranong Tunnels.

Buried Pipeline Sections

Excavation, pipe laying and backfilling of the trench began in September 1973. Construction progressed east from the Coppins Crossing Road and reached the north portal of Ryan Tunnel in March, a distance of 3444 m. Construction then continued west from Coppins Crossing Road and had proceeded 4390 m by 19 October. At the end of October, 85 percent of the pipe laying had been completed, and the associated bridge structures were under construction.

The Winslade Fault was crossed at chainage 4880 m. The excavation east of the Winslade Fault was through Painter Porphyry except for about 60 m near the north portal of Ryan Tunnel which was through shale, limestone

* Unless otherwise stated, engineering geophysical investigations referred to in this report were conducted by the Bureau's Engineering Geophysics Group.

and tuffaceous and quartz sandstone. West of the Winslade Fault the excavation has been through massive welded dacitic tuffs except for three small lenses of fossiliferous shale and limestone.

The welded tuffs are generally less weathered than the Painter Porphyry, necessitating heavy blasting and resulting in slower excavation progress. Problems with backfill material have also occurred as hard blocky rock cannot be placed directly against the pipe because of the risk of damage to the pipe.

No significant stability problems have been encountered with the trench or the pipe foundations.

The Molonglo River bridge has been completed.

BELCONNEN OUTFALL SEWER

A preliminary investigation is being undertaken for a sewer line from the existing Belconnen Water Pollution Control Centre to the Lower Molonglo Water Quality Control Centre, which is under construction. Two routes are being investigated; the route favoured at present involves a 2.36 m diameter concrete lined tunnel approximately 5700 m in length with two concrete lined shafts, 38 m and 60 m deep. The tunnel will be in two sections, joined by a bridge with a span of about 75 m.

Geological mapping is almost complete and the compilation of maps and sections is in progress. Seismic traverses and diamond drilling are being recommended.

GOOGONG WATER SUPPLY PROJECT by D.C. Purcell

Construction of Googong Dam was scheduled to begin in March 1974 but was delayed for one year. Early in the year the Project Geologist, G.B. Simpson, attended meetings and site inspections with the tenderers and answered questions related to the engineering geology of the project. He prepared reports on the geology of the proposed pipeline and access road from the dam to the proposed pump station site, and on geological investigations of the proposed pump station.

Further seismic refraction work was carried out along the Googong access road alignment and the proposed pipeline from the pump station to the treatment plant. The results were forwarded to DHC together with a brief report on the geology prior to re-calling of tenders for construction of the dam late in 1974.

TUGGERANONG LAKE DAM by D.C. Purcell

At the request of NCDC a seismic survey and a preliminary geological assessment of the site for the proposed embankment was undertaken. The seismic traverses were located along the embankment axis and in the spillway area. A geological map of the area was compiled and an exploratory costean excavated on the south abutment was mapped.

A brief report was prepared and recommendations for further investigations, including drilling, were made.

Preliminary geological investigations indicate that construction of the dam is feasible although rock quality in the spillway area has yet to be proven and a large defect zone crossing the dam axis has yet to be fully assessed.

FOUNDATION AND SLOPE STABILITY INVESTIGATIONS by D.C. Purcell

RESERVOIR SITES

Weetangera Reservoir

Geological advice was sought by DHC during excavation of the site when unrippable rock was encountered at shallower depths than had been expected on the basis of the seismic profiles. However on inspection it was found that the velocities obtained were realistic; because of uniform weathering and the massive nature of the dacite, rock with a velocity of greater than 1300 m/s proved to be unrippable.

Deakin Reservoir

The site of the proposed reservoir was mapped at 1:5 000 scale and a short report prepared for DHC. The site is on Painter Porphyry and Deakin Volcanics and includes part of a partly-filled, disused quarry.

Wanniassa Reservoir No 1

Following a request from DHC a geological appraisal, including a seismic survey, of the proposed site was carried out. Most of the site will have to be excavated in hard rock except for a thin surface layer of soil and slopewash with low seismic velocity. A recommendation was made that two boreholes be drilled to confirm the seismic results.

LUNAR LASER RANGER SITE

Following a BMR report written in 1973 on the proposed Lunar Laser Ranger site in the Orroral Valley, the Department of National Mapping agreed that further investigations were necessary for a full assessment of the foundations.

During the first half of 1974 the foundations were mapped by G.B. Simpson. Four diamond-drill holes were designed and the cores logged and oriented. The results confirmed that the foundation is a granite boulder which is capable of moving independently of the surrounding rocks. The foundation load of the Ranger and its building will be about 15 percent of the weight of the boulder, but for stability within the operational limits of the ranger, the load should not exceed 2 percent of the boulder's weight. In the foundation report issued in mid-1974 it was concluded that differential movement of the boulder outside the limits specified for the Ranger must be considered a real possibility.

ROAD CUTS, TUGGERANONG FREEWAY

Advice on the stability of several road cut sections of the Freeway

was given to the consulting engineers for NCDC. Brief reports on each problem area were prepared.

MURRUMBIDGEE CABLEWAY SITE

Advice on the foundations for the proposed cableway was given to DHC. Foundations for the west bank of the river were found to be adequate but poor foundation conditions on the east bank resulted in a re-design of the method of anchoring the cableway.

MOLONGLO PARKWAY

Following a request from DHC, geological investigations of the Parkway route along the base of Black Mountain continued through the year. Investigations were made of proposed cuts in the Acacia Inlet area and Black Mountain Peninsula; investigation of the foundations for the Black Mountain lake fill section were also carried out. The work included geological mapping, seismic refraction surveys and diamond drilling.

Initially the investigations were planned around a road alignment requiring cuts in the order of 15 m. However, following a decision by NCDC to downgrade the size of the parkway the maximum cut will now be about 8 m. The reduction in the size of the parkway will, however, only mean a reduction of about 10 percent in the amount of fill material required in Lake Burley Griffin.

Two alternative quarry sites were also investigated. The sites were geologically mapped and diamond drilled, and a seismic survey was carried out by DHC. A site situated about 2 km southwest of Scrivener Dam has been selected as the most feasible.

CITY EAST INVESTIGATION, CANBERRA

Site investigations for a proposed office building for the Department of the Capital Territory in the eastern part of Canberra City encountered unusually deep weathering, causing problems with foundation design (Fig. GS 2). BMR was requested to carry out geophysical surveys and rotary core drilling in the area in order to ascertain the extent of deeply weathered rock and evaluate the feasibility of building construction in the area.

The investigation included six seismic refraction traverses and 14 rotary core drillholes. It defined a trough of deeply weathered and sheared Silurian mudstone 100 - 200 m wide and up to 70 m deep. This is part of the City East Fault Zone which probably extends along a lineament trending south from Ainslie through City East to Lake Burley Griffin.

The great depth of weathering, and its irregularity within the fault zone poses problems of differential settlement of building foundations. A decision was made by NCDC to shift the site of the proposed office building outside the fault zone. Three other possible sites were investigated by diamond drilling; all are geologically suitable.

CONSTRUCTION MATERIALS by D.C. Purcell and G. Jacobson

EAST LAKE SAND RESERVES

At the request of NCDC, an appraisal of possible sand and gravel reserves in the area immediately east of the East Basin of Lake Burley Griffin and extending eastwards to the Molonglo River was undertaken. The area was geologically mapped, and an extensive seismic refraction survey was carried out. The area appears to be complex, with clay, silt, sand a gravel mixtures, and locating areas of clean sand and gravel will require a comprehensive augering program.

SAND AND GRAVEL RESOURCES, ACT AND ENVIRONS

At the request of NCDC, a brief review was undertaken of known sand and gravel resources in the ACT and environs. Additional investigations are required for land use planning purposes.

CAPTAINS FLAT

Several possible quarry sites were investigated at Captains Flat, NSW, where about 150 000 m^3 of rock fill is required for reclamation and stabilisation of the tailings dumps from the treatment plant of the old Lake George Ltd's mine. The investigation was done on behalf of the Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River.

ENVIRONMENTAL GEOLOGY

HYDROLOGY AND DRAINAGE INVESTIGATIONS by G. Jacobson

ACT OBSERVATION BORE NETWORK

Routine measurements of water levels in about 70 observation bores in the ACT network continued throughout the year.

The network records seasonal fluctuations of the water table, thereby assisting the evaluation of groundwater conditions and resources. Some of the observation bores are used to monitor the effects of filling of the lakes in Canberra; while others monitor the effects of tunnelling on groundwater conditions and the effects of urbanisation on groundwater.

LAKE GEORGE

Monitoring of the level and salinity of Lake George continued throughout the year. The lake fell to a level of 0.71 m in January with a conductivity of 24,000 micromhos/cm. Heavy winter and spring rains brought the level up to 2.58 m on October 8 with a conductivity of 1900 micromhos/cm. This is the highest level recorded since 1967 and the lowest conductivity reading since 1960.

BORE SITING

A water bore was drilled at the National Fitness Camp, Paddy's River, but the supply from the fractured granite aquifer proved to be insufficient for the camp. Two water bores were sited for farmers in areas of NSW close to the ACT border, and groundwater advice was given to government authorities and others.

JERVIS BAY GROUNDWATER INVESTIGATION

Monitoring of piezometers at Jervis Bay continued in an attempt to ascertain possible leakage paths of water from Lake Windermere. Several additional piezometers were installed, and the piezometers were levelled by surveyors of the Department of Services and Property to enable groundwater contour maps to be drawn. Lake Windermere attained its highest level for several years and the frequency of observations in the piezometers was increased.

ISABELLA PLAINS DRAINAGE INVESTIGATION

At the request of NCDC, investigations continued into a drainage problem affecting an area of several square kilometres in the new town of Tuggeranong (see GS2). Piezometers were installed, and groundwater levels were monitored during and after construction of preliminary drainage channels. Analysis of water level data has indicated that the preliminary drainage works are not completely effective.

LANYON DRAINAGE INVESTIGATION

Two poorly drained areas proposed for suburban development at Lanyon, in the southern part of Tuggeranong, were investigated by J.R. Kellett at the request of NCDC (Fig. GS 2). Soils augering indicated that the problems occur in pediment basins containing sandy colluvial aquifers which are confined by more clayey colluvium above and indurated alluvium below. The potentiometric surface is above ground level in much of the area. A total of 35 piezometers were installed to monitor water level changes, and several pumping tests were carried out to determine the permeability of the aquifers. Additional investigation is necessary to define fully the locations of the aquifers, and provide information for the design of drainage works.

CANBERRA SUBURBS DRAINAGE INVESTIGATIONS

A drainage problem in the suburb of Duffy, Weston Creek, was investigated by P.D. Hohnen and R.S. Abell, and remedial measures were recommended. P.D. Hohnen completed reports on previous investigations into seepages from colluvial aquifers at Red Hill and Ainslie.

DATA STORAGE AND RETRIEVAL by A.W. Schuett

Hydrology and groundwater records have been maintained throughout the year and carded for computer storage. All programs have been converted to metric, and the conversion of all programs to Cyber 76 is completed. Documentation of the programs is in progress and about one quarter of the task has been completed.

URBAN GEOLOGY, ACT AND ENVIRONS by G.A.M. Henderson and G. Jacobson

Geological studies of urban development areas in the ACT and environs were undertaken for NCDC. The location of the main study areas is shown in Fig. GS 2.

ACT 1:10 000 ENGINEERING GEOLOGY MAPS

Proposals for a series of 1:10 000 scale engineering geology maps

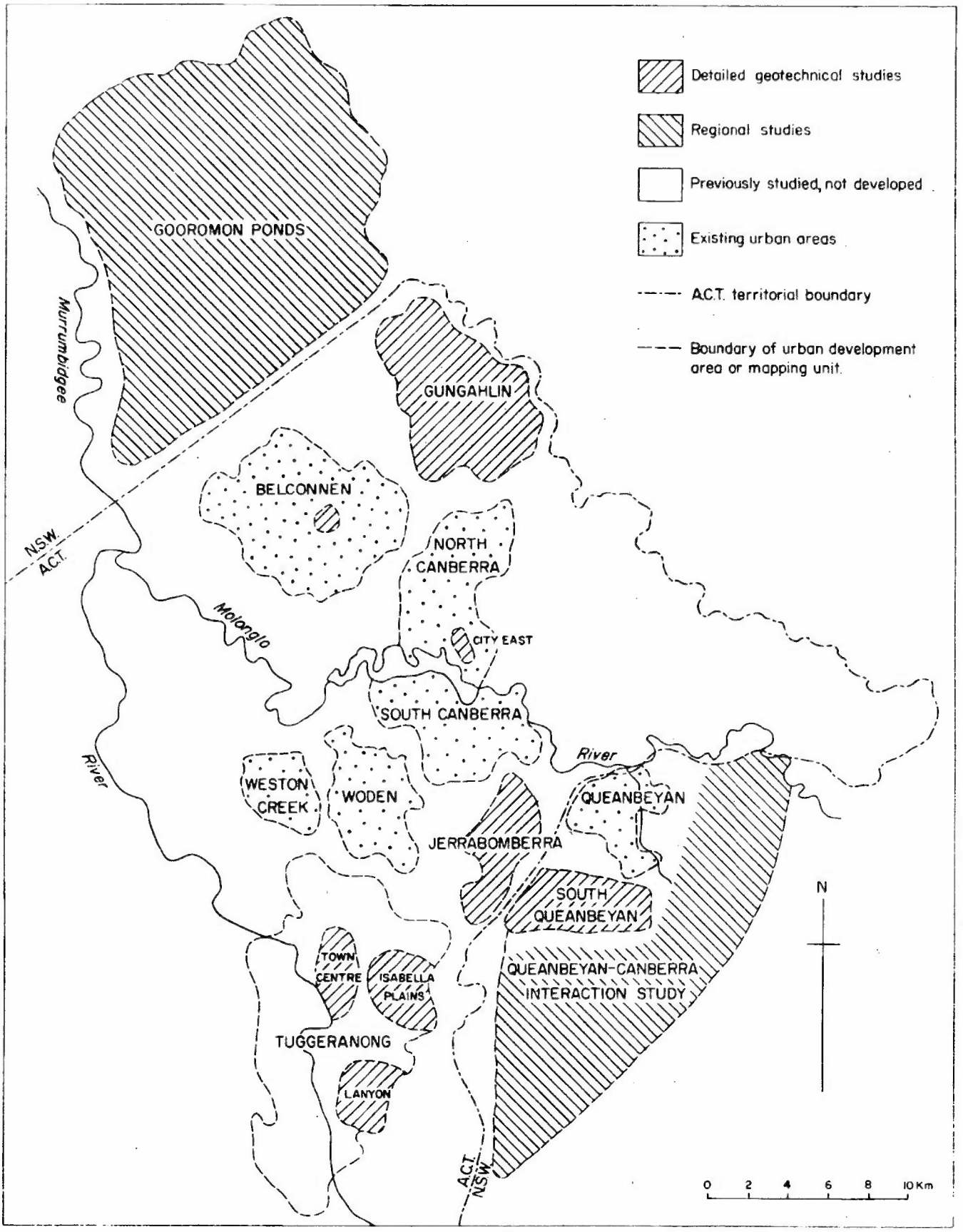

Fig GS 2 Geological studies for urban development planning, 1974. A.C.T. and Environs

Record 1974/127

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of the Canberra urban area were formulated. 1:10 000 scale base maps issued in a preliminary form by the Department of Services and Property were used to compile data on newly issued sheets of North and South Canberra, and the geological interpretation of data previously compiled on sheets covering the Woden and Belconnen areas was added to and amended. Compilation of one sheet - Coppins Crossing area - is complete and five other sheets are in various stages of compilation. Mapping of building and pipeline excavations continued throughout the year; particular attention was given to Belconnen Area 2, where the stratigraphic relationships between Ordovician, Lower and Middle to Upper Silurian formations were revealed. Other excavations mapped included the Calvary Hospital site at Belconnen, the National Gallery site and a building site in Brisbane Avenue, Barton.

WODEN-WESTON CREEK

A report on the geology of the Woden-Weston Creek area was edited and amended. Further amendments are now required to take into account the results of mapping in the Cooromon Ponds area, and in the Uriarra area which is being mapped by the Tantangara Field Party.

A report was prepared for NCDC on the engineering geology of O'Malley and the northern part of the suburb of Stirling. A report was also prepared on a 1973 soil augering investigation of the proposed suburb of Isaacs.

TUGGERANONG

Geological mapping and soils augering of the Tuggeranong town centre were completed by P.H. Vanden Brook, and a report on the engineering geology of the town centre was compiled. The town centre area is mainly underlain by rhyodacite; weathering of rock is irregular in depth and varies laterally.

GUNGAHLIN

A report on the engineering geology of the proposed new town of Gungahlin was completed by P.D. Hohnen. Gungahlin will be in the most northern part of the ACT and is expected to house 100 000 people in the 1980's. A series of thematic maps at 1:25 000 scale was prepared; these cover the geology, superficial deposits, natural resources, hydrology and design constraints and are being used by the town planners. The main geological features relevant to development planning of Gungahlin are the occurrence of some poorly drained areas with a high water table; soils of poor bearing strength; certain areas where hard rock would make deep excavations costly; and some potential sources of construction materials, including brick shale.

QUEANBEYAN

A preliminary geological and soils investigation of an area south of Queanbeyan proposed for urban development was undertaken by J.P. Caplecha, at the request of the Queanbeyan City Council. Design constraints for urban planning include the occurrence of some hard rock outcrops requiring blasting for excavation; some talus slopes with poor foundation and stability characteristics; and some saturated soils requiring drainage.

A more comprehensive review of the engineering geology of Queanbeyan and its environs began late in the year in connection with a planning study by NCDC of the future interaction of the Queanbeyan and Canberra population centres.

JERRABOMBERRA INDUSTRIAL ESTATE

A soils augering program was carried out by P.D. Hohnen in the area of the proposed Jerrabomberra Industrial Estate. Transported and residual soils up to 5 metres thick overlie weathered Silurian rocks. Groundwater aquifers were intersected in the soils and in fractured rock. Some poorly drained alluvial areas will require remedial drainage works before building construction starts.

GOOROMON PONDS

An area of about 285 sq. km adjacent to the northwestern border of the ACT, known as the Gooromon Ponds area, was mapped between December 1973 and February 1974, with the aid of University vacation students and an Indonesian Colombo Plan geologist. The mapping was done as part of a geological study of the Canberra region for development planning purposes. The mapping also resulted in some useful information on which to base correlations between the Canberra and Yass stratigraphic successions. A short preliminary report was prepared.

OTHER URBAN GEOLOGY STUDIES by P.H. Vanden Broek and G. Jacobson

ALBURY WODONGA

Liaison was maintained on behalf of Cities Commission and the Albury-Wodonga Development Corporation with the NSW and Victorian Geological Surveys which are doing most of the geological investigations for Albury-Wodonga. Soils augering was undertaken by the State Surveys in proposed development areas, and comprehensive reports on the environmental geology were produced by them. Augering specifications were prepared by BMR. Several visits were made to the area by Bureau officers.

HOLSWORTHY, NSW

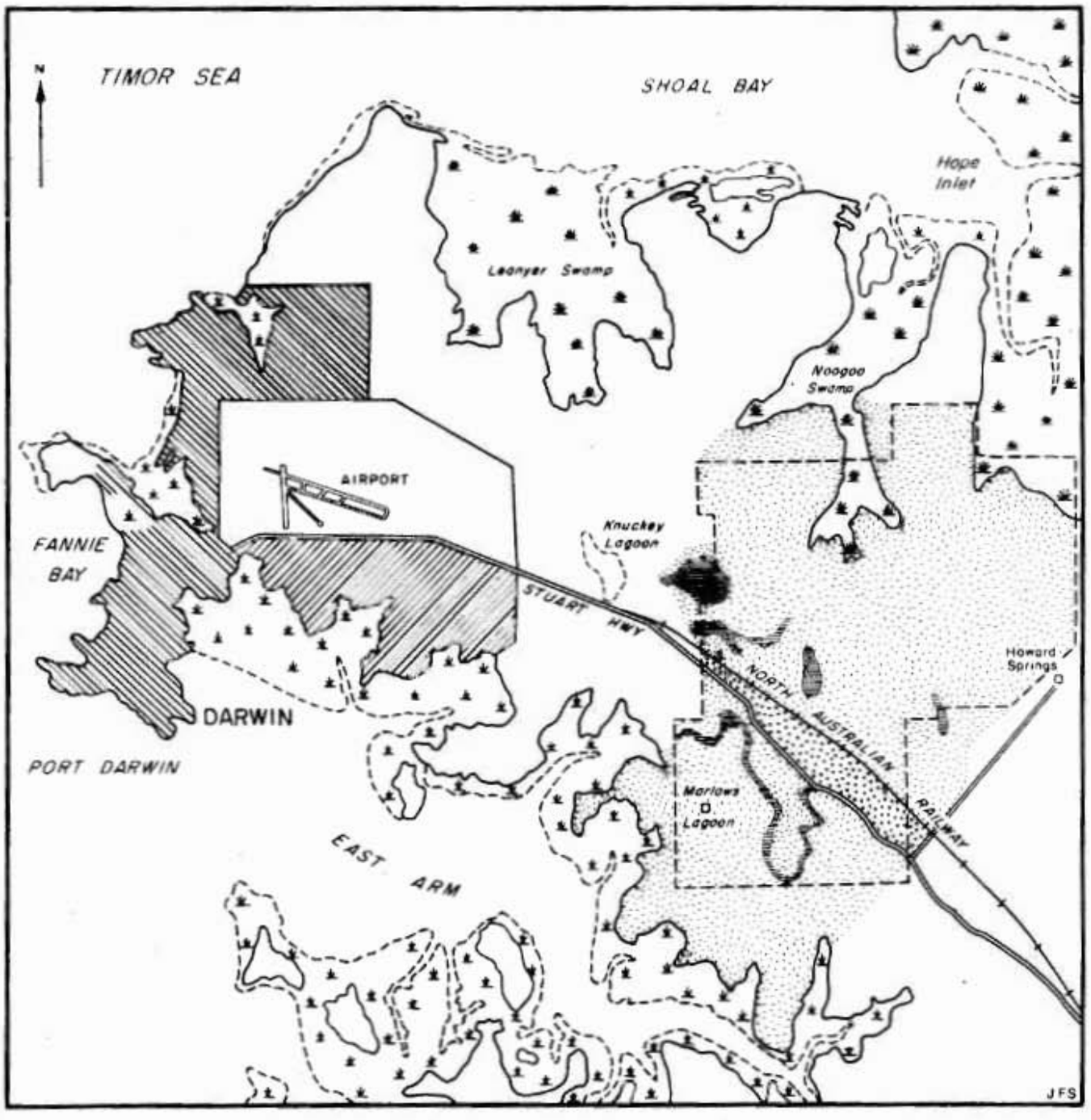
On behalf of the Cities Commission, liaison was maintained with the NSW Geological Survey who are doing the geological investigations of Holsworthy, NSW for proposed urban development. Bureau officers inspected the area.

DARWIN EAST, NT.

At the request of the Cities Commission and in collaboration with the Mines Branch, Department of the Northern Territory, a broad geotechnical study was made of the 80 km^2 acquisition area, known as the Darwin East development area. Its relation to the existing city of Darwin is shown in Figure GS 3.

The geology of the area was mapped at 1:25 000 scale and 14 drillholes were sunk in areas of poor exposure. Over much of the area Lower Cretaceous Mullaman Beds unconformably overlie Lower Proterozoic rocks of the Golden Dyke Formation, which forms part of the Goodparla Group. Many previously unknown exposures of silicified dolomite, silicified shale breccia, quartzite and siltstone have been located.

Soil types were mapped in detail in the central part, and on a reconnaissance scale over the remainder of the area. Soil types are less



Record 1974/127 Fig GS 3 Darwin East Urban Development Study D52/A4/142

complex than previously thought, and soils on the central plateau area are essentially the same as those that occur in the lower-lying coastal plain areas. The main soils are skeletal soils; thin lateritic red earths; lateritic red earths; colluvial gravelly sands and silts; silty and fine sandy drainage soils; and sandy soils. Heavy clay cracking soils occur in the coastal estuarine swamplands.

A general appraisal of groundwater conditions was made and one hundred piezometers were installed and monitored. The Water Resources Branch of the Department of the Northern Territory is continuing to record water levels on a monthly basis. Further groundwater studies are continuing.

Specific geological problems relating to the urban development of the area were reviewed. These included the occurrence of seepage water at the base of the Mullaman Beds; the drainage of perched swamps in the central part of the area; and the practicability of landscape treatment of Marlows Lagoon. Most of these problems are soluble but will involve the developer in additional expense.

Some recommendations have been made to the Cities Commission regarding various problems, and three progress reports have been prepared; a detailed report covering the entire investigation is in preparation.

MISCELLANEOUS

E.G. Wilson attended the Second Congress of Engineering Geologists in Brazil in August, and the Third Congress on Rock Mechanics in USA in September; he also visited offices of the US Geological Survey engaged in environmental studies in Washington, DC, Long Island, Pittsburgh and San Francisco.

P.D. Hohnen attended the Groundwater and Engineering Hydrology Course at the University of NSW from August to October, and G. Jacobson attended an ERTS interpretation course. G. Briscoe and P. Lang attended an Engineering geology one-week course at the ANU, G. Anderson and A. Schuett attended a well-drilling course.

MAP EDITING AND COMPILATION

by

G.W. D'Addario and W.D. Palfreyman

STAFF: G.W. D'Addario, W.D. Palfreyman, D.E. Gardner, J.S. Morlock (from 4 March to 2 October), J.M. Wedgbrow

GENERAL

Map Committee meetings were held on 6 November and 20 June. G.W. D'Addario attended a meeting of the ADP group; drafted a report on the Oceania section activities for the plenary meeting of the Commission of the International Map of the World; prepared notes on colour schemes for special and 1:100 000 scale maps for the Chief Geologists' Conference; and attended a meeting on topographic contouring from digital display models held by the Automated Cartography Study Group. W.D. Palfreyman generally supervised the Stratigraphic Index/Technical File/Mineral Reports group; he attended a meeting to consider ADP applications; supervised BMR and Colombo Plan geologists in short map compilation and editing courses and gave assistance to the Secretary General, IGC. He also proof-read Bulletin 148 (PNG Mineral Deposits).

Advice was given to authors on aspects of map and reference compilation. Some assistance was given to various sections in preparation for Open Day.

EDITING

Two special maps and nineteen 1:250 000 scale maps were edited. The editing of one special map, six 1:250 000 and two 1:100 000 scale maps is in progress.

Author's Corrections (J.M. Wedgbrow)

Corrections were made to seven maps and colour guides were made for three maps. Assistance was given in the production of draft references for several 1:100 000 scale Preliminary maps.

COMPILATION

Papua New Guinea Mineral Deposits Map, 1:2 500 000 Scale
(D.J. & R.L. Grainger, W.D. Palfreyman)

The map was printed in October 1973; the notes were proofed and are now at the printers.

Geological Map of the Northern Territory, 1:2 500 000 scale
(G.W. D'Addario)

The Preliminary Edition was printed at the end of October. Author's corrections and the Cainozoic cover overprint for the First Edition were completed. Tenders have been called for fair drawing the map.

Map of the Cainozoic of the Northern Territory, 1:2 500 000 scale (G.W. D'Addario)

Compilation was completed; the map awaits the calling of fair drawing tenders.

Geological Map of Australia, 1:2 500 000 scale (W.D. Palfreyman, G.W. D'Addario, and E.K. Carter)

A draft of the reference was completed and reductions to 1:2 500 000 scale made of all states except Western Australia. A draft of the reference for Western Australia was commenced.

Marginal Maps to Accompany the Geological Map of Australia (G.W. D'Addario, J.S. Morlock and J.W. Wedgbrow)

Small scale marginal maps were selected and compilation commenced.

Geological Map of Papua New Guinea, 1:2 500 000 scale (G.W. D'Addario and D.B. Dow)

The 1:1 000 000 scale map was reduced to 1:2 500 000 scale and the results from more recent mapping incorporated. A draft of the reference was prepared. Colour guides and cross sections were completed and edited. Work commenced on the description to accompany each map unit.

INDEXES, TECHNICAL AND MINERAL REPORTS

by

K. Modrak and N.D. Knight

STAFF: J.A. Ingram (transferred to the Batchelor field party, June), B. Hall (resigned February), K. Modrak (full-time from March, part-time prior to then), N.D. Knight, L. Kay (CA4, from January), L. Walraven (from March), M. Shackleton (until December 1973).

Administrative supervision of the group was provided by W.D. Palfreyman.

STRATIGRAPHIC INDEX

Literature received in the Bureau Library was indexed for stratigraphic names. The publications were indexed under the headings of author, 1:250 000 Sheet areas, Basin names and broad subject headings. Copies of the index cards, as required, were sent to the Library (BMR), State Geological Surveys and the Basin Study Group (BMR).

New names encountered during indexing were added to the Central Register of Stratigraphic Names and all references to previously published names were noted in the card index. Both the Register and the Index are maintained by the Stratigraphic Indexing group.

Bimonthly variation lists, giving the additions to the Central Register, were compiled and sent to State Geological Surveys, Universities and interested companies.

Inquiries, and visits, from authors, State Survey officers and authors regarding various aspects of stratigraphic names, definitions and literature references were received and answered.

The indexing of papers to be published by the Australian Institute of Mining and Metallurgy in the four-volume "Economic Geology of Australia and Papua New Guinea" is virtually complete.

The first proofs of the manuscript of Volume 5H - Australia, General - of the International Stratigraphic Lexicon were received, corrected by proof readers and returned to Paris.

Mr Modrak attended the Conference on "Information for Engineering and the Sciences" in Sydney July 18-19 and a Basic Fortran Course in Canberra June 24 to July 5.

TECHNICAL FILES

Work continued on the indexing of unpublished data and newspaper clippings. Searching for technical information of all BMR files in Archives was completed. The material extracted was indexed, and this material together with all other indexed information was filed under 1:250 000 Sheet areas. Use was made of these files to answer many technical enquiries from Bureau officers and visitors.

MINERAL INDEX

Typing and checking of the pre-1950 mineral index was completed.

This will be published as soon as the final format is decided.

The bibliographic index to current literature on mineral deposits (arranged by commodity and State) and a card index of major mineral deposits were maintained throughout the year.

MINERAL REPORTS

The mineral resources report on uranium deposits was sent to the printers and the report on tin deposits completed and submitted for editing. The report on molybdenum deposits is nearly complete and one on tungsten deposits is being prepared. These reports are compiled with the co-operation of State Mines Departments and mining companies and in collaboration with the officers of Mineral Resources Branch.

Work began on a joint project with Mineral Resources Branch on the assessment of the base metals (Cu, Pb and Zn) in Australia. The Geological Branch contribution will be a compilation of data on a geological province basis and will include a qualitative discussion of the base metal potential of each province.

MUSEUM AND TRANSIT ROOM

by

D.H. McColl

MUSEUM

STAFF: D.H. McColl, G. Young (until August), J. Reid, J. Falla (temporary until July), G. Sparksman (trainee Technical Officer from February).

Collections and Displays

The major event this year was the acquisition of the mineral collection made by Reverend A.E. Gardner of Sydney. It consists of 1284 superb examples of mineral and ore specimens selected for perfection of form and crystallisation from famous Australian and world localities over a period of about 30 years. The specimens are uniformly sized in the miniature range (3 to 6 centimetres average diameter). Catalogue and other data relevant to this collection have been added to the automatic processing system which is progressively being extended to cover all the museum reference collections.

Over 1000 other specimens have also been added to the collections this year, partly as a result of field excursions by Museum staff to North Queensland and Broken Hill and partly by donations, exchanges and purchase. The most notable organisation of the latter category was the purchase of an extremely rich piece of gold-quartz ore weighing 1.6 kg which came from the historic Fraser Mine in the Yilgarn Goldfield of West Australia.

Special new displays were prepared for the BMR Open Days in May, the Canberra Gem Society in October, Narrabundah High School in February, and others from time to time around the building. Assistance was also given to the Australian Exhibit Organisation for the gem display at Expo '74 in Spokane, Washington, USA, the National Museums Secretariat in relation to gold mining artifacts, and the Department of Overseas Trade in relation to a mineral specimen gift for China.

Amongst the new collections added to the museum during the current year are the following:

Sulphide minerals and host rocks donated by Cobar Mines Ltd

Sulphide copper Minerals donated by Gunpowder Copper Ltd

Polished slabs of semiprecious gemstone donated by The Crystal Cave Ltd

A display of polished South Australian jade loaned by Jade Australia

Oxidised ores from Broken Hill collected by courtesy of South Mine (MMM) Ltd

Wolfram Camp mineralisation collected by courtesy of Mount Arthur Molybdenum NL and Mines Exploration NL.

A new shortwave ultraviolet fluorescent display case was built and put into operation this year. Arrangements are also functioning to provide a series of displays for the Sydney Regional Office of the Department of Minerals and Energy.

Education and Services to Schools

The set of rocks and ores kept for public displays has been in virtually continuous use throughout the year in varying arrangements for visiting school groups. Fifteen such classes visited the museum this year usually in small groups having a specialised interest in some topic within the earth sciences.

Assistance was also given to the Australian National University, the Canberra Science Teachers Association, The Canberra Technical College and the Canberra College of Advance Education in respect to various projects involving geology. Interested persons and groups from various Embassies in Canberra were also catered for.

Exchanges and Loans

Mineral and rock exchanges have increased during the current year as the museum now has a wider range of duplicates to offer which have been collected on field trips or sorted from older bulk material. It is estimated that specimens with a current market value of over $2,000 were added to our collections this year by trading with other individuals, companies and institutions.

Loans of material have been in less demand than previous years but we are able to respond to requests from several universities, museums and a college.

Field Work

D. McColl visited Broken Hill in March to collect from the open-cut firm which oxidized lode material is being mined by South Mine (MMM) Ltd; collecting proved too difficult at this stage of development. D. McColl and J. Reid visited North Queensland in August to collect specimen material from the mining fields of Wolfram Camp, Agate Creek and Mount Surprise. A good range of specimens and photographs were obtained from each, with minor collections from the Mt Isa-Cloncurry and Windorah districts. Visits to further museum interests were also made to Sydney, Brisbane, Coolangatta and Cairns.

G. Young was engaged for six weeks in June-July collecting Devonian fish fossils from several horizons in the Dulcie Sandstone, Georgina Basin, Northern Territory.

Visitors to the Museum

The museum has continued to provide, where facilities permit, the services of an earth science museum for visitors and the general public. Apart from organised school groups, other students and persons of all ages have brought specimens to be identified and made enquiries about the local geology. Gemmological questions continue to be common indicating the lack of qualified information services within this field in Canberra. The total number of visitors was 492, excluding organised school groups and Bureau personnel.

Commonwealth Palaeontological Collection

This now comprises 14,669 specimens with allocation of an additional 328 numbers for microfossils and 518 for macrofossils in the current year. Approximately 13,000 of these type or figured specimens are estimated to be presently housed in the systematic security storage.

TRANSIT ROOM

Survey and other samples requiring petrological, petrographic, chemical or other research investigations are forwarded to contractors or relevant Bureau laboratories by the officer-in-charge (G. Nolan). Incoming results are now being abstracted for inclusion in the proposed Bureau sample data storage and retrieval system, which is not yet operational.

The total number of samples processed was 10,003, which are made up of the following classifications.

Thin section preparations (unconsolidated)	- 35
Thin section preparations (normal)	- 4,406
Polished section preparations	- 18
Polished thin section preparations	- 323
Radio isotope age determinations (various)	- 176
Chemical analyses (various)	- 3,953
Palaeontological sectioning and other investigations	- 1,092

Systematic storage and cataloguing of the petrological thin section collection has been continued so that there are now 14,000 microscope slides available for intermittent loans to allied institutions.

GEOLOGICAL DRAWING OFFICE

by

H.F. Boltz and P.A. Boekenstein

GENERAL

H.F. Boltz and P.A. Boekenstein attended the 6th Conference of Chief Draftsmen of States Mines Departments and the Bureau of Mineral Resources, held at Melbourne in March 1974. Developments in thematic mapping, including the progress of automation in cartography and the availability of geological cartographic data, were discussed.

H.F. Boltz attended 9 meetings of the AGPS-BMR Committee. This committee was formed in 1974 to coordinate the printing of BMR maps and publications processed by the AGPS. He also attended two meetings of the Cartography Advistory Committee which culminated in the acceptance of the proposed Undergraduate Course in Cartography to be conducted at the Canberra College of Advanced Education.

H.F. Boltz and E.H. Feeken attended the first Cartographic Conference held by the Australian Insitute of Cartographers at Sydney in October 1974. E.H. Feeken delivered a paper entitled "The Use of Colour in Thematic Mapping".

Two draftsmen worked in the field as members of geological field parties. P. Blythe, Tantangara and Georgetown parties; M. Little, Cloncurry party. J. Mifsud was temporarily transferred to the Darwin office to replace P. Fuchs who was on furlough.

J.M. Fetherston (Senior Draftsman) visited BMR geological field parties at Batchelor, Cloncurry and Georgetown in a supervisory and advisory capacity and to check compilation and drafting progress. He also visited the Darwin Office where he checked material compiled during the year and arranged drafting schedules for the remainder of the 1974-75 year.

J. Zawartko, (Photographer-in-Charge) visited field parties in the Alice Springs and Mt Isa areas to continue the photographic record of BMR field activities.

PRODUCTION

STAFF: Supervising Draftsmen: M. Nancarrow, K. Matveev, H. Hennig, R. Molloy

MAPS	1:100 000	1:250 000	Other Scales
(a) Preliminary Edition			
Compilation by BMR in progress	5	5	1
Compilation by BMR completed (ready for printing)	1	1	-
Preliminary Edition printed	4	24	2

	1:100 000	1:250 000	Other Scales
(b) 1st or 2nd Editions			
Fair drawing in progress ((a) BMR; (b) Contract*)	-	12(b)	2(a)
Fair drawing completed ((a) BMR (b) Contract*)	-	10(b)	4(a), 2(b)
Printing** in progress ((a) BMR, (b) GSWA)	-	8(i), 3(ii)	4
Printing** completed ((a) BMR, (b) GSWA)	-	18(i), 5(ii)	7
Reprinting	-	5	-

Notes: *Contract drafting stages over period: Geological Drawing Office prepares specifications (24 maps); recommends contractor (19 maps); checks first proof (16 maps); checks second proof (13 maps).
**Printing stages over period - (a) BMR maps: Geological Drawing Office prepares specifications (20 maps); prepares colour designs and colour guides (20 maps); supervises performance as required; checks screen masters and dyeproofs (21 maps); checks machine proofs (19 maps); checks printed map (25 maps).
GSWA maps: Geological Drawing Office prepares specifications; supervises performance and checks proofs as required.

FIELD COMPILATIONS

All scales: 31 completed

TEXT FIGURES, DIAGRAMS AND PLATES:	Completed	In Progress
(a) Records and miscellaneous	1297	110
(b) Reports	147	3
(c) Explanatory Notes	46	2
(d) Bulletins	250	64
(e) Outside publications	31	-

COMPLETION OF PICTORIAL INDEX OF ACTIVITIES

The first three maps in the 1:1 000 000 Marine Geology Series, Rowley Shoals, Scott Reef and Arafura Sea were published. Two more Sheets, Timor Sea and Capricorn Channel are being printed.

Compilation was commenced of the 1:2500 000 Geological Map of Australia and compilation of the 1:2500 000 Geological Map of Papua New Guinea was completed. Both maps are scheduled to be published in time to be released at the International Geological Congress to be held at Sydney in August 1976.

Investigations began on the use of computers to produce linework for Preliminary geological maps, and the specification sheets for lettering and symbols on text figures and diagrams were revised.

The Geological Drawing Office played a major role in preparing exhibits for BMR "open days". Several wall displays depicting 1:250 000 and 1:100 000 scale geological mapping, ERTS, radar and thermal imagery, and SKYLAB missions have become permanent displays in the BMR.

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)

* indicates that the status of the publication is in the second of the categories listed in the heading.

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 Geobiological 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*

121	OPIK, A.A.	Templetonian and Ordian Xystridurid Trilobites of Australia.
139	[1]PLUMB, K.A. [1]BROWN, M.C.	Revised correlations and stratigraphic nomenclature in the Proterozoic carbonate complex of the McArthur Group, Northern Territory.
148	[1]GRAINGER, D.J. [1]GRAINGER, R.L.	Explanatory Notes on the 1:2 500 000 Mineral Deposits Map of Papua New Guinea.
*150	BELFORD, D.J.	Foraminifera from the Nassau Range, Illaga Valley, Irian Jaya.
	BURGER, D.	Palynology of subsurface Cretaceous strata in the Surat Basin, Queensland.
	SKWARKO, S.K.	Marine Triassic molluscs of Australia and Papua New Guinea.
	SKWARKO, S.K.	Jurassic fossils of Western Australia, 1: Bajocian Bivalvia of the Newmarracarra Limestone and Kojarena Sandstone.
	SKWARKO, S.K.	Some Ordovician graptolites from Canning Basin, W.A. Pt. 2. Graptolites from the Goldwyer No. 1 Well.
*151	NORVICK, M.A. BURGER, D.	Palynology of the Cenomanian of 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.
156A	[4]JONES, P.J. [4]CAMPBELL, K.S.W. [1]ROBERTS, J.	Correlation chart for the Carboniferous System of Australia.
*158	DRUCE, E.C.	Conodont biostratigraphy of the Upper Devonian Reef Complexes of the Canning Basin, Western Australia.

*159	ÖPIK, A.A.	Cymbric Vale Fauna
*160	BURGER, D.	Some Early Cretaceous plant microfossils from Queensland, Australia.
	KEMP, ELIZABETH M.	Palynological observations in the Officer Basin, Western Australia.

BULLETINS

IN PREPARATION

BURGER, D.	Palynological studies in the Great Artesian Basin, Australia. Pt. 1: Early Cretaceous, Surat Basin, Queensland.
BURGER, D.	Tertiary pollen grains from the Ngalia Basin, Northern Territory.
COOK, P.J. MAYO, W.	Sedimentology and Holocene history of a tropical estuary (Broad Sound, Queensland).
DICKINS, J.M.	A correlation chart for the Permian System in Australia.
EXON, N.F.	The geology of the Surat Basin in Queensland.
MARSHALL, J.F.	Marine geology of the Capricorn Channel area.
PAGE, R.W.	Geochronology of the igneous and metamorphic rocks in the New Guinea region.
[4]REINSON, G.E.	Sedimentology and geochemistry of a temperate estuary (Mallacoota Inlet, Victoria).
SENIOR, B.R.	Notes on the geology of the central part of the Eromanga Basin.
SENIOR, B.R. HARRISON, P.L. MOND, A.	Notes on the geology of the northern part of the Eromanga Basin.
SHERATON, J.W. LABONNE, B.	Petrology and geochemistry of acid igneous rocks of northeast Queensland.
[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.

REPORTS

PUBLISHED OR IN PRESS*

*	140	[2]EXON, N.F. [2]REISER, R.P. [2]CASEY, D.J. [2]BRUNKER, R.L.	The Post-Palaeozoic rocks of the Warwick Sheet area.
*	152	[1]GELLATLY, D.C. DERRICK, G.M. PLUMB, K.A.	Geology of the Lansdowne 1:250 000 Sheet area, W.A.
*	153	[1]GELLATLY, D.C. [2]SOFOULIS, J. DERRICK, G.M. [1]MORGAN, C.M.	The older Precambrian geology of the Lennard River 1:250 000 Sheet area, W.A.
	154	[1]GELLATLY, D.C. DERRICK, G.M. [2]SOFOULIS, J. [2]HALLIGAN, R.A.	Geology of the Charnley 1:250 000 Sheet area, W.A.
	161	SWEET, I.P. PONTIFEX, I.R. MORGAN, C.M.	The Geology of the Auvergne 1:250 000 Sheet area, Northern Territory (excluding Bonaparte Gulf Basin).
*	162	[1]BENNETT, R. PAGE, R.W. BLADON, G.M.	Catalogue of isotopic age determinations carried out on Australian rocks, 1966-70.
	166	SWEET, I.P. MENDUM, J.R. MORGAN, CM. PONTIFEX, I.R.	The Geology of the Northern Victoria River Region, Northern Territory.
*	167	SWEET, I.P. MENDUM, J.R. BULTITUDE, R.J. MORGAN, C.M.	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 1:250 000 Sheet areas, Northern Territory.

MINERAL RESOURCES REPORTS

6	INGRAM, J.A.	Uranium Deposits
7	INGRAM, J.A.	Tin Deposits

BMR PAMPHLET

TOWNLEY, K.A. VERVERS, J.J. Revised by STRUSZ, D.L.	Rocks and Fossils Around Canberra. 2nd edition.

REPORTS

IN PREPARATION

BLAKE, D.H. HODGSON, I.M.	Geology of the Highland Rocks, The Granites, and Precambrian parts of the Billiluna, Lucas, and Stansmore 1:250 000 Sheet areas, Northern Territory and Western Australia.
EXON, N.F. MORRISSEY, JEAN	Wireline logging of water-bores in the Surat Basin, 1960 to 1974.
HOHNEN, P.D.	Geology of New Ireland, PNG.
STEWART, A.J.	Petrographic and geochemical study of the Ringwood evaporite deposit.

OUTSIDE PUBLICATIONS

PUBLISHED OR IN PRESS*

[2]ABELE, C. PAGE, R.W.	Stratigraphic and isotopic ages of Tertiary basalts at Maude and Airey's Inlet, Victoria, Australia.	Proc. Roy. Soc. Vict., v.86, 143-150, 1974.
[4]ADAMS, C.G. BELFORD, D.J.	Foraminiferal biostratigraphy of the Oligocene/Miocene limestones of Christmas Island, Indian Ocean.	Palaeontology, 17(3).
ANFILOFF, W. SHAW, R.D.	The gravity effects of three large uplifted granulite blocks in separate Australian Shield areas.	Proc. Symposium on Earth's Gravitational Field and Secular Variations in Position (1973), 273-289. School of Surveying, Univ. N.S.W., Sydney.
[4]ARMSTRONG, R.L. STEWART, A.J.	Rubidium-strontium dates and anomalous argon in the Arltunga Nappe Complex, N.T.	J. geol. Soc. Aust.*
BLAKE, D.H.	An analysis of metal distribution and zoning in the Herberton tinfield, north Queensland, Australia (discussion).	Econ. Geol. 69, 557-60, 1974.
BLAKE, D.H. [4]EWART, A.	Petrography and geochemistry of the Cape Hoskins volcanoes, New Britain, Papua New Guinea.	J. geol. Soc. Aust. 21, 3, 1974, pp 319-332.
BLAKE, D.H. HODGSON, I.M.	The Precambrian Granites-Tanami Block and Birrindudu Basin - geology and mineralization.	In Economic Geology of Australia and Papua New Guinea; AIMM ed. C.L. Knight*
[3]BUBELA, B.	Effect of copper on the growth characteristics of Bacillus stearothermophilus.	Zentralblatt für Bakteriologie, 1973, 128, 274-284.
[3]BUBELA, B. FERGUSON, J.	Apparatus for studies of artificial sediments.	J. Sed. Pet., 1973, 43, 1167-1170.
[3]BUBELA, B. FERGUSON, J. DAVIES, P.J.	Biological and abiological processes in a simulated sedimentary system.	J. geol. Soc. Aust.*
[3]BUBELA, B. POWELL, T.G.	Effect of copper on the composition of bacterial cell wall peptides.	Zentralblatt für Bakteriologie, 1973, 128, 457-466.
[2]BUNTING, J.A. [2]VAN DE GRAAFF, W.J.E. JACKSON, M.J.	Palaeodrainages and Cainozoic palaeogeography of the Eastern Goldfields, Gibson Desert and Great Victoria Desert, Western Australia.	Ann. Rep. W. Aust. Geol. Surv. 1973.

BURGER, D.	Spore zonation and sedimentary history of the Neocomian, Great Artesian Basin, Queensland.	Geol. Soc. Aust. Spec. Publ. 4, 87-118.
[5]CHILDS, C.W. [3]DOWNES, C.J. [5]PLATFORD, R.F.	Thermodynamics of multi-component electrolyte solutions: aqueous mixtures of two salts from among NaCl, KCl, NaH_2PO_4, and KH_2PO_4, at 25°C.	J. Solution Chemistry 1974, 3, 139.
CLEMENS, W.A. PLANE, M.	Mid Tertiary Thylacoleonidae (Marsupialia, Mammalia).	Jour. Paleontology, July 1974.
COOK, P.J.	Geochemistry and diagenesis of interstitial fluids and associated calcareous oozes, DSDP site 262, Timor Trough.	In Initial Reports of the Deep Sea Drilling Project. Scripps Institution of Oceanography.*
COOK, P.J.	Major and trace element geochemistry of sediments from Deep Sea Drilling Project Leg 27, sites 259 to 263, Eastern Indian Ocean.	In Initial reports of the Deep Sea Drilling Project. Scripps Institution of Oceanography.*
COOK, P.J.	Regional geology of the phosphogenic province of the Georgina Basin.	In Economic geology of Australia and Papua New Guinea. C.L. Knight (Ed.). Aust. Inst. Mining Met.*
COOK, P.J.	Sedimentary phosphate deposits.	In K.H. Wolf (Ed.) Sedimentary ore deposits. Elsevier, Amsterdam.*
COOK, P.J.	The supratidal environment and geochemistry of Recent dolomite concretions, Broad Sound, Queensland.	Jour. Sed. Petrol. 43(4), 998-1011.
COOK, P.J.	The distribution of phosphorus at DSDP sites 259 to 263.	In Initial Reports of the Deep Sea Drilling Project. Scripps Institution of Oceanography.*
[2]COOPER, R.A. DRUCE, E.C.	The Lower Ordovician sequence at Mount Patriarch, West Nelson, New Zealand.	N.Z.J. Geol. Geophys.*
[5]CREEVY, P. [3]DONNELLY, T.H.	Sulphur isotope study of six copper sulphide occurrences at Pernatty Lagoon, South Australia.	Econ. Geol.*
DAVIES, P.J.	Arsenic on the continental shelf of southeast Australia.	Search, (8), p.394-397.
[3]DAVIES, P.J. [3]BUBELA, B.	The transformation of nesquehonite into hydromagnesite.	Chem. Geol., 1973, 12, 289-200.

DAVIES, P.J. MARSHALL, J.F.	High magnesium calcite ooids from the Great Barrier Reef.	Journal Sedim. Petrol.*
DERRICK, G.M.	Stratigraphic and palaeogeographic evolution and revolution in the Mount Isa area.	AIMM Northwest Queensland Branch Conference Proceedings, 1974.
DODSON, R.G. NEEDHAM, R.S. WILKES, P.G. PAGE, R.W. SMART, P.G. [1]WATCHMAN, A.L.	Uranium mineralization in the Rum Jungle-Alligator Rivers Province, Northern Territory, Australia.	IAEA Symp. on formation of uranium ore deposits. Athens, May, 1974.*
DODSON, R.G., PRICHARD, C.E.	Uranium in the Pine Creek Geosyncline.	In Economic Geology of Australia and Papua New Guinea; AIMM ed. C.L.Knight*
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SB55/5	Ramu	BAIN, J.H.C.* MACKENZIE, D.E.
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SB55/14	Wau	[1]DOW, D.B.* [1]SMIT, J.A.J. PAGE, R.W.
SB56 - 5 and 9	Talasea-Gasmata	RYBURN, R.J.*
SB56/6	Pomio	RYBURN, R.J.*
SC52/16 and SC53/13	Cobourg Peninsula/part Melville Island	SENIOR, B.R.* SMART, P.J.
SC52/3	Fog Bay	[1]SENIOR, Daniele* HUGHES, R.J.
SE51/3	Yampi	[1]GELLATLY, D.C.* [2]SOFOULIS, J.
SE52/3	Waterloo	SWEET, I.P.
SE52/4	Victoria River Downs	SWEET, I.P.
SE52/11	Birrindudu	BLAKE, D.H.*
SE52/15	Tanami	HODGSON, I.M.*
SF53/10	Alcoota	SHAW, R.D.* WARREN, R.G.
SF54/14	Jericho	[1]SENIOR, Daniele*
SG51/4	Warri	[2]VAN DE GRAAFF, W.J.E.
SG51/7	Herbert	KENNEWELL, P.J.*
SG52/1	Cobb	[2]VAN DE GRAAFF, W.J.E.*
SG54/2	Machattie	SENIOR, B.R.
SH51/4	Neale	[2]VAN DE GRAAFF, W.J.E.*
SH52/6	Mason	[2]VAN DE GRAAFF, W.J.E.*
SH56/1	Goondiwindi	[1]SENIOR, Daniele

EXPLANATORY NOTES AND MAPS

WITH EDITORS

SE54/8	Red River	SMART, J. BAIN, J.H.C.
SF51/4	Dummer	WYBORN, Lesley A.I.
SF52/3	The Granites	HODGSON, I.M.
SF52/6	Stansmore	BLAKE, D.H. YEATES, A.N.
SF52/8	Mount Theo	STEWART, A.J.
SG51/3	Madley	KENNEWELL, P.J.
SG51/8	Browne	JACKSON, M.J.
SH52/1	Vernon	[2]VAN DE GRAAFF, W.J.E.
SH52/2	Wanna	KENNEWELL, P.J.

SPECIAL MAPS

PUBLISHED OR IN PRESS*

1:2 500 000	Geology of the Kimberley to Mount Isa region, northern Australia.	PLUMB, K.A. DERRICK, G.M.

WITH EDITOR

1:2 500 000	Geology of Papua New Guinea.	DOW, D.B. D'ADDARIO, G.W.
1:100 000	Marraba 6956	DERRICK, G.M. HILL, R.M. MITCHELL, J.E. [2]GLIKSON, A.Y. WILSON, I.H.
1:100 000	Mary Kathleen 8856	DERRICK, G.M. HILL, R.M. MITCHELL, J.E. [2]GLIKSON, A.Y. [2]WILSON, I.H. [5]RUSSELL, R.E.

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