RECORD No. 1973/59

BMR SYMPOSIUM
CANBERRA, 22-23 MAY 1973
ABSTRACTS

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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TRENDS IN THE MINERAL INDUSTRY

L. C. Noakes

Trends in the mineral industry result from the interplay of many factors both domestic and overseas. Future trends of the industry in Australia seem unusually difficult to gauge in early 1973 because one most important domestic factor, that of Federal Government policy, is not yet clear, parities between world currencies are unstable and the mineral industry is responding to new pressures from the community at large.

One can only attempt at this stage to identify major trends in both domestic and overseas fields, consider the likely resultant of these factors on the domestic industry and suggest some likely future trends.

Domestic Trends

Some important trends in the industry seem clearly discernible in the events of the immediate past.

- Overseas funds, technology and market facilities have played an essential role in the industry's progress; but overseas funds - and the limited marshalling of domestic finance into the industry - have decreased Australia's equity and apparent control in the industry to the extent that a need for some stay or correction is widely accepted.
- Controversy over the market value of some of our mineral exports, ill-spent exploration money, and fraudulent practices during the boom argue for more and better controls.
- New pressures have arisen emphasizing conservation, preservation, control of pollution and mineral conservation; these pressures are inevitably placing constraints on the mineral industry which is moving from a position of relative isolation toward closer integration with other community interests.
- Recent currency adjustments and financial controls are new and potent factors; their effect in the short term has been drastic, particularly in the curtailment of exploration funds, but longer term effects are unpredictable except that some revaluation of the Australian dollar seems likely to persist and to decrease, to some extent, our competitiveness in world markets although hopefully to cheapen our imports.

In practice these trends suggest :

- Some decrease in exploration funds from overseas and postponement of some mineral development projects as a result of revaluation.
- More cumbersome administrative arrangements for exploration and mining to allow proper consideration of environmental factors - at least until guidelines and procedures are better established.

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- More effective marshalling of domestic finance into the mineral industry.

- Levels of Australian equity required will probably control the amount of funds available for exploration and development.

Overseas Trends

Rising world demand for minerals and concern about future supplies indicate a promising future for potential suppliers of mineral resources like Australia but,in the short term, most metals are not in short supply and Australia has active competitors in most major exports.

However, many overseas trends are encouraging: important factors include :

- Strengthening economies, particularly in Japan, Europe and USA, suggest that, despite revaluation of the Australian dollar, our exports of iron ore, coal and products of the aluminium industry, which currently provide 65% of our mineral exports, should increase in the 70's although probably not as fast as was recently expected.

- Prices and markets for copper and nickel seem encouraging for current or moderately increased levels of production.

- Uranium production and exports can be expected and gold mining is reviving.

- The market for zinc and mineral sands is improving (although those for lead, tin and tungsten cause concern).

- Many developed countries continue active interest in mineral exploration and development in Australia as a means of securing some equity in available mineral resources.

- Although levels of domestic processing of lead, nickel, copper, tin and bauxite to alumina remain fairly high or are improving, market patterns, finance, revaluation and costs are likely to prove short term restraints to the further processing of zinc, iron ore, alumina and titanium minerals.

Synthesis

Consideration of these various and, to some extent, contrary trends emphasizes a number of points :

- Overseas trends, by themselves, seem to set the stage for further major expansion of the Australian mineral industry in the 70's, reminiscent of that of the 60's, particularly for raw rather than processed materials - but at the risk of continued fall in Australian equity and apparent control.

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- However, domestic trends and events indicate slower and more deliberate development in the 70's in line with concern for Australian equity, better control and planning, currency adjustments, and with the need to compromise between the interests of the mining industry and those of the wider community.

- The most important single factor controlling the tempo of exploration and development seems likely to be the level of overseas participation induced or allowed to contribute funds, technology and markets.

Conclusions

The optimum pace at which the Australian mineral industry should proceed is of course a matter of judgment; however, the desirability of increased Australian equity and the need for realistic consideration of the environment have been well recognized by governments and industry in recent years. In a country as well endowed with mineral resources as Australia, planned and deliberate development of the mineral industry makes good sense provided the inevitable compromises, in relation to equity and the environment, are realistic and planning recognizes likely world trends in the fields of mineral supply, demand, substitution and technology.

POSSIBLE CORRELATIONS BETWEEN THE GRAVITY MAP OF AUSTRALIA AND MINERAL PROVINCES

B.C. Barlow

Most of Australia has been covered by reconnaissance or more detailed gravity surveys, and the remaining areas in the south east quadrant will be completed by the end of 1974. Throughout the last decade BMR has compiled the results of nearly all gravity surveys into successive editions of a Gravity Map of Australia (GMA), which shows Bouguer anomaly contours at a scale of 1 inch = 40 miles. This map is available either as a dyeline print or as a transparent overlay to the 1960 Tectonic Map of Australia (1 inch = 40 miles). Correlations between the GMA and this Tectonic Map can be seen only when the map and overlay are studied in detail. The correlations are not obvious to the eye because the main emphasis in the 1960 map is on structure and much of the tectonic information is only implied in the body of the map.

In 1971 a new Tectonic Map of Australia was produced at a scale of 1: 5 000 000 and a Metallogenic Map at the same scale was published in 1972. In these later maps, units delineated as tectonic domains have been recognised, classified as orogenic, transitional or cratonic, and are the basis for the colour scheme used in the body of maps. This tectonic framework is ideal for the description of metallogenesis. A transparent copy of the Gravity Map of Australia has been produced at a scale of 1: 5 000 000. When this GMA is overlain on either the new Tectonic or Metallogenic Map, correlations between the tectonic domains and gravity features are immediately obvious.

On a continental scale the gravity pattern in the eastern third of Australia is much less complex than the pattern over the western two-thirds or shield area of Australia. The boundary between these two regions is quite sharp in the northern half of Australia where it lies to the east and south of the Mt Isa Geosyncline. In the southern half of Australia the boundary is less clearly marked, and the gravity pattern gradually becomes less complex across the Gawler Block and Adelaide Geosyncline.

The gravity pattern over the Kimberley Block is monotonous and sharply contrasted against the complex linear pattern to the east and south of the block. In this area gravity indicates a stable craton flanked by a mobile belt.

In the south west quadrant of Western Australia, gravity indicates a number of stable cratons girdled by mobile belts. These features will be discussed in more detail by another speaker at this seminar.

In central Australia a succession of intense east-west gravity features overlie the Officer, southern and northern Amadeus and Ngalia Basins. These features can only partly be explained by the sediments of the various basins, and much of the gravity effect is due to structure in the deeper crust and upper mantle. Although this region is stable at present, strong north-south compression must have occurred in early orogenies.

GRAVITY FEATURES OF THE WEST AUSTRALIAN SHIELD

A.R. Fraser

Gravity surveys by the Bureau of Mineral Resources and private companies have covered the entire western part of the Australian Precambrian Shield and the adjoining basins, at a station density of at least 1 per 120 square kilometres. Bouguer anomaly contours show the distribution of the principal elements of the tectonic framework of the West Australian Shield and indicate that this framework differs in some significant respects from that proposed in previous literature.

An oval-shaped gravity province of disturbed contour pattern in the northwest of Western Australia corresponds to the Pilbara Nucleus which embraces both the exposed Archaean area known as the Pilbara Block, and most of the Lower Proterozoic Hamersley Basin adjoining it to the south. Broad elongate gravity ridges surrounding the Pilbara Nucleus are interpreted as the gravity expressions of Proterozoic mobile belts containing dense metamorphic rocks. One of these ridges extends southeastwards across the Canning Basin and is continuous with an east-trending gravity ridge coincident with the Musgrave Block, and with a southwest-trending gravity ridge which can be traced through basic granulite outcrops in the Fraser Range area to the south coast near Esperance.

A province of disturbed contour pattern to the southeast of the Fraser Range metamorphic belt is believed to represent a shield block partially buried beneath the Eucla Basin sediments. The name 'Eucla Block' is proposed for this element. Low Bouguer anomaly values to the east of the Eucla Block are attributed to low density rocks of the crystalline basement.

Gravity contours indicate that the Yilgarn Block extends beyond its exposed limit to form the basement of the adjacent parts of the Officer and Bangemall Basins. The block is flanked on all sides by elongate gravity depressions which relate to Phanerozoic sedimentary basins in the west, but elsewhere to mass deficiencies within the Precambrian sheild. A province of high gravity in the southwest corner of the block corresponds to an area in which a dense lower crustal layer is supposed to be unusually shallow.

The central part of the Yilgarn Block is divided into two gravity provinces along a sinuous line extending between Norseman and Wiluna. In the western province, intense residual highs are disjointed and predominantly north-trending, whereas in the eastern province, residual highs are longer, trend mainly north-northwest, and are of smaller amplitude and intensity. The boundary between the two gravity provinces may represent the westward limit of the main nickel province in Western Australia as known structural lineaments associated with nickel mineralization are all confined to the eastern side. The two gravity provinces are considered to represent discrete tectonic units within the Yilgarn Block - a cratonic nucleus to the west, comparable with the Pilbara Nucleus and a younger Archaean geosynclinal belt to the east.

The gravity field segments corresponding to the Pilbara Nucleus and the Yilgarn and Eucla Blocks are quite dissimilar in contour pattern, suggesting that the three cratons were widely separated at one time. Their present juxtaposition implies that plate tectonics was operative in the Proterozoic era. Mobile belts interposed between the cratons may therefore be basal remnants of Proterozoic geosynclines.

THE MOUNT ISA-CLONCURRY AREA; DETAILED MAPPING

G.M. Derrick

Participating Geologists: G. Derrick, R. Hill, A. Glikson, J. Mitchell, R. Page (BMR); I. Wilson (CSQ).

Introduction: In 1969 a programme of detailed regional mapping commenced in the Mt Isa-Cloncurry area, with the following aims:

1. Detailed mapping at 1:25 000 photoscale of Sheet areas noted below.

2. A detailed revision of stratigraphy and structure of these areas, including relations between the eastern and western "geosynclines".

3. Detailed appraisal of the economic geology of the region, including the relations between mineralization and metamorphism, types of mineralization, etc.

4. Reconstruction of the sedimentary and metamorphic history of the region.

5. Detailed geochemistry and more precise age determination of various rock units.

A strip has been mapped from just east of Cloncurry to just west of Mount Isa, and covers the 1:100 000 Sheets of Cloncurry, Marraba, Mary Kathleen and Mount Isa, a total area of 12,000 km^2 (Two-thirds of a 1:250 000 Sheet). It is intended to deal with some highlights of the geology of the area, and present, for the entire strip, a model of sedimentary, volcanic, tectonic and magmatic evolution.

Stratigraphy: Three fundamental stratigraphic divisions exist: a central crystalline basement "welt", and an Eastern and Western sedimentary-volcanic succession. (See Stratigraphic table attached). Taking past and future work into account, 4 new groups, 7 new formations, 8 new members and one redefinition have been proposed.

Highlights:

1. Creation of stratigraphic order in basement areas:

Three units occur in the basement areas; an older and younger acid volcanic suite, separated by an extrusive metabasalt which is extensive and an excellent marker bed. As well, a complete type section of the basement and Eastern successions has been recognized, and shows that thicknesses are generally much less than originally thought.

2. Origin of breccia in the Corella Formation

Thin bedded carbonates and impure quartzites of the Corella Formation are commonly brecciated. The breccia was formerly considered to be mainly sedimentary/diagenetic origin associated with fringe reefs and slumping. In the main we now think the breccia is of tectonic origin - it is confined to synclinal zones and faults, and is a product of preferential brecciation of certain beds during folding, together with extensive recrystallization and flowage of a carbonate matrix.

3. Origin of the Chumvale Breccia:

The origin, relationships and age of the Chumvale Breccia were not resolved by earlier workers. It is now thought to be a product of brecciation, carbonate leaching and silicification of the overhang jaspilite, a unit of iron-formation below the Corella Formation. The processes are similar to those forming Corella Formation breccia.

4. Stratigraphic Revision, Mt Isa area:

The current programme has confirmed many of the conclusions and allusions of Carter et al. An unconformity has been established between the Mt Guide Quartzite and the basement complex, and in some areas between the Mt Isa Group and Myally Beds. The Mingera Beds (Mt Isa Group equivalents) overlie the Sybella Granite and Judenan Beds unconformably, and, therefore, the Sybella Granite is possibly older than the Mt Isa Group. A rhyolite sequence has been recognized between the Judenan and Mingera Beds.

5. Fault Fillings and Metasomatism:

Only a few faults in the Eastern and Western successions show "classic" quartz vein filling. The calcareous nature of parts of the sequence have resulted in many unusual fault fillings, the most common of these being actinolite/chlorite masses. These form in association with quartz, secondary calcite, and massive albitite breccia. Elements such as Ca, Mg, Ti, Fe, and Si are all available from the country rocks. The source of Na is not obvious, but in or near all albitite fault breccias some acid porphyry is present, which may have been a possible source.

The migration of elements and their deposition in fault zones has taken place under low to medium grade metamorphism; migration and distances of hundreds of metres may be involved.

"Beds" of microcline, scapolite and diopside at Mary Kathleen are probably of small-scale metasomatic or metamorphic origin.

6. Faulting:

The unusual nature of some fault fillings in the area is one factor which has led to a considerable underestimation of the numbers of faults in the region. In the Eastern succession, a previously unrecognized sequence of thrust/high angle reverse faults with throws of up to 8000 m has been established. Large faults in shales and basalts are also difficult to recognize, and this fact is important in re-interpretation of penecontemporaneous faults in the Mt Isa area (see later).

7. Ore Deposits:

Copper and acid and basic rock are commonly associated throughout the area. The composition of hydrothermal fluids may have been modified by the NaCl content of much of the sedimentary sequence. Cu, Pb and Zn occur in the sedimentary environment. Cu is commonly stratabound, forming as vein fillings and impregnations in black slate, limestone and pelite. Leaching and migration of Cu from favourable source rocks (shale, basalt) into favourable structural and lithological sites (e.g. fold and fault zones with abundant pyrite) is thought to be a likely process at Mt Isa and elsewhere.

8. Palaeogeography:

Features such as iron-formation, stromatolites, thin-bedding in carbonates, Na and K-rich beds, carbonaceous shales, rift-valley tectonics, etc. suggest, but do not prove, that intra-continental and continental margin palaeoenvironments have existed in the Mt Isa-Cloncurry region. Shore-line sands, fluviatile sands and fan glomerates are also recognized.

9. Metamorphism:

This is a high temperature - low pressure type, reaching hornblende-hornfels and amphibolite grades. Indicator minerals include andalusite, cordierite, staurolite, sillimanite, kyanite, diopside, garnet, etc. In some cases the low pressure regional (?) metamorphism is overprinted by local contact metamorphism.

10. Geochemistry:

Topics studied include:
(a) gossans
(b) blackshales
(c) acid volcanics
(d) basic volcanics

Andy Glikson has compared basalt of the Soldiers Cap Formation (SCF), Marraba Volcanics (MV) and Eastern Creek Volcanics (ECV), and has shown that the ECV are continental tholeiites metamorphosed under high water and CO_2 pressures, while the SCF are deeper water tholeiites, possibly more oceanic than the ECV, and metamorphosed under low water and CO_2 pressures. Ian Wilson has compared acid volcanics from the Leichhardt Metamorphics and Argylla Formation. These units differ geochemically in Ca, Sr, Rb + K contents, and may have originated at different crustal levels.

11. Age Determination: (from Rod Page)

The oldest rocks (Big Toby Granite intruding Yaringa Metamorphics) may be about 1810 m.y. old, and the youngest rocks near 1400 m.y. old. The Leichhardt Metamorphics appear to be about 1710 m.y.; two ages of Naraku Granite are indicated, about 1380 & 1700 m.y. The Mount Isa Group may be younger than 1550 m.y.

12. Reply to C.J.L. Wilson:

Dr Wilson recently published data which showed the Mt Isa Group sequence to have been deposited in the span 1800 - 1930 m.y. age. Evidence will be presented to show that in all probability the Mt. Isa Group is at least younger than 1656 m.y., and possibly younger than 1550 m.y.

13. Reconsideration of Penecontemporaneous Faulting (P.F.):

The criteria for P.F. in the Mt Isa area are questioned, on the basis of more detailed mapping, and previously unrecognized faults, which, together with lenticular sedimentation, can explain some, if not all, of the major thickness variations which apparently occur across faults in the region.

14. Geological history:

The sedimentary and tectonic history of the area is shown on the accompanying sheet.

STRATIGRAPHIC TABLE

MT. ISA - CLONCURRY REGION

WESTERN SUCCESSION

West of Mt. Isa Fault

- Pilpah Sandstone
- Paradise Creek Fmn. (carbonates)
- Mingera Beds (shale, sst, cgm)
- ~~~~ (unconformity)
- SYBELLA GRANITE
- Carters Bore Rhyolite
- Judenan Beds
- Eastern Ck. Volcanics
- Mt. Guide Quartzite
- May Downs Gneiss
- BIG TOBY GRANITE
- Yaringa Metamorphics

East of Mt. Isa Fault

Mount Isa Group:
- Magazine Shale
- Kennedy Siltstone
- Spear Siltstone
- Urquhart Shale
- Native Bee Siltstone
- Breakaway Shale
- Moondarra Siltstone
- Warrina Park Quartzite

~~~~ ? (unconformity)

- Surprise Creek Beds

Haslingden Grp.:
- Myally Beds
- Eastern Ck. Volcanics (basalt)
- Mt. Guide Quartzite

BASEMENT

- Kalkadoon Granite

Tewinga Group:
- Argylla Formation (acid volcanics)
- Magna Lynn Metabasalt
- Leichhardt Metamorphics (acid volcanics)

EASTERN SUCCESSION

- NARAKU GRANITE
- TOMMY CREEK MICROGRANITE
- BURSTALL GRANITE

Portal Group:
- White Blow Formation
- Deighton Quartzite
- Roxmere Quartzite

Mary Kathleen Grp.:
- Lunch Creek Gabbro
- Corella Formation
- Marimo Slate
- Overhang Jaspilite

Malbon Group:
- Ballara Quartzite
- Mitakoodi Quartzite
- Marraba Volcanics (basalt)

Soldiers Cap Formation (basalt)

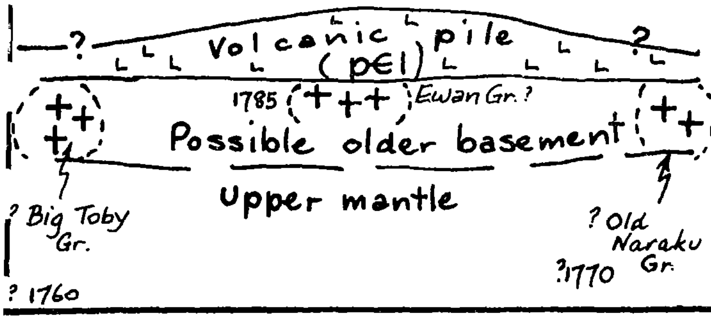
- ? WONGA GRANITE
- Argylla Formation

Note : Dolerite of various ages intrude the stratigraphic succession.

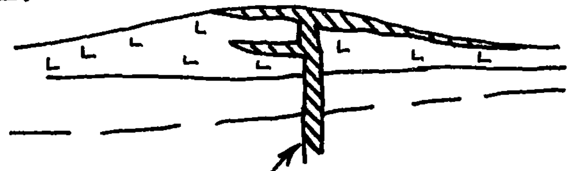
~~~~ Unconformity

Geological history : Mount Isa – Cloncurry area.

1. ?1710

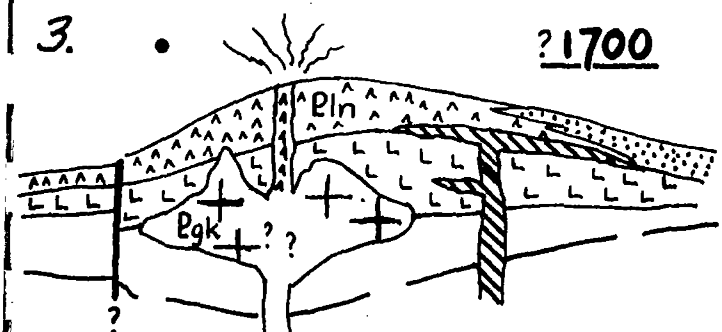


2.



extrusion of Magna Lynn Basalt

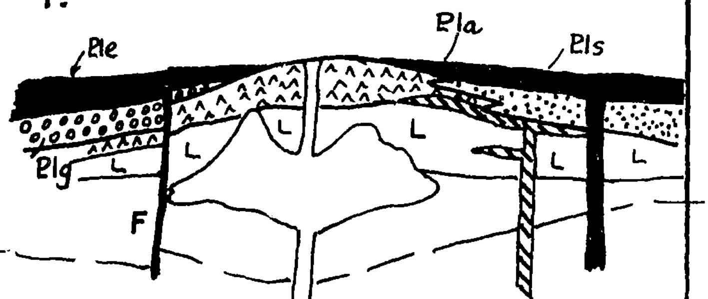
3. ?1700



extrusion of Argylla Fmn, interfingers c̄ sst.* to east : intrusion of ?old phase of Kalkadoon Gr. (Pgk)

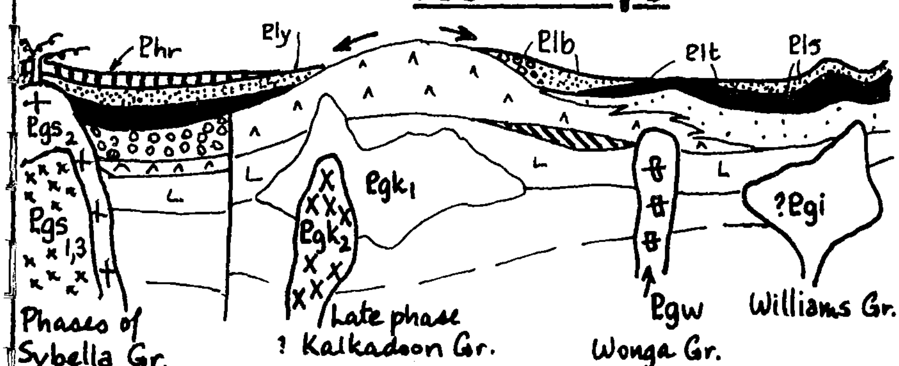
*(sst. basal Soldiers Cap Fmn.)

4.



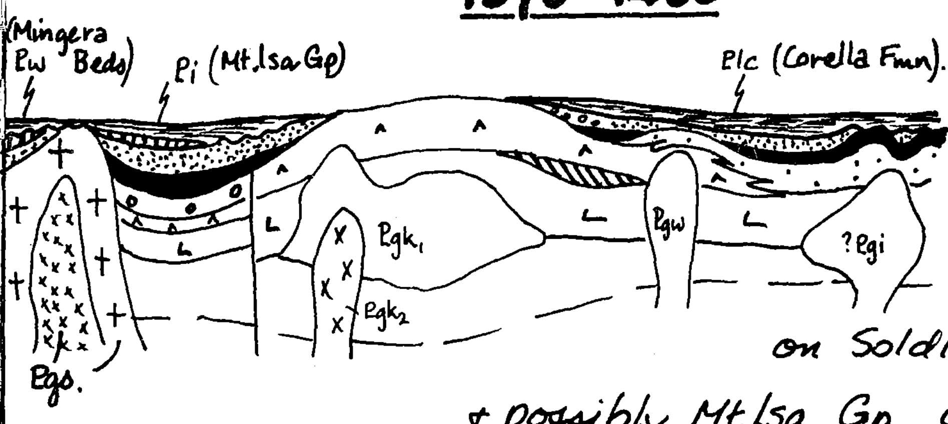
extrusion of tholeiitic basalt in east + west; overlies cgm. and qtzite of Plg in west.

5. 1650 – 1570



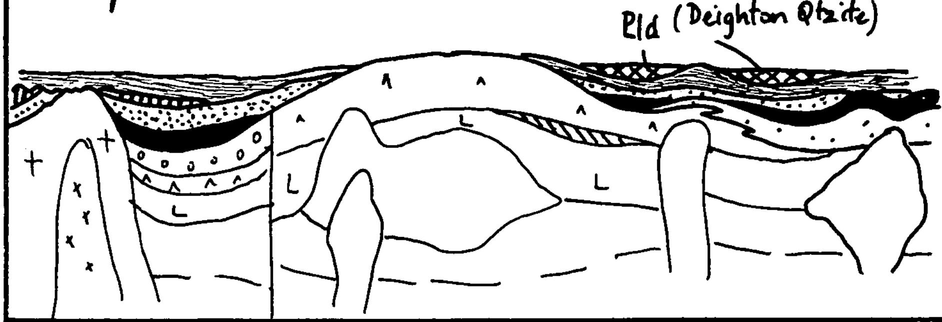
Cgm. + quartzite depositn: Ballara + Mitakoodi Qtzites in east, Myally Beds in west: Carters Bore Rhyolite " " . Intrusion of Sybella Granite in west. Deformation of Soldiers Cap Fmn. in east.

6. 1570 – 1450



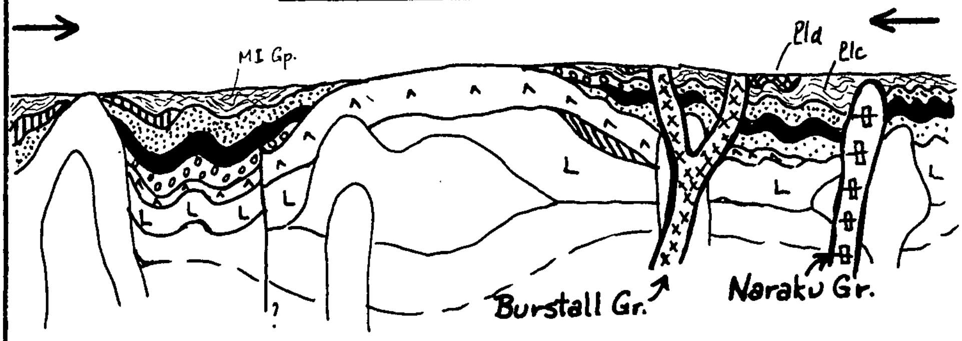
Shale and carbonate deposition – Corella Fmn. in east, Mt. Isa Gp + Mingera Beds in west. Corella Fmn u/c on Soldiers Cap Fmn: Mingera + possibly Mt. Isa Gp. u/c on Sybella Gr.

7. ?1450



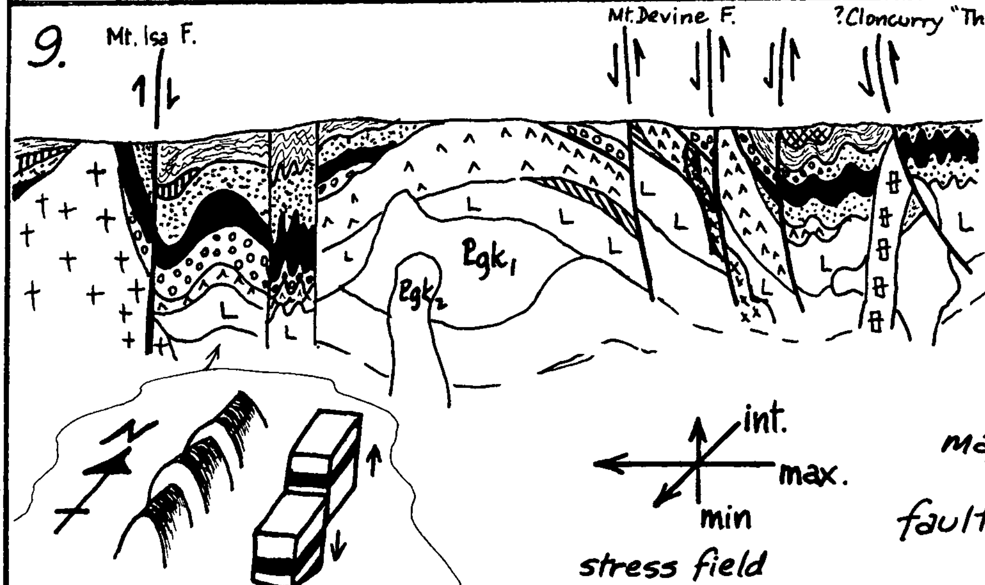
Increasing crustal movement; regression of Corella sea – deposition of ?fluvial Deighton Qtzite in east.

8. 1450 – 1400



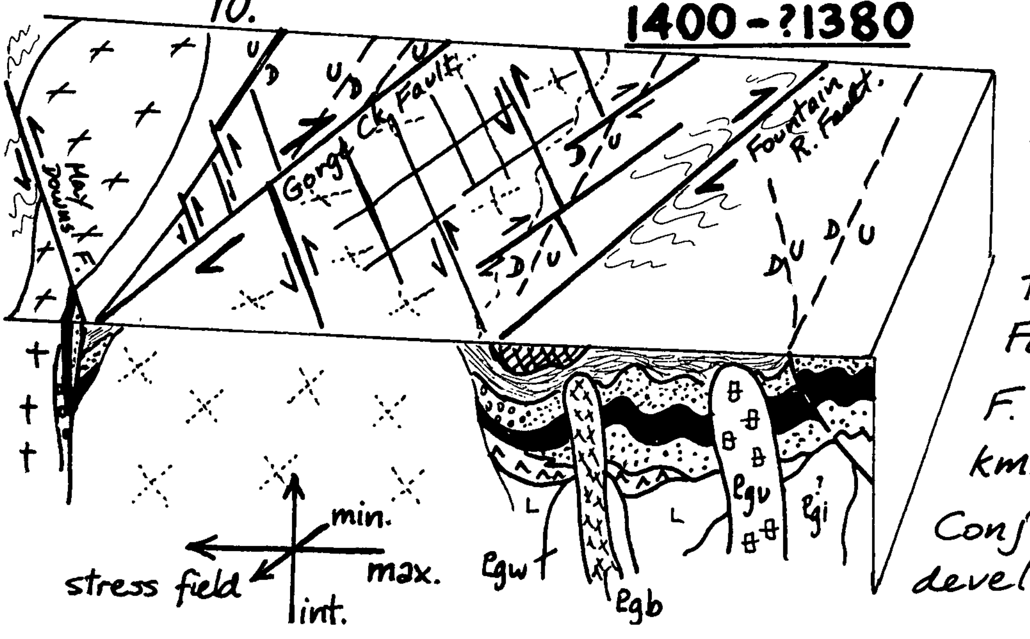
East-west compression resulting in folding and granite intrusion: major low P and contact mmism. Cross-folding in east in Pls and Plc.

9.



Folding gives way to faulting with large vertical component. Mt. Isa Fault fully developed; some major E-W 'normal' faults in W trough.

10. 1400 – ?1380



Transition to strike-slip tectonics; drag folding along major faults. Fountain Ra. Fault and Gorge Ck. F. each show 20-25 km. dextral movement. Conjugate pattern well developed.

SLAR INTERPRETATION OF THE MT ISA AREA

C. Maffi

The Mt Isa area is one of those used by BMR to test remote sensing methods. Side Looking Airborne Radar (SLAR) imagery was flown between Mt Isa and Cloncurry in June 1972. Its evaluation is still in progress and the preliminary results are given below.

SLAR imagery is a display of the reflectivity of the terrain to radiation in the microwave region of the electromagnetic spectrum. The system can be operated day and night, in any but the worst weather. The microwave reflection is strongly affected by the morphology of the terrain; the resulting imagery is a faithful reproduction of terrain features. The approach to the geological interpretation of SLAR imagery is thus mainly geomorphological. SLAR coverage of large areas is obtained by flying parallel runs with a constant look direction. The resulting radar strips have a maximum scale error of 1% due to excellent navigation and processing systems. Stereoscopic coverage is obtained by flying partially overlapping strips.

The specifications for the Mt Isa SLAR coverage were: system, Goodyear; flight direction, east-west; look direction, south; flight altitude, 9 000 m a.s.l.; original scale, 1:400 000; wavelength, 3.12 cm; resolution, 16m.

The preliminary results of the study are:

1. The uniformity of signature and the correct geometry of the imagery over large areas make it possible to prepare excellent radar mosaics. The lateral look direction enhances the relief thus making the mosaic a valuable interpretation and navigation tool.

2. It was possible to obtain in a short time uniform coverage of the area irrespective of the weather.

3. The lithological interpretation was best carried out on enlarged radar strips under stereoscopic vision. Rock types that have a strong morphological expression were readily identified. For other rock types identification was difficult. However, by relying on subtle differences in relief, drainage pattern and fracture pattern, different "Radar units" could generally be distinguished, then related to lithological units by means of existing geological information.

4. Many structural features, such as faults, lineaments, fracture patterns and bedding trends, were easily identified both on the strips and on the mosaic. Structural features having regional size (bigger than 50 km) are well displayed on the mosaic.

5. SLAR is better suited for regional than for detailed geological mapping. Mapping at scales larger than 1:100 000 is better done on air photographs.

USES OF AIRBORNE GAMMA-RAY SPECTROMETRY WITH EXAMPLES FROM ALLIGATOR RIVER, N.T.

P.G. Wilkes

This paper describes the use of airborne gamma-ray spectrometry in the direct search for uranium and in the differentiation of petrologic units from their content of potassium-40, uranium-238 and thorium-232.

Background theory is presented at a level required for an appreciation of the technique and an understanding of the results which it can produce. In particular, reference is made to data corrections which can remove or reduce the effects due to non-geological sources, ground clearance variations and compton interactions. The importance of ratio measurements in interpretation is demonstrated.

Radiometric results are presented and discussed from the 1972 B.M.R. airborne survey which covered the Alligator River, Cobourg Peninsula and the northern half of Mt Evelyn 1:250 000 scale geological map sheets. These results include:-

1. Examples of total-count profiles (as released early in 1973) and interpretation maps which show the radiometric anomalies divided into groups determined by their radio-element content.

2. The correlation between thorium anomalies and bauxite occurrences on the northern part of Cobourg Peninsula.

3. Results over known uranium deposits.

4. The ability to distinguish basic volcanics in areas extensively covered by Kombolgie Formation.

5. A discussion of the relationship between radiometric anomalies and the Nanambu Complex.

MAGNETIC CHARACTERISTICS OF PRECAMBRIAN SEDIMENTS IN THE ADELAIDE GEOSYNCLINE, AS REVEALED BY AIRBORNE AND GROUND SURVEYS

D.H. Tucker

Over the steeply dipping Adelaide System sediments in the Adelaide Geosyncline, the aeromagnetic pattern in some areas shows broad circular anomalies attributable to a magnetic basement at depths of 2 000-5 000 m or more. In other areas it shows sharp anomalies due to magnetic material at the surface. The presence of sharp magnetic anomalies is due to a regional increase in magnetic mineral content of some of the sediments. This increase is associated with a regional increase of metamorphic grade. Interpretation of the magnetic data from the Adelaide Geosyncline is of special interest for mineral exploration. In addition, the difference between the two magnetic patterns provides a useful example of the problem of interpreting depth to magnetic basement in oil prospective basins, where the basement consists of Precambrian sediments.

Most of the shallow source magnetic anomalies are long linear features which are caused by magnetic sedimentary beds. Of the 12 magnetic beds recognised in the Wilpena and Umberatana rock groups near Orroroo, only the Holowilena Ironstone is an iron formation; the others lie within shales, slates and quartzites, and probably contain less than 1% of strongly magnetic minerals. The magnetic beds have the form of multilayered thin sheets, conformable with the sedimentary layering. These thin magnetic sheets are interbedded with non-magnetic layers to form beds with a total thickness of up to 300m. Individual magnetic sheets within beds are weathered to depths of up to 200 m. The variable depth of weathering of sheets often gives rise to ground magnetic anomalies which consist of a long wavelength component and superimposed short wavelength components on one side.

The beds are usually magnetized in a direction close to the geological layering. In most cases remanent magnetization is a more important contributor to the anomalies than is induced magnetization. Interpretation of the anomalies indicates that in the lower Tapley Hill magnetic bed, a component of remanent magnetism was acquired before folding and lies in a direction of 135° east of north; this is close to the geological layering. The direction of the pre-folding component of the remanence was deduced by a study of vertical field anomalies over anticlinal structures. The strength of magnetization of the most strongly magnetic beds is about 10^{-3} c.g.s. units. While the background value of the magnetic susceptibility of the sediments is less than 10^{-4} c.g.s. units, the susceptibility of samples from the most strongly magnetic beds lies within the range of 10^{-3} - 10^{-1} c.g.s. units.

BATHURST ISLAND - COBOURG PENINSULA N.T. GEOLOGY, HEAVY MINERAL SANDS AND BAUXITE

B.R. Senior

SUMMARY

A reconnaissance geological survey of Bathurst Island, Melville Island, Cobourg Peninsular and Fog Bay 1:250 000 Sheet areas was carried out between June and October 1972. The programme of geological mapping also included an auger sampling survey of beach sands, and a distribution and chemical study of laterite and derived bauxite.

A generalized geological map of the area which also serves as a location map is shown in Figure 1.

GEOLOGY

Basement comprises Lower Proterozoic metamorphic and igneous rocks of the Pine Creek Geosyncline and the Litchfield and Nimbuwah Complexes. These rocks are unconformably overlain by the Upper Proterozoic moderately folded Moyle River Formation in the southwest and the flat lying fluviatile? Kombolgie Sandstone to the south and east.

Permian sediments onshore are restricted to a small area in southern Fog Bay Map Sheet. These sediments consist of sandstone and diamictite and are possibly glacial in origin. Petroleum exploration drilling and seismic surveys indicate thick Palaeozoic to Cainozoic sediments offshore in the Money Shoal and Bonaparte Gulf Basins. These sediments thin or are truncated against a broad structural platform called the Bathurst Terrace. This terrace is delineated by an increase in gradient, both in bathymetry and in the subsurface, and delineates the southern margin of the Money Shoal Basin which lies to the north. A similar gradient change known as the Van Diemen Rise forms the northwestern margin of the Bonaparte Gulf Basin.

Evidence for pre-Cretaceous sediments over the Bathurst Terrace is lacking and the sedimentary record begins with a Lower Cretaceous marine transgression which eventually covered approximately the northern third of the Northern Territory. Palaeontological evidence suggests that this shallow epicontinental sea persisted from Neocomian to Aptian time. Partial regression of the sea occurred in upper Albian time possibly due to slight epeirogenic uplift of the southern edge of the Bathurst Terrace. Sedimentation continued in the Bathurst and Melville Islands and produced a distinct series of facies to this portion of the Bathurst Island Formation. Mud was deposited in open marine conditions (Wangarlu Mudstone Member) and was bordered by shallow marine deltaic sands, silts and muds (Moonkinu Member). A distinctive facies of arenite was deposited around archipelagoes of upstanding basement in the southern portion of Cobourg Peninsula. New stratigraphic names for Cretaceous and Cainozoic sediments of the area and their relationships are shown diagrammatically in Figure 2.

In late-Cretaceous or early Cainozoic time the area was uplifted and the exposed Cretaceous sediments were chemically weathered and a trizonal laterite up to 40m thick formed. Slight northwest tilting followed and resulted in a marine transgression over Bathurst and northern Melville Islands. This sea was fed by north flowing rivers which transported quartzose sand (Van Diemen Sandstone) from the mainland. Aspley Strait, which separates the two islands, and underfit drainage patterns on Melville Island and Cobourg Peninsula mark the position of this former river system.

Further uplift resulted in retreat of the sea and the landscape was subjected to further chemical weathering. Cainozoic tectonic movement is indicated by the present day distribution of laterite which in general has been gently tilted towards the northwest.

BAUXITE

The bauxite is closely associated with the lateritic chemical weathering of Cretaceous sublabile sandstone, siltstone and mudstone. In favourable situations this laterite was subjected to continuous chemical weathering and formed an alumina rich pisolitic residuum up to 5 m thick. Where present the pisolitic sediments overlie or grade down to an in situ ferruginous laterite. This laterite is markedly tubular in structure. The pisolitic layer appears to have formed after slight warping, accompanied in downslope areas by further silica-leaching of the parent laterite. As a result the bauxitic pisolitic layer is restricted to the northernmost headlands of Cobourg Peninsula and northern Croker Island. This distribution and apparent gentle dip below sea level suggest the presence of offshore bauxite.

Major oxide analyses show an aluminium oxide content between 26 and 45% and a silica content of 7 to 30%. Silica is mainly in the form of discrete quartz grains. Mapping infers a greater distribution than previously thought but outcrops away from coastal sites are sparse and subject to surface iron oxide enrichment. The bulk of samples from this area were lost in transit and the area will be reinvestigated this year. Reynold Metals Co. estimated reserves on Croker Island as 650 000 long tons of greater than 30% available alumina.

HEAVY MINERAL SANDS

Hand auger holes were put down into beach sands at 37 locations around the periphery of Bathurst and Melville Islands. Holes varying from .5 to 1 m deep were positioned wherever extensive sandy beaches occur. The majority of samples were collected from the high water mark in the central portion of a beach. The objective was to gain a regional distribution picture of detrital heavy minerals and no attempt was made to select specific sites or layers of possible heavy mineral concentration.

Nine of the representative sand samples contained more than 2% by weight of heavy minerals. The heavy mineral concentrate is dominated by opaques (ilmenite, altered ilmenite and leucoxene) with subsidiary zircon and rutile. Areas of high concentration include Cape Van Diemen, Boradi Bay, Cape Fourcroy and Murrow Point. The results of this survey are encouraging and the anomalous areas together with ancient beach strandlines, and sand bodies exposed at low tide, will be investigated during 1973.

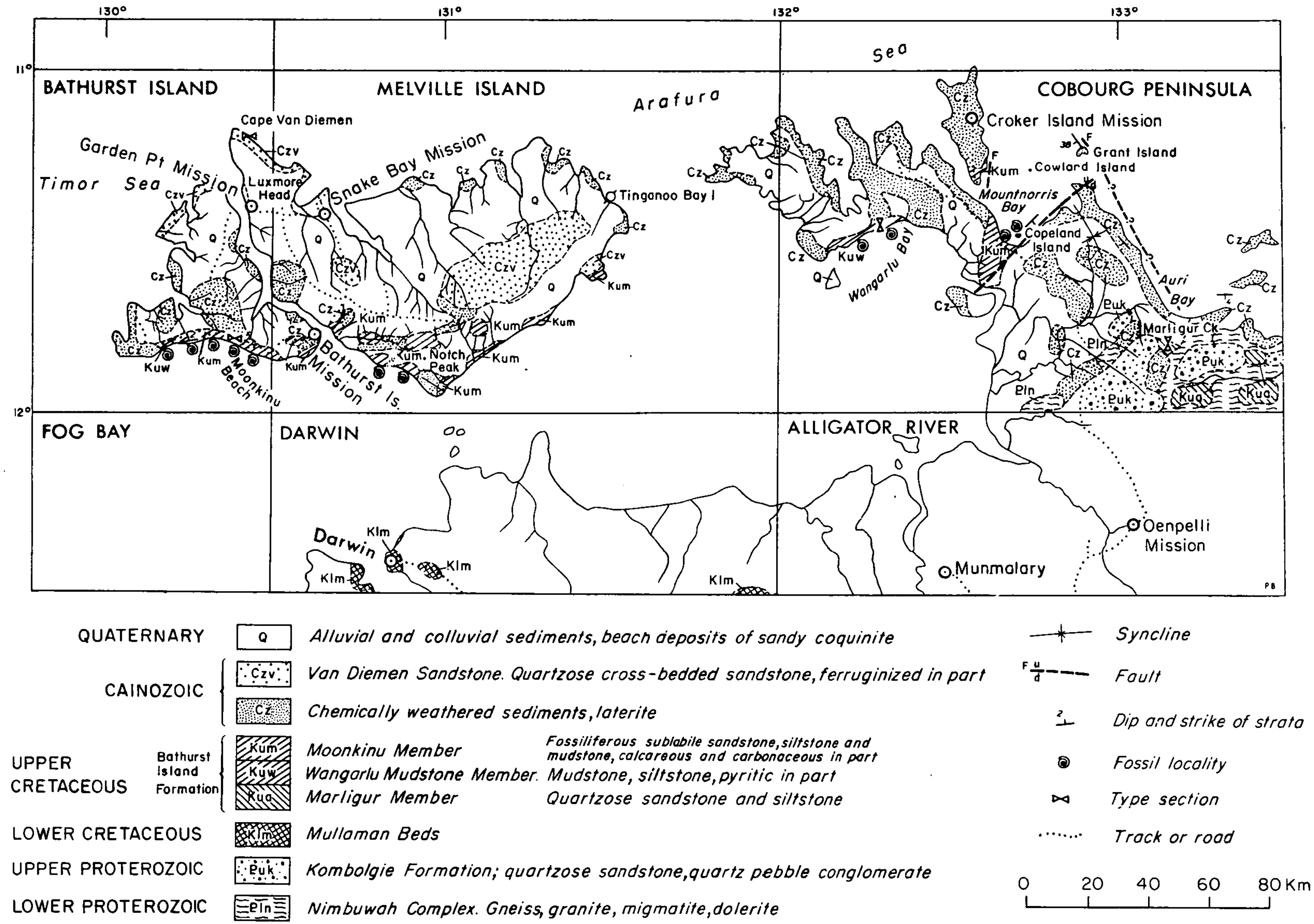


FIG. 1 GEOLOGICAL SKETCH MAP OF BATHURST ISLAND, MELVILLE ISLAND, AND COBOURG PENINSULA 1:250,000 SHEET AREAS

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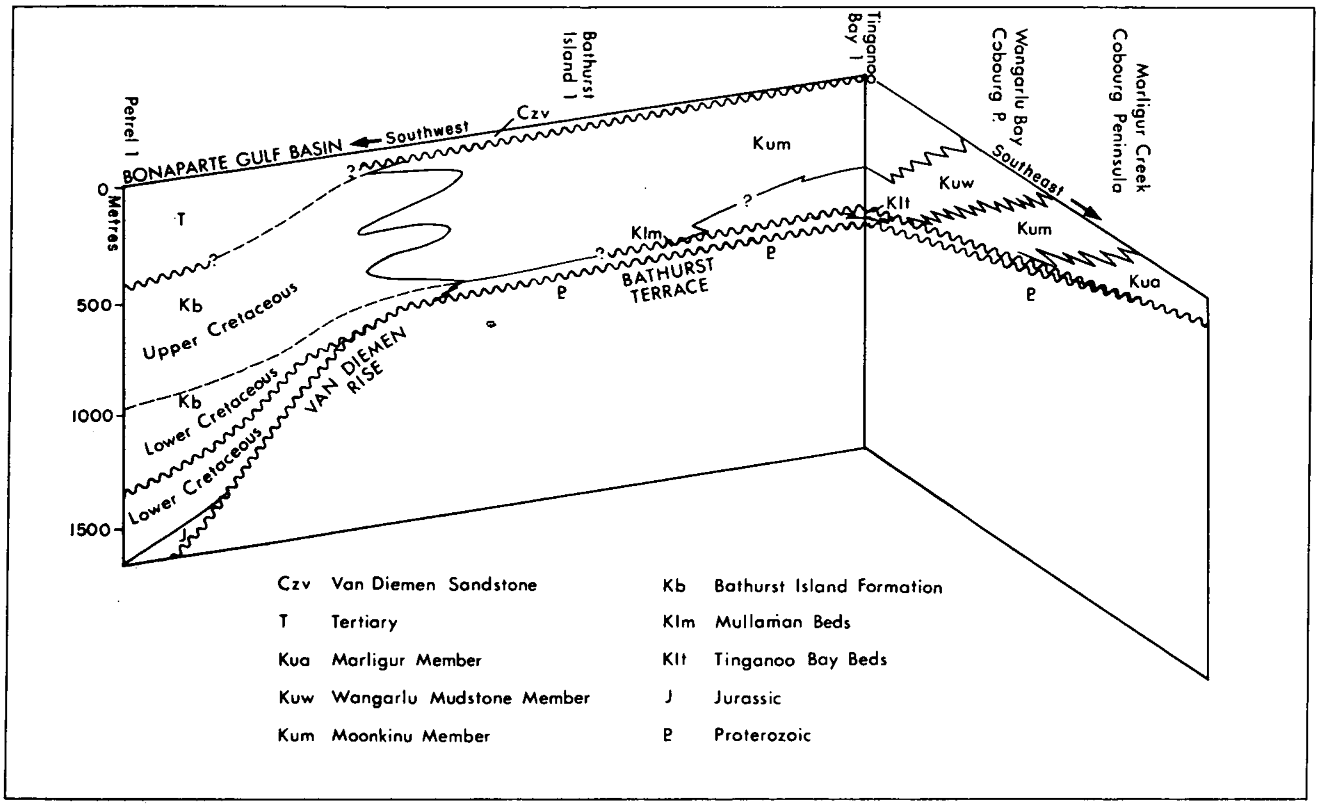


FIG. 2 Interpreted stratigraphic relationships of proposed units from Bonaparte Gulf Basin across the Bathurst Terrace

NT/A/376

RESULTS OF RECENT GEOPHYSICAL AND GEOLOGICAL SURVEYS IN THE OFFICER BASIN IN WESTERN AUSTRALIA

P.L. Harrison & M.J. Jackson

Recent geophysical and geological surveys in the Western Australia part of the Officer Basin have:

- indicated the presence of about 10 000 metres of mainly Proterozoic sedimentary rocks. The sedimentary pile is about 4 000 metres thicker than previously estimated.
- shown that the Phanerozoic section is a relatively thin, mostly flat-lying sequence of widespread Lower Cambrian basalt, overlain by shallow water marine sandstone, Lower Permian glacials, fluvial and lacustrine deposits and then Lower Cretaceous clastics.
- confirmed that the petroleum potential of the Lake Throssell-Warburton Mission area is poor.

Reconnaissance geological mapping and geophysical work was done in the basin previously mainly during the period 1961-1966. The BMR made a reconnaissance seismic survey along a line across the northern part of the basin in 1961-1962 and a reconnaissance helicopter gravity survey in the same area in 1962. Hunt Oil Co. explored the area southwest of the Musgrave Block by an aeromagnetic survey using a flight line spacing of 48 kilometres in 1961 followed by a gravity survey and detailed seismic surveys between 1963 and 1965 and stratigraphic drilling in 1965 and 1966. Sediments and basalt thought to be of Proterozoic age were intersected at shallow depth and operations were terminated.

A combined Bureau of Mineral Resources-Geological Survey of Western Australia geological party mapped twenty 1:250,000 Map Sheets covering the Western Australian portion of the Officer Basin in 1970 and 1971. Sparse outcrops mainly of flat-lying Palaeozoic and Mesozoic rocks, about 1 000 metres thick, were found throughout most of the area. Geophysical work and stratigraphic drilling by the BMR in 1972 were planned to provide additional information on the sedimentary pile.

The BMR completed the reconnaissance helicopter gravity coverage of the basin in 1972 and conducted a seismic and detailed gravity survey on a line between the Hunt Oil Co. seismic survey area and the Yilgarn Block (Fig. 1). Magnetic and radiometric readings were taken in addition to the gravity measurements at intervals along the line and on short cross-traverses to assist in the interpretation of the seismic survey results over gaps in the seismic coverage. Additional gravity, magnetic and radiometric readings were made on an easterly line in the southern part of the basin to assist in the interpretation of the regional gravity results.

The reconnaissance helicopter gravity results indicate that the Officer Basin in Western Australia may be divided into several regional gravity provinces on the basis of Bouguer anomaly level, contour trend and degree of contour disturbance. The seismic traverse crosses two provinces which appear to be conformable with the geotectonic pattern of the Precambrian shield and may correspond to the mass distribution within the basement under the Officer Basin. There is little control for interpretation of the regional gravity features apart from the seismic and detailed gravity work.

Preliminary interpretation of the seismic results indicates that the basin sediments are about 10,000 m thick near the centre of the basin, dip gently northeast, and thin significantly about 30 km northeast of the exposed Yilgarn Block. The 1961 aeromagnetic interpretation gave a markedly different picture with an asymmetrical sedimentary trough, 6000 m deep in the northeast and shallowing to a broad platform less than 1000m deep in the southwest. Hunt Oil Co. refraction work gave a refractor which corresponded in depth to the magnetic basement near the Musgrave Block. Seismic reflection surveys for Hunt Oil Co. yielded little continuous deep reflection information, but succeeded in mapping a strong reflection, horizon A, over a large area, at depth of 500-1500m. The horizon corresponded to the Lower Cambrian Table Hill Volcanics in Hunt Oil Co.'s Yowalga No. 2 well. Horizon A was identified on the northeasternmost BMR probe by refractor velocity and dip and reflection quality. From a depth of 1500m near the centre of the basin it gradually shallowed southwestward and the Table Hill Volcanics were intersected in a seismic shot-hole about 100 km northeast of the Yilgarn Block. Two deeper sedimentary sequences were identified from analysis of interval velocities and refractor velocities and depths. The base of sequence I is about 7000 m deep near the centre of the basin and shallows to 1000 m, 60 km to the southwest. The shape and depth of the trough resembles the aeromagnetic basement profile. Sequence II, about 8000 m thick in the southwest, was not defined to the northeast. The seismic traverse crosses an L-shaped gravity ridge which consists of gravity highs trending north and east. Some features of the gravity may be qualitatively explained if the densities of sequence I, sequence II and basement increase in that order. The two gravity highs may be caused by more dense blocks within the basement. Magnetic anomalies which correspond to the gravity highs may be caused by dikes. At the southwest margin of the basin seismic results indicate that 8000m of sediments thin significantly over less than 20 km and that basement faulting may occur. A sharp increase in level on the magnetic profile occurs where basement faulting is postulated. The Bouguer anomaly level decreases over the northern part of the Yilgarn Block and may reflect a change from basic to acidic basement.

Although processing of the geophysical data is incomplete, preliminary results plus the data from shallow stratigraphic drilling and field mapping allow the following tentative conclusions to be drawn. The oldest rocks filling the 10 000m deep depression are probably an easterly extension of the Proterozoic Bangemall Basin. Shallow marine rocks (e.g. glauconitic sandstone, stromatolitic dolomite, chert, feldspathic sandstone), crop out extensively between Lake Carnegie and Lake Disappointment on the western edge of the basin (Fig 1). They are intruded by dolerite sills dated at 1 050 x 10^6 years and the total thickness of these rocks in this area has been estimated at 9000 m. It is likely that these rocks fill at least the lower 5000 m of the basin. Between about 5000 m and 1000 m below the surface are the lateral equivalents of the southwesterly dipping sandstone, siltstone and tillite that flank the southern margin of the Musgrave Block. Hunt Oil wells Yowalga No. 2 and Browne Nos 1 & 2 were drilled into part of this sequence and penetrated evaporite-bearing beds. Correlation with similar rocks in South Australia shows that these rocks are probably Adelaidean. Capping this thick sequence of Proterozoic rocks is a mantle of flat-lying Palaeozoic and Mesozoic rocks. The basal unit, the Lower Cambrian Table Hill Volcanics, is a widespread basalt layer about 100 m thick. Overlying the basalt are two shallow-water marine sandstone formations (Lennis Sandstone and Wanna Beds) totalling about 400m and which are overlain unconformably by Lower Permian glacial , fluvial and lacustrine rocks about 350 m thick. Fossiliferous shallow marine Lower Cretaceous clastics about 150 m thick are present in the north and west of the area. This recent information on the stratigraphy of the Officer Basin is shown on Fig 1, a geological map of the area, and Fig 2, a stratigraphic column.

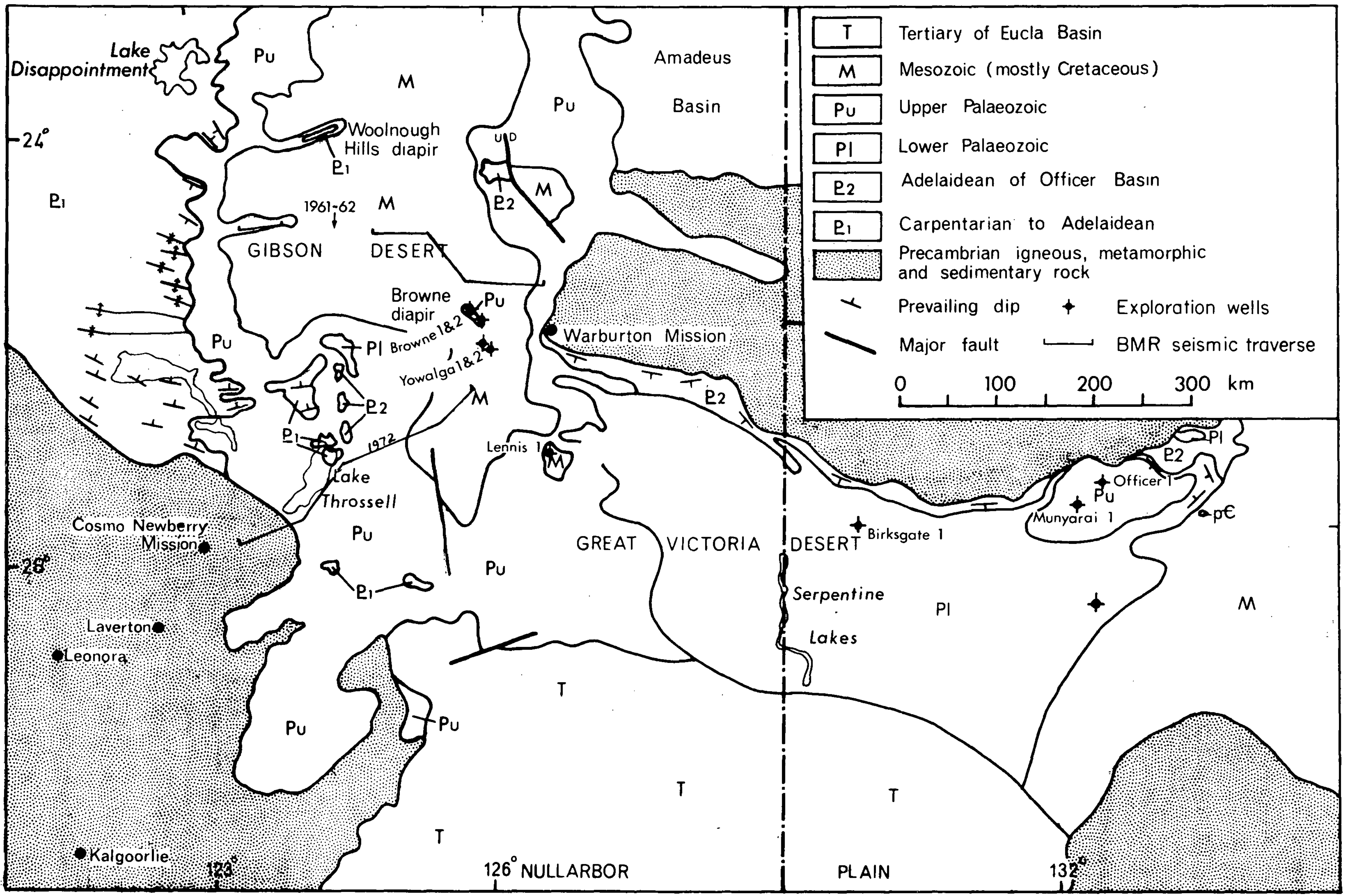
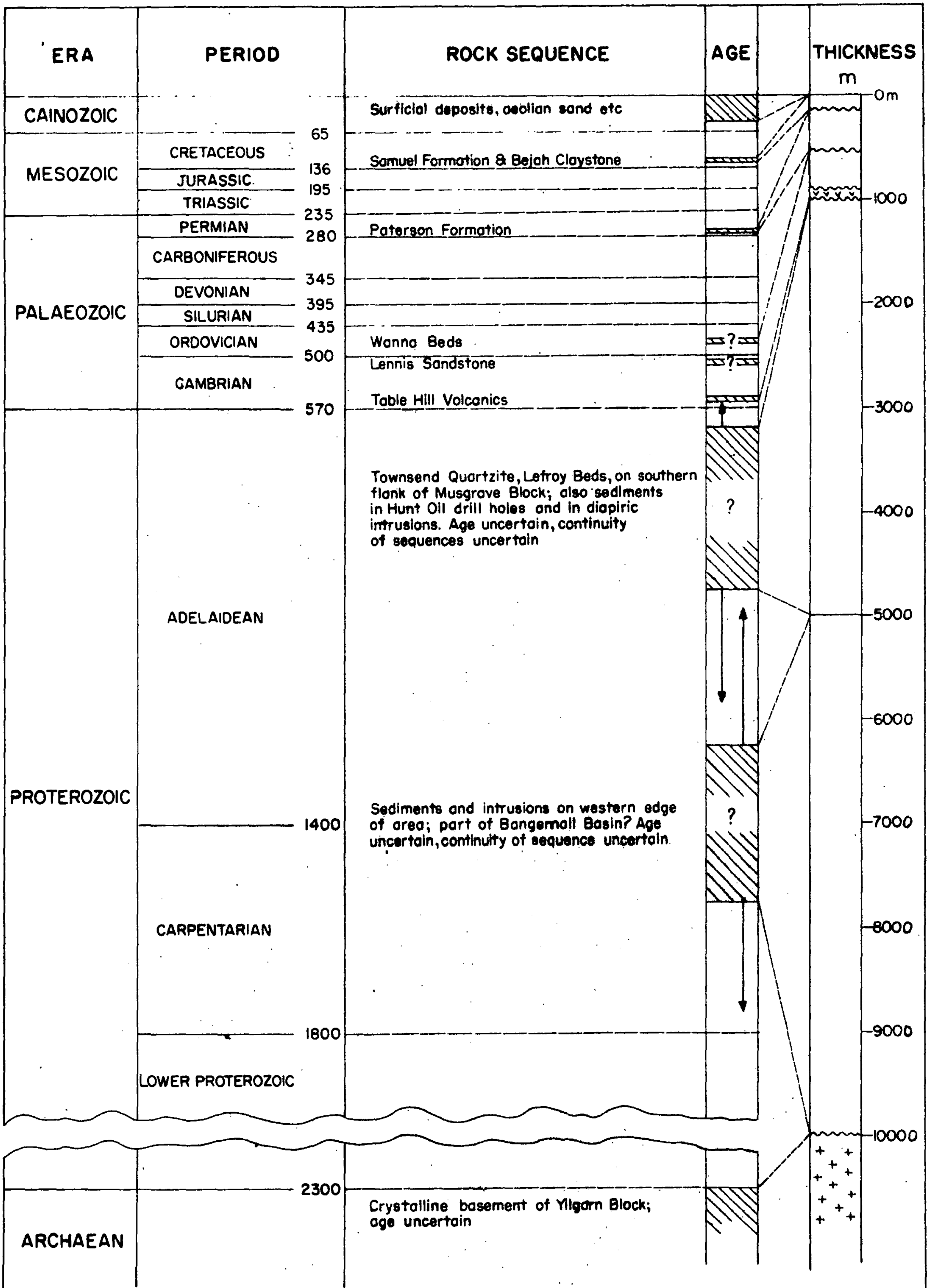


Fig 1 Solid geology map of Officer Basin



Major stratigraphic units in the Officer Basin, Western Australia

Fig. 2

To accompany Record No

DEVONIAN REEF COMPLEXES, W.A.

E.C. Druce

Devonian carbonates were first recognised in the Canning Basin in 1890 when fossils collected by Hardman in 1883 were determined. The interpretation of the carbonates as a reef complex was first proposed by Wade in 1936. Subsequent work by Caltex, BMR, West Australian Petroleum, and the Geological Survey of Western Australia have strengthened this interpretation.

The reef model depends on the interpretation of the complex petrological, palaeontological and stratigraphic evidence within the carbonate province. The most satisfactory explanation is that it is the remnant of a Devonian reef complex although some workers, especially those from the University of Western Australia, consider that a reef model is not necessary to explain the sedimentary petrology of the carbonates.

Carbonate sediments in the area can be divided into four main types; Playford and Lowry recognize these as the litho types for the four depositional environments associated with a reef complex. The flat bedded biostromal stromatoporoid and algae limestones represent the back-reef (lagoonal) facies; the massive bedded biogenic limestone represents the reef facies; the strongly dipping, bioclastic limestone represents the fore-reef facies; and the thin-bedded (fine-grained) clastic and limestone represents the inter-reef facies.

These four facies contain a distinct but varied fauna. Stromatoporoids and algae form the majority of the biota in the reef and back-reef; the fore-reef contains abundant brachiopods and nautiloids; Receptaculites occurs near the reef - fore-reef contact. Conodonts and goniatites occur and are useful in erecting the biostratigraphic framework for the Lennard Shelf region. No regional break in sedimentation can be recognized.

The reef complex overlies faulted Precambrian basement and is overlain by Devonian-Carboniferous platform carbonates and shales, Carboniferous sandstones and Permian conglomerates and sandstones.

Three phases in the development of the complex can be distinguished.

1. In the latest Middle Devonian, reef growth began; through the early Frasnian a reef with associated back-reef and fore-reef deposits was formed. Deposition of this type continued until the Middle Frasnian when the sedimentary regime was altered by minor tectonism.

2. Movement along pre-existing faults in the Precambrian caused tilting in the NW-SE orientated basement blocks in the Middle Frasnian. This caused shallowing in some areas and deepening in others. Superimposed was a general eustatic change in sea level giving drowning. This phase lasted until the early Famennian; it is characterised by the apparent non-development of the back-reef facies and thick fore-reef deposits with allochthonous blocks of reef and back-reef material forming mega-breccias.

3. The final phase marked a return to a more normal type of reef development with back-reef deposits.

During all phases minor eustatic changes in sea-level have taken place producing fore- and back-stepping of the reef and the onlapping of the various facies.

The Upper Devonian carbonates of the Canning Basin are closely comparable to deposits of a similar age in Western Canada, and to some areas of the Devonian and Carboniferous outcrop in the Mississippi Valley. These areas contain commercial deposits of hydrocarbons and lead and zinc. The occurrence of sedimentary lead and zinc deposits is reviewed and the potential of the Canning Basin as a lead-zinc province is assessed.

THE ROLE OF PRECAMBRIAN ALGAE AND BACTERIA IN ORE DEPOSITION

M.R. Walter

Algae and bacteria potentially have a four-fold role in ore deposition: 1) active scavenging; 2) passive scavenging; 3) action of sulphate-reducing bacteria in organic-rich sediments to produce H_2S, which precipitates metals; 4) construction of favourable rock associations. Active scavenging ideally involves concentration of elements or compounds essential for the life of an organism, but there are few significant reactions of this sort. The life processes of bacteria cause the concentration and precipitation of iron and manganese oxides. The deep sea manganese nodules may have formed this way. Passive scavenging involves more clearly "accidental" reactions between organic and inorganic compounds. Such reactions are still specific to particular organisms and can, for instance, concentrate phosphates. Precambrian stromatolitic phosphorites may have formed this way. The contribution that Precambrian palaeontology can make to the exploration for ores resulting from both active and passive scavenging is to determine the time range and distribution of the organisms involved, and so help delineate exploration targets. Present knowledge of Precambrian microfossils is reviewed in this light.

The two last roles of algae and bacteria are described together to show that during the Precambrian, permeable carbonate reefs, rich in organic matter, formed adjacent to shales and evaporites. This provides a rock association typical of the Mississippi Valley type lead-zinc deposits. Australian examples of this rock association occur in the Adelaide Geosyncline and the McArthur Basin.

PRELIMINARY RESULTS FROM A MARINE GEOPHYSICAL SURVEY IN THE GREAT AUSTRALIAN BIGHT

J.B. Willcox

Gravity, magnetic and seismic reflection records were obtained in the Great Australian Bight (between 124° and 141°E) as part of the Continental Margins Survey. Lines are oriented north-south and separated by 20-25 nautical miles.

High noise levels and interference from multiples has resulted in poor seismic records over the continental shelf, but elsewhere the quality is fair. Gravity and magnetic data are good throughout.

Bathymetric measurements outlined the continental shelf, continental slope, continental rise, Eyre Plateau, Ceduna Plateau, and small areas of abyssal plain.

Sediment thicknesses of 0.5 - 1 kilometres are confirmed in the offshore Eucla Basin and also on Eyre Plateau. The Denman Basin probably extends onto the continental shelf for 50 kilometres and occupies a total area of 10,000 sq. kilometres. The Polda Trough is a true graben containing at least 2 kilometres of sediments, and with boundary faults extending westwards across the northern edge of the Ceduna Plateau and southern edge of the Eyre Plateau. The gravity anomalies indicate 3 or 4 kilometres of sediments under the Ceduna Plateau. The Duntroon Basin and Ceduna Plateau are sediment piles overlying a downfaulted block of the Gawler Craton. Both are bounded by a basement rise or band of intrusions along their southern edges.

The outcropping Gawler Block is encircled by a Bouguer anomaly ridge which may originate from an ancient mobile belt.

Faults along the margins of the Eyre Plateau, Ceduna Plateau and Duntroon Basin, together with the Polda Trough graben, and graben development during the early stages of formation of the Otway Basin, support the notion that the present continental margin developed as a rift during the Jurassic. The fault pattern is consistent with that predicted by the sea-floor spreading hypothesis.

TRANSIENT E.M. TEST SURVEYS IN NORTHERN TERRITORY AND QUEENSLAND, 1972

B.R. Spies

Electromagnetic methods have been used in mineral exploration for more than 50 years. Most of these systems operate in the frequency domain, which means the transmitter sends at a fixed frequency and the sensor coil receives continuously. In many parts of the world climatic weathering has produced relatively conductive surface layers which often mask the response of underlying conductors at the frequencies commonly used.

More recently time domain (Transient) E.M. systems have come into use. The transmitter sends a series of pulses and the receiver measures the transient decay during the transmitter off-time. The primary field is created by a strong D.C. pulse in an ungrounded loop. The changing current in the loop induces eddy currents on the surface of a good conductor. The eddy currents diffuse inwards towards the centre of the body, being gradually dissipated due to resistance losses and the skin effect. In a relatively short time interval, which depends on the physical and geometrical properties of the conductor, the secondary field practically vanishes.

The receiving coil has an output voltage proportional to the time derivative of the field decay. An analysis of the decay curve is important in the interpretation of results and in determining the parameters of the conductor. Analysis of the shape of the received transient waveform is equivalent to measuring the response at a number of frequencies for a harmonic source. The transient method is quite effective in distinguishing between highly conductive orebodies and overburden of intermediate conductivity.

The main disadvantage of the method is that the receiver must have a wide band pass in order to receive the transient signal. Thus the receiver cannot be tuned in order to reject electrical interference, and this has proven to be a problem in some areas.

In 1972 the Bureau of Mineral Resources acquired a Russian-built MPPO-1 (one - loop version) and conducted field tests in Northern Australia in areas where geological and geophysical control was available.

The MPPO-1 equipment transmits a series of square pulses 20 ms wide at a frequency of 18 Hz. The power supply consists of rechargeable silver-zinc batteries supplying 5 volts at a current of ½ to 2 amps. The transient decay curve is sampled at 12 discrete points ranging from ½ to 15 ms after the termination of the current pulse. The MPPO-1 is a one-loop version employing the same loop for transmitting and receiving. The loop size can range from 5 m square to 200 m square.

Results are given from a number of localities. At Rum Jungle a well-defined anomaly was obtained over a dipping carbonaceous shale bed, and the results agreed well with those of other geophysical methods. A survey near Cloncurry gave large anomalies over a carbonaceous shale sequence in an area of steep topography. Other electrical and electromagnetic methods could not be used in this area because of high surface conductivities. In the Mary River area (N.T.) the method was used in a reconnaissance mode and areas of conducting surficial deposits were mapped out. By studying the response at late sample times anomalous zones of very high conductivity were delineated and subsequently re-surveyed using smaller loops. A survey was done over the Woodlawn Orebody at Tarago, N.S.W. By the use of different loop sizes information on the depth, strike and dip of the sulphide lens was obtained.

EARTH RESOURCES TECHNOLOGY SATELLITE, ERTS 1

W.J. Perry

Background information

Launch: July 23, 1972. Altitude: 915 km (570 miles).

Orbit: near-polar, sun-synchronous; spacecraft completes coverage of world between latitude 81 degrees north and 81 degrees south every 18 days; time of imagery over Australia, about 9.30a.m. local time.

Sensors: i) Three return vidicon television cameras (RBV's) imaging in three spectral bands: Band 1, green (.475 to .575 micrometers)
Band 2, red (.58 to .68 ")
Band 3, infrared (.69 to .83 ")

Size of area imaged: 185km x 185 km

ii) Multispectral scanner (MSS) imaging in four spectral bands:

Band 4, green (.5 to .6 micrometers)
Band 5, red (.6 to .7 ")
Band 6, infrared (.7 to .8 ")
Band 7, infrared (.8 to 1.1 ")

Scanner images a strip 185 km wide.

Information from the sensors is recorded electronically, and data from Australia stored on either of two tape recorders in the spacecraft, and later telemetered to ground stations in the U.S.A. when the spacecraft is in view of them. Data are converted to images on photographic film at a scale of 1:3 369 000.

The Director of BMR is Chairman of the interdepartmental Australian Committee for ERTS (ACERTS) which organized the original ERTS proposal to NASA and coordinates all Australian navigation. NASA supplies BMR with 70 mm imagery which is distributed through the Division of National Mapping to 53 organizations taking part in the experiment.

Because of an RBV and tape-recorder malfunction on August 8, only MSS images of Australia have been taken.

The second tape-recorder became faulty and was switched off on March 29, and since then no more images of Australia have been taken. It is estimated that total coverage of Australia is about 80%; coverage actually held by the Division of National Mapping at present is about 60%.

Results

Preliminary studies in the Alice Springs and Canberra areas have been made, mostly by examining positive transparencies enlarged to 1:1 000 000 scale on a light table with a magnifier or mirror stereoscope.

In the Alice Springs area the gross features of the geology, known from regional mapping, can be discerned on the imagery. Some new information, principally broad lithological divisions in the Arunta Complex, and a broad differentiation of soil types in alluviated areas, has been obtained.

In the Canberra area most lithostratigraphic boundaries shown on the 1:250 000 geological maps are not recognizable on the imagery, though in places a broad distinction between sedimentary and intrusive rocks can be made on the basis of topographic expression and fracture pattern. Many lineaments can be seen, some of which correspond with previously mapped faults, some are on the continuations of such faults and some are new. In the south of the sheet area some semicircular depressions apparently associated with intrusive rocks are not shown on the map.

No field checking of either area has been done.

HAIL CREEK THERMAL INFRARED INVESTIGATIONS

RESULTS AND PROBLEMS

C.J. Simpson

The BMR Photogeology and Remote Sensing Group has been attempting to evaluate the geological applications of aerial thermal infrared imaging techniques. For most geological problems the technique must be regarded as experimental rather than operational at this stage.

In August, 1971, an aerial thermal imaging survey was carried out over parts of the extensive coking coal deposits of the Hail Creek Syncline in the Bowen Basin.

The Upper Permian sediments of the Hail Creek Syncline contain the Fort Cooper and Elphinstone coal measures. Three main coal seams within these measures form an asymmetrical synclinal structure approximately 6km wide and 12km long which closes to the northwest. On the east limb seams dip west at 15°-60° while on the west limb they dip east at 6°-12°.

Erosion over the sediments of the syncline is at a mature stage resulting in low topography and extensive soil development. These factors make it virtually impossible to predict where the measures should occur in the subsurface. The area was a good target for evaluating thermal imagery because it contained a specific geological problem, there was extensive subsurface drill hole data, and the surface was relatively undisturbed.

The aims of the BMR project were to evaluate the potential of infrared imagery for; (a) detection of coal under varying depths of soil,
(b) its capability to differentiate soil derived from coal from soil of other derivation. If positive results could be obtained for one or both of the above then thermal imaging could be applied as an exploration technique over other areas of the Bowen Basin.

In planning a thermal infrared survey the following factors have to be determined. Type of detector to be used, optimum time, flight details, operational support requirements, ground data to be collected.

Of the two detector types available (ie. 3-5.5 and 8-14 micrometre) the 8-14 micrometre detector is preferred for most terrain features since it coincides with the peak blackbody radiation of the earth's surface. At Hail Creek an 8-14 micrometre detector was flown under contract by QASCO Air Surveys using a "Daedalus" scanner, owned by the University of Newcastle.

The optimum time of surveying will be controlled by the target under consideration. At Hail Creek it was hoped to conduct the survey during a dry time of the year to minimise effects of soil moisture content. Unfortunately (and unpredictably) rain occurred in the area 2 days before the survey commenced. The optimum time to image within the diurnal cycle is when the maximum difference occurs between the thermal energy of the target and that of the surrounding material. There are so many variables which can affect estimation of this time that at present accurate prediction is not possible for other than a few geological situations.

At Hail Creek three flight times were planned approximating to pre-dawn (0400 hr) midday (1100 hr) and post-sunset (2000 hr).

For best sensor resolution and target detectability it is advisable to keep the flight altitude below 900 m. At Hail Creek the survey was carried out at 600 m above mean ground level.

The main operational support requirements to be considered are those assisting aircraft navigation. This is particularly essential during night time flights and will require ground markers (preferably in the form of amber flashing lights). The type of marker required will largely depend on the vegetation cover in the survey area. At Hail Creek a fairly uniform open forest cover presented aircraft navigational problems during both day and night flights.

It is essential to collect some ground data to assist with interpretation of the imagery. It may be necessary to record temperatures (e.g. in streams or dams) to allow calibration of the image grey scale. The fastest method of recording information about culture, vegetation, etc. is by aerial photography and to date all BMR thermal surveys have included conventional aerial photography flights during daylight. This has proven essential for assisting image interpretation.

On the imagery obtained, coal, or thermal effects attributable to coal were not detected. Cool anomalies on the post sunset imagery of the eastern limb occupy positions approximating to shallow coal seams. It is believed that the cool areas in this case are due to the effects of vegetation. The anticipated thermal effects of the coal have been masked by the presence of soil and vegetation.

It is concluded that in the environment studied thermal infrared imaging is unlikely to provide any data of value to coal exploration.

Whilst the survey was not successful in locating the coal target it is considered that in such experimental evaluation negative results are as just as informative as positive results.

The co-operation and assistance of Mines Administration Pty. Limited is gratefully acknowledged by the author and his co-worker on the project, W.J. Perry.