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DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/44

GEORGINA BASIN PROJECT 1974-1980
A PROPOSAL

by

E.C. Druce

with the collaboration of P. Jell, B. Radke,
J.H. Shergold & M. Walter

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SUMMARY

The Georgina Basin rocks are mainly Lower Palaeozoic carbonates. Previous work by BMR has shown that the basin is an ideal area for the study of the relations between sediments and fossils in time and space. Furthermore, widespread and continuous limestone deposition (in the Cambrian and Ordovician), abundant fossils, interfingering of marginal facies, and uncomplicated structure combine to make it an ideal area for the setting up of a detailed Cambrian and early Ordovician chronostratigraphy. Such a stratigraphy would facilitate not only the international correlation and understanding of Cambro-Ordovician sequences but also the mapping and interpretation of other early Palaeozoic sedimentary basins in Australia.

Because of the importance of the Georgina Basin, it is proposed that BMR undertake a study concerned ultimately with sedimentary and tectonic history. The results should contribute to the search for economic hydrocarbon accumulations and metalliferous deposits of the Mississippi Valley type. Other advantages of the study will be in the interpretation of palaeo-climates and palaeogeography of part of the Australian plate in the early Palaeozoic, which could have had an important bearing on the localization of economic mineral deposits.

Outstanding fields of investigation include: (1) the extent of Lower Cambrian sedimentation; (2) the relations between the sedimentary facies in the Middle Cambrian; (3) the mapping of Middle Cambrian lithostratigraphic units; (4) the recognition and mapping of lithostratigraphic units in the Late Cambrian and Early Ordovician; (5) the environment of deposition in the Ordovician; and (6) the correlation of the Adelaidean rocks.

Apart from these specific tasks the project aims at adding to the fund of geochemical, petrological, and biostratigraphic knowledge (particularly the algae, conodonts, trilobites, and molluscs).

The proposed project will be undertaken by BMR officers from several different sections; the help of outside specialists is also proposed. The work will span seven years and comprise three field seasons, the alternating years providing time for sample preparation, data processing, and documentation of results.

This project is seen as producing a regional biostratigraphic and environmental framework which can be used to advantage in the interpretation of the more structurally complex Amadeus and the relatively poorly exposed Wiso and Daly River Basins.

The results will be published in BMR Bulletins, Reports, the 1:100 000 and 1:250 000 Map Series, and where appropriate, outside publications.

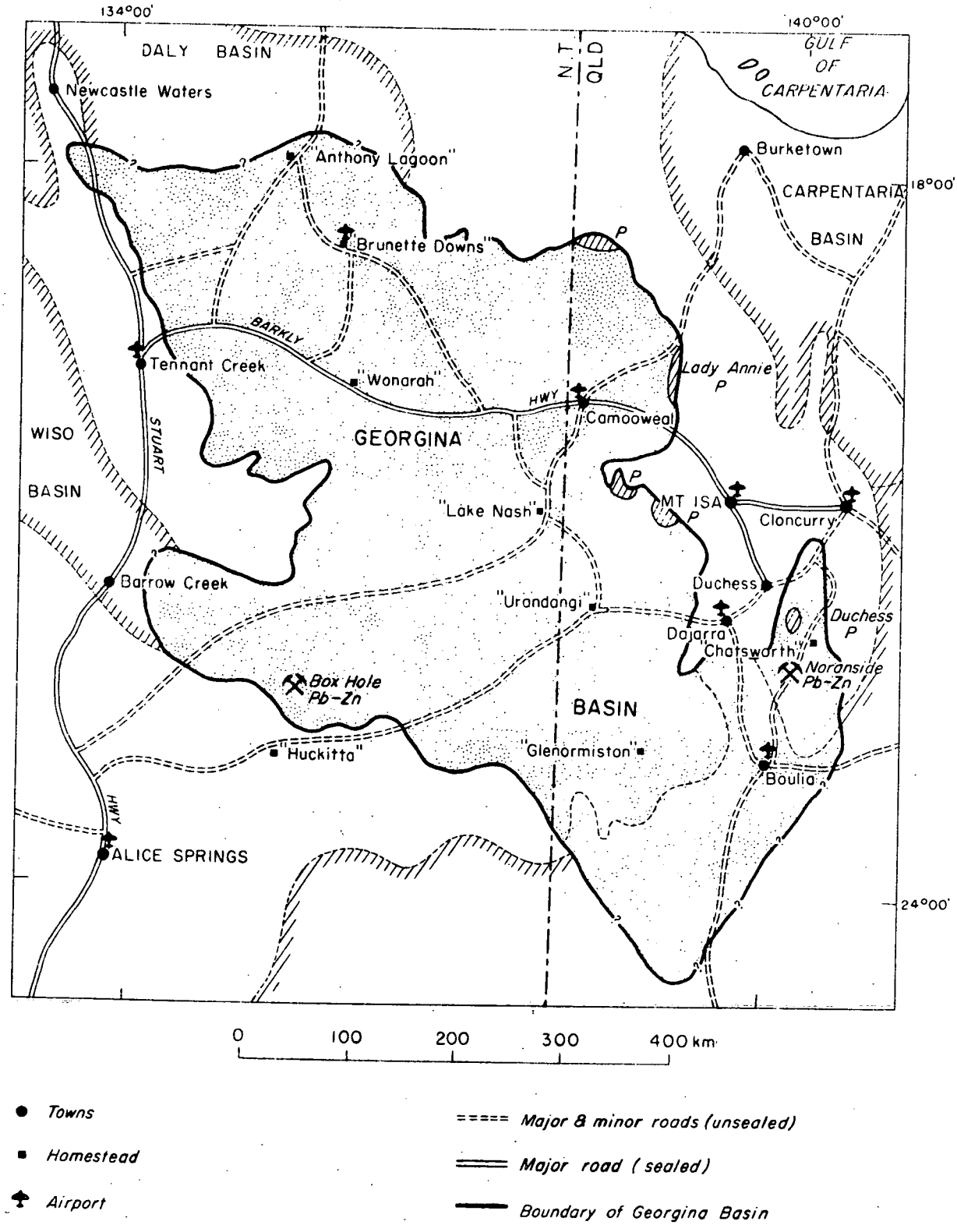

Fig.1 Geographical setting: Georgina Basin

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1. INTRODUCTION

Geographical setting (Fig. 1)

The Georgina Basin covers an area of roughly 325 000 sq km in western Queensland and the Northern Territory extending over all, or part of, twenty-one 1:250 000 Sheet areas.

The country ranges from desert to semi-desert; sheep stations predominate in the southeast and cattle stations in the north and west, but much of the central and southern area cannot be utilized.

Urandangie (pop. 30) and Boulia (pop. 300), the only towns situated within the basin, provide fuel, stores, and telegraphic and postal communications. The main town near the eastern margin is Mount Isa (pop. 20 000) and on the western margin Alice Springs (pop. 5000). Both centres can provide stores and supplementary equipment and both have airports, hospitals, and RFDS radio and aircraft bases.

Sealed roads, unsealed roads, and station tracks suitable only for four-wheel-drive vehicles provide access to all but the desert areas. The basin is cut from east to west by the Barkly Highway, a sealed road, and the main north-south highway (Stuart Highway) skirts the western margin. The sealed Dajarra-Boulia-Bedourie and Boulia-Winton roads provide access to the southeastern margin, and the sealed Anthony Lagoon-Wonarah road provides access to the northern part. The road from Urandangie to Alice Springs which is not kept in good condition, provides access for four-wheel-drive vehicles to the south central part. Access is poor in the region between the Barkly Highway and the Urandangie-Alice Springs road, and south of Tobermory Station in the northern part of the Simpson Desert.

Apart from the major airports at Mount Isa and Alice Springs, scheduled services are flown to Boulia, Brunette Downs, Camooweal, and Tennant Creek. Station 'milk run' services are operated to most stations in the area by Bush Pilots Airways (Mount Isa) and Connellan Airways (Connair, Alice Springs).

Stratigraphic setting (Figs. 2, 3) (after Smith, 1972)

The basin consists predominantly of marine rocks of Cambrian and Early Ordovician age. The Precambrian-Lower Cambrian sequences are conformable in the southwestern (Huckitta) area; elsewhere in the southern margin Middle Cambrian rocks overlie late Precambrian Field River Beds. In the northwestern area Middle Cambrian rocks unconformably overlie the folded Precambrian of the Cloncurry Complex. In the northern and western

Magnetic surveys (Fig. 6). BMR conducted an aeromagnetic survey of the Georgina Basin in 1963-64 (Wells et al., 1966) from which it was concluded that the sedimentary section within the basin is at least 3000 m thick in several places but that much of the sequence may be Proterozoic. Most of the magnetic basement is considered to belong to the Precambrian Arunta Complex. The major depressions in the magnetic basement coincide with the gravity lows; depth to magnetic basement is up to 6000 m in the Toko Syncline. Depths to basement of over 2500 m are present in the Dulcie Syncline in the west; in the southeast Sandover River area extending southeast to the southwest corner of the Glenormiston Sheet in the south central part; and in the Ranken-Avon Downs-Camooweal area in the north of the basin.

Large-scale mapping

The discovery of phosphate deposits in the northeast part of the Georgina Basin by Broken Hill South in 1966 stimulated a detailed stratigraphical and palaeontological study of the Cambrian sediments in this area by BMR. The results were published in several BMR publications (de Keyser & Cook, 1972; Cook & Armstrong, 1972; de Keyser, 1968, 1969a, b, 1973).

The reassessment of the geology of this area, by Cook & de Keyser, was based on the idea of lithosomes - gross lithological units interfingering with one another. Previously the geology had been interpreted as a 'layer-cake' sequence.

They also modified Smith's (1972) definition of the basin to include late Proterozoic sediments.

Most of their work was concerned with Middle Cambrian rocks and was confined to the northeast and central eastern margin of the basin. Phosphorite is widely distributed in this region and is present in the Chert-Siltstone-Limestone-Phosphorite Lithosome. The depositional environment is considered to be shallow and near-shore, probably open marine.

Other detailed surveys have been conducted by companies with leases in the phosphate-bearing areas.

Local geophysical surveys

Gravity surveys (Fig. 5). Mines Administration Pty Ltd conducted a gravity survey for The Papuan Apinaipi Petroleum Co. Ltd during 1959 (PAP, 1962) in the southeastern part of the Basin over the Toko Syncline Low and the Cloncurry Gravity High.

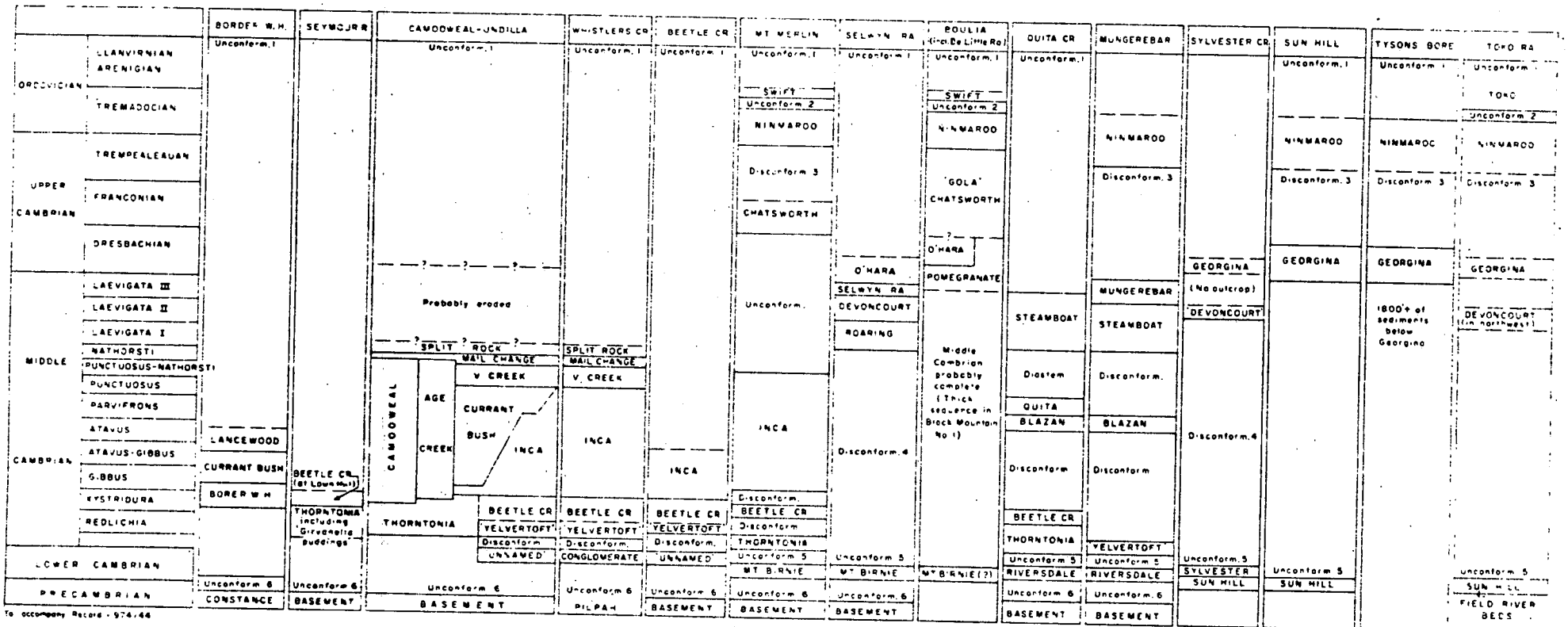

Fig. 2 Stratigraphic columns: Georgina Basin (from Smith, 1972)

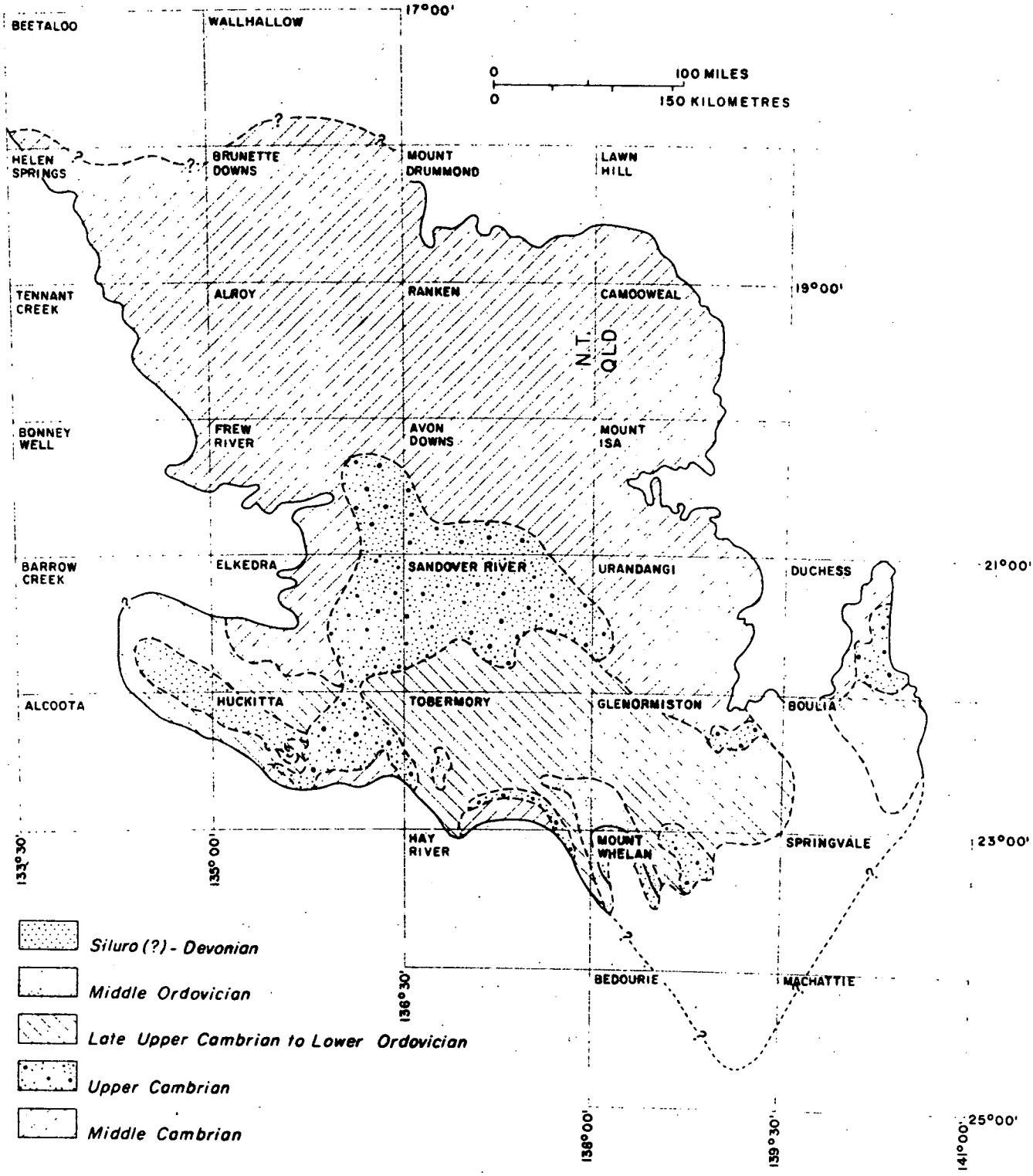

Fig. 3 Generalized geological map: Georgina Basin

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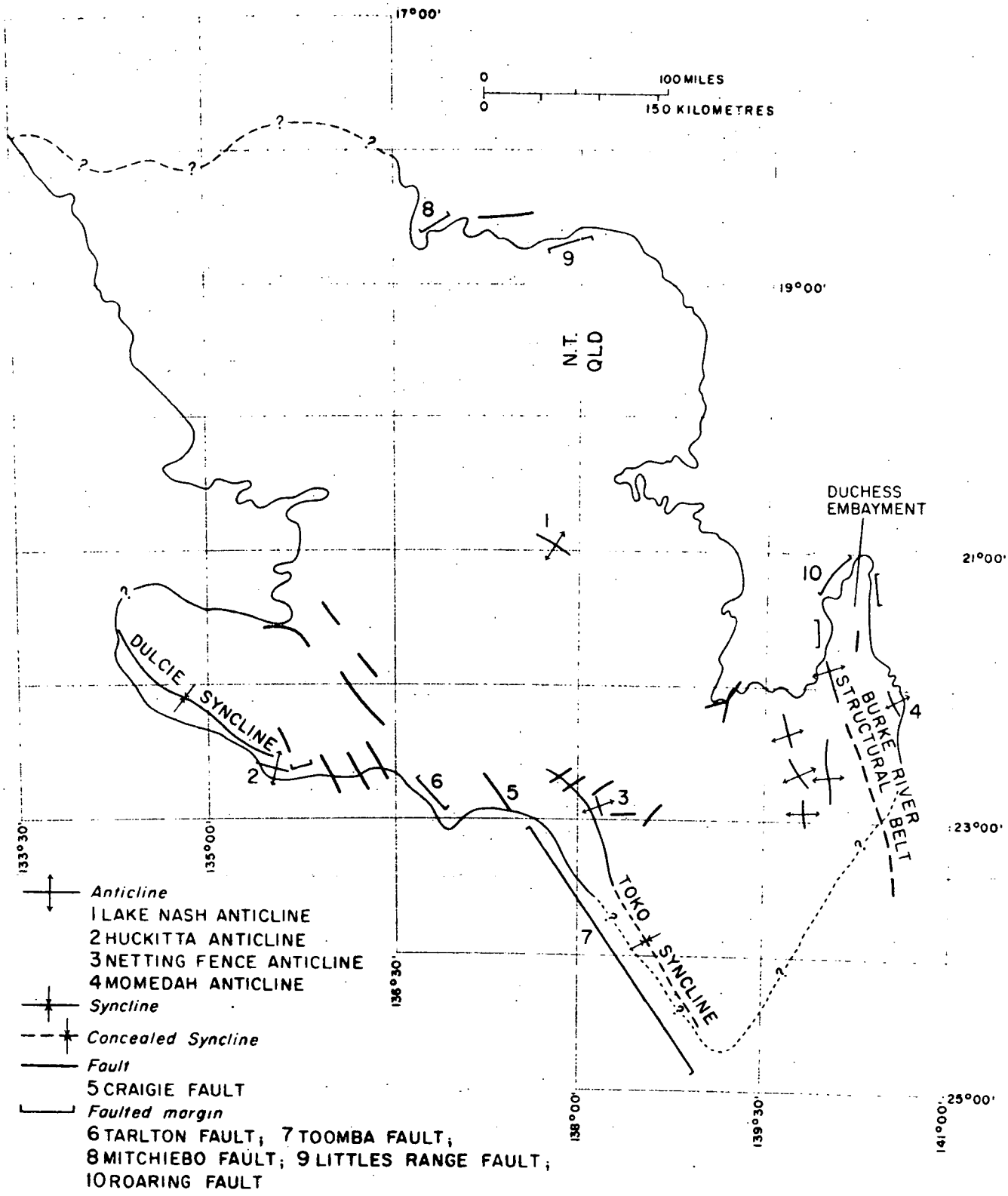

Fig. 4 Main structural features: Georgina Basin

Major faulting has occurred; the general trend is NW-SE, parallel to the basin axis. Virtually the whole of the southern margin is faulted, from the Toomba Fault in the southeast to the Tarlton Fault in the south central area. The Duchess embayment in the east also has a faulted margin. The central northern margin is formed by the Mitchiebo and Littles Range Faults.

The Georgina Basin is situated to the east of the Amadeus and Ngalia Basins, both of which have been affected by the Alice Springs Orogeny (?Carboniferous). Little of the effects of this orogeny are seen in the Georgina Basin except in the southwest part where folding (Dulcie Syncline) and marginal faulting are common.

2. PREVIOUS INVESTIGATIONS

Regional mapping

The first systematic mapping of the Georgina Basin was carried out by BMR in the period 1950-65. The eastern margin was mapped in a joint survey by BMR and the Geological Survey of Queensland in the period 1950-54; the major part of the basin was mapped in the period 1957-65; and in the southeast some 1:250 000 Sheets were mapped during a survey of the Great Artesian Basin.

The results of these surveys were presented by Smith (1972) in the BMR Bulletin series. The main conclusions are in the sections dealing with stratigraphic and structural setting; additionaly it should be noted that formal division of the Middle Cambrian was based on faunal content although lithologically many of the units are similar, and that minor tectonism occurred in the Middle Ordovician.

Regional geophysics

Gravity surveys. The first regional gravity study of the basin was conducted by BMR in 1960-61. The results were presented by Barlow (1966). The regional gravity picture is in close accord with the surface structure. The Toko Syncline is a region of low gravity, as is the southwest margin (Hay River and Huckitta Gravity Lows). A thicker sequence of sedimentary rock is also suggested by the lows in the Ammaroo Sub-basin (northern part of Huckitta and southern part of Elkedra Sheets) and the Sandover Gravity Low in the central part of the basin. The Cloncurry Gravity High characterizes the eastern margin of the basin. The Ooratippra Gravity High separates the Ammaroo Sub-basin from the Sandover Gravity Low.

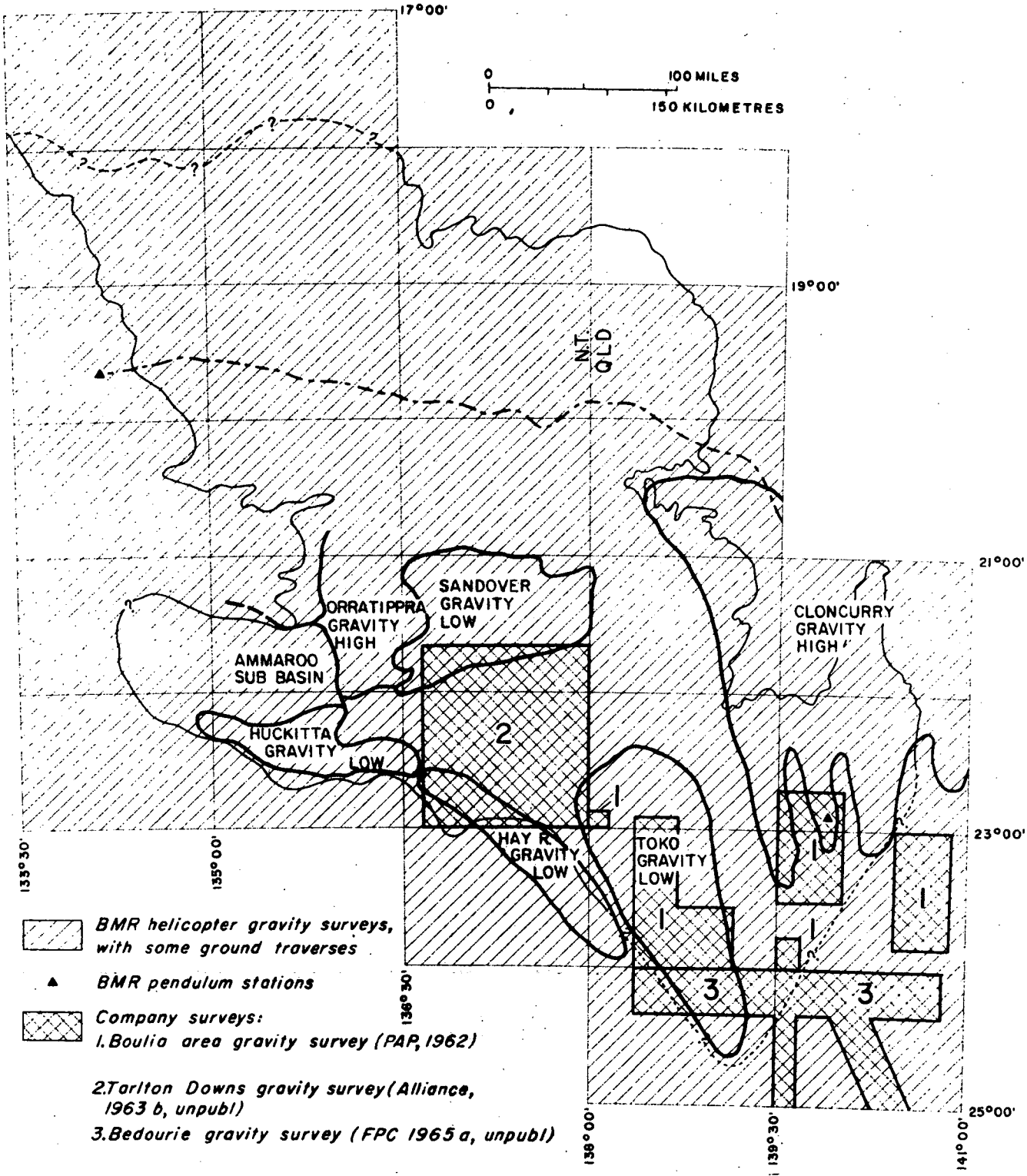

Fig.5 Gravity surveys: Georgina Basin

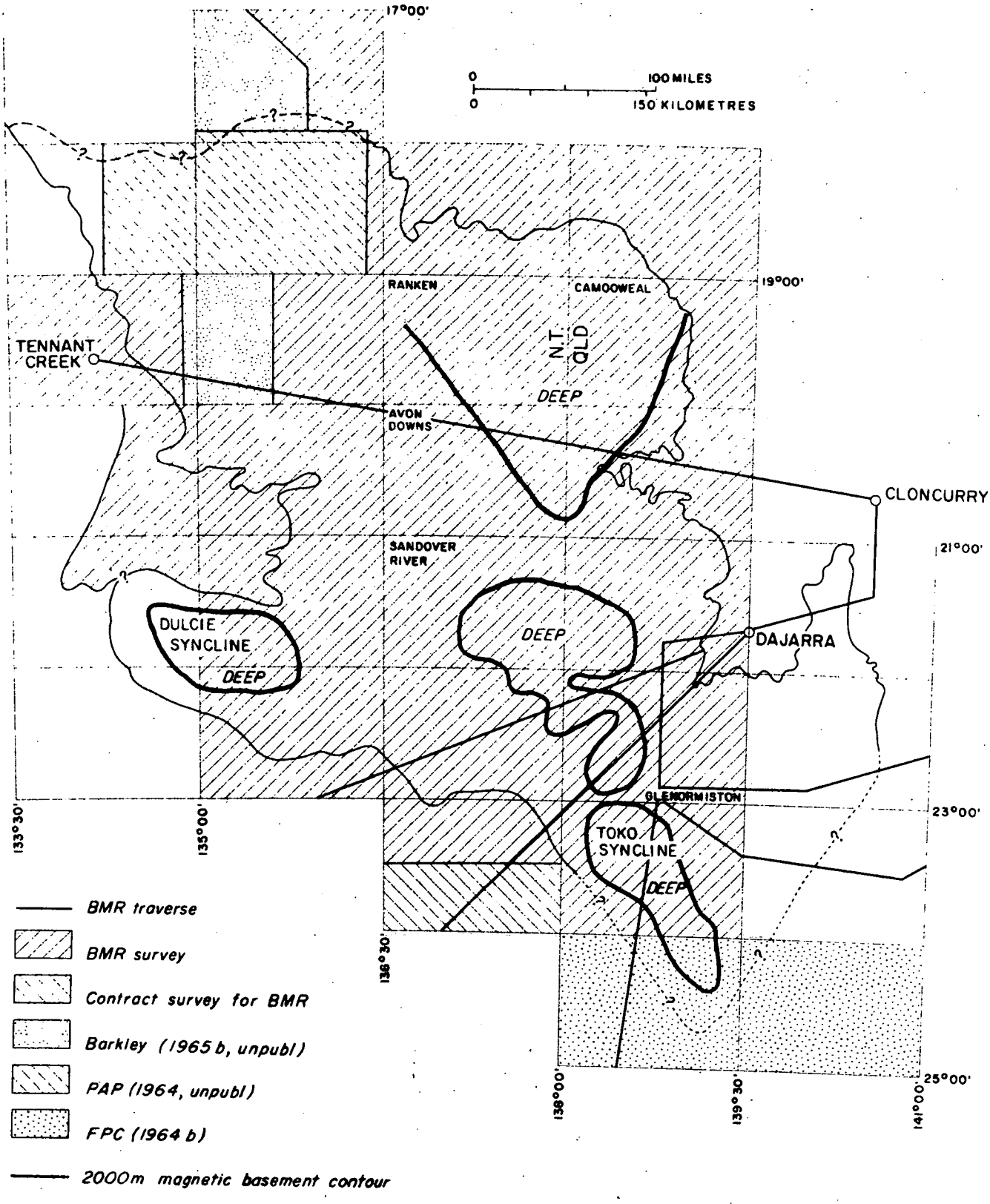

Fig.6 Magnetic surveys: Georgina Basin

The Cloncurry Gravity High is shown to be a series of four separate parallel highs orientated NNW-SSE. They are situated near Glenormiston homestead, 16 km west of Boulia, just east of Hamilton, and 16 km west of Middleton.

The highs are interpreted as indicating the presence of Precambrian structural features. The difficulties in interpretating the results are compounded by the fact that the Palaeozoic limestones have a similar density to the Precambrian rocks (Gibb, 1966).

Seismic surveys (Fig. 7). Detailed seismic surveys have only been conducted in the southeastern part of the basin, and have been especially concerned with the Toko Syncline area. Poor results have been obtained in areas of massive cavernous limestone (Robertson, 1965; Montecchi & Robertson, 1966; Jones & Robertson, 1967). The major surveys have been conducted by BMR, French Petroleum, and Alliance Oil Development.

The Ninmaroo Formation is a major reflector in this area. There are no reflectors above this formation and only one reflector below, which is presumed to be the sediments/basement boundary.

Seismic investigations have suggested the presence of up to 1500 m of sediments in the core of the Toko Syncline but the nature and age of this sequence is unknown.

In the region of the Toomba Fault the presence of 'basement' (inferred from gravity surveys) overlying deepening reflectors of the Ninmaroo Formation indicates overthrusting.

Palaeontology

Algae. Stromatolites from the Arrinthrunga Formation were briefly studied by Madigan (1932) and Casey & Tomlinson (1956). Walter (1972) described one species from the Mount Baldwin Formation. These papers demonstrated the presence of stromatolites within the Precambrian and Lower Palaeozoic sequence.

Conodonts. Conodonts were found by P.J. Jones in 1960 in the Middle Cambrian to Middle Ordovician part of the sequence. Later, Druce spent one field season and two part field seasons in the field collecting detailed sections, especially in the Burke River Structural Belt and the Toko Range area. Some of these results were published in Druce & Jones (1968; 1971) and Jones, Shergold & Druce (1971). A thesis on conodonts from the Toko Range was submitted to Queensland Univ. by Miss C. Nieper.

These studies have shown that a workable conodont zonation can be erected in the Georgina Basin and that it is closely similar to a zonation independently erected for sedimentary basins in the USA.

Crustaceans. The major groups known from the Georgina Basin are the Ostracoda and Bradoriida; the latter may be ancestral to the Ostracoda.

The Bradoriida have been recovered from Middle Cambrian and Upper Cambrian rocks. Opik (1961, 1963, 1967a, 1968) and Fleming (1973) show that the order has considerable taxonomic diversity in time and a wide geographic distribution throughout the Australian Cambrian succession, criteria necessary for useful biostratigraphic use.

Ostracoda have a first occurrence in the Lower Ordovician; they have been recorded from the Lower and Middle Ordovician of the Basin, from isolated localities. They are also present in the Lower Devonian non-marine sequence.

The few reports show that ostracoda are present, though not abundant, and are some of the oldest known in Australia.

Fish. Fish faunas collected by BMR officers in the Dulcie Range (southwest part of the Basin) have been described by Hills (1959) and Tomlinson (1971). This work established the presence of both Bothriolepis and Phyllolepis in the sequence and indicates Late Devonian age. Material from lower in the sequence is probably Middle Devonian.

The fauna from the Craven's Peak Beds was discovered by P.J. Jones in material collected in shotholes drilled by Austral Geoprospectors Pty Ltd in 1960. The material was studied by Jones and he concluded that the fauna was Dittonian (Early Devonian).

In a personal communication, Ritchie (Australian Museum) reports that a Middle Devonian fish has been discovered from the Craven's Peak Beds in the Toko Range area.

Molluscs. Extensive collections of ribeirioids have been made by BMR parties from the Ninmaroo, Tomahawk, and Kelly Creek Formations, all of Early Ordovician age. No detailed account has yet been published but some control of distribution by environment is apparent. The forms in the Tomahawk Beds (the lateral clastic equiavelent of the Ninmaroo Formation) are different from those in the Ninmaroo Formation. Gastropods (Tomlinson, 1971) also occur in the Ordovician.

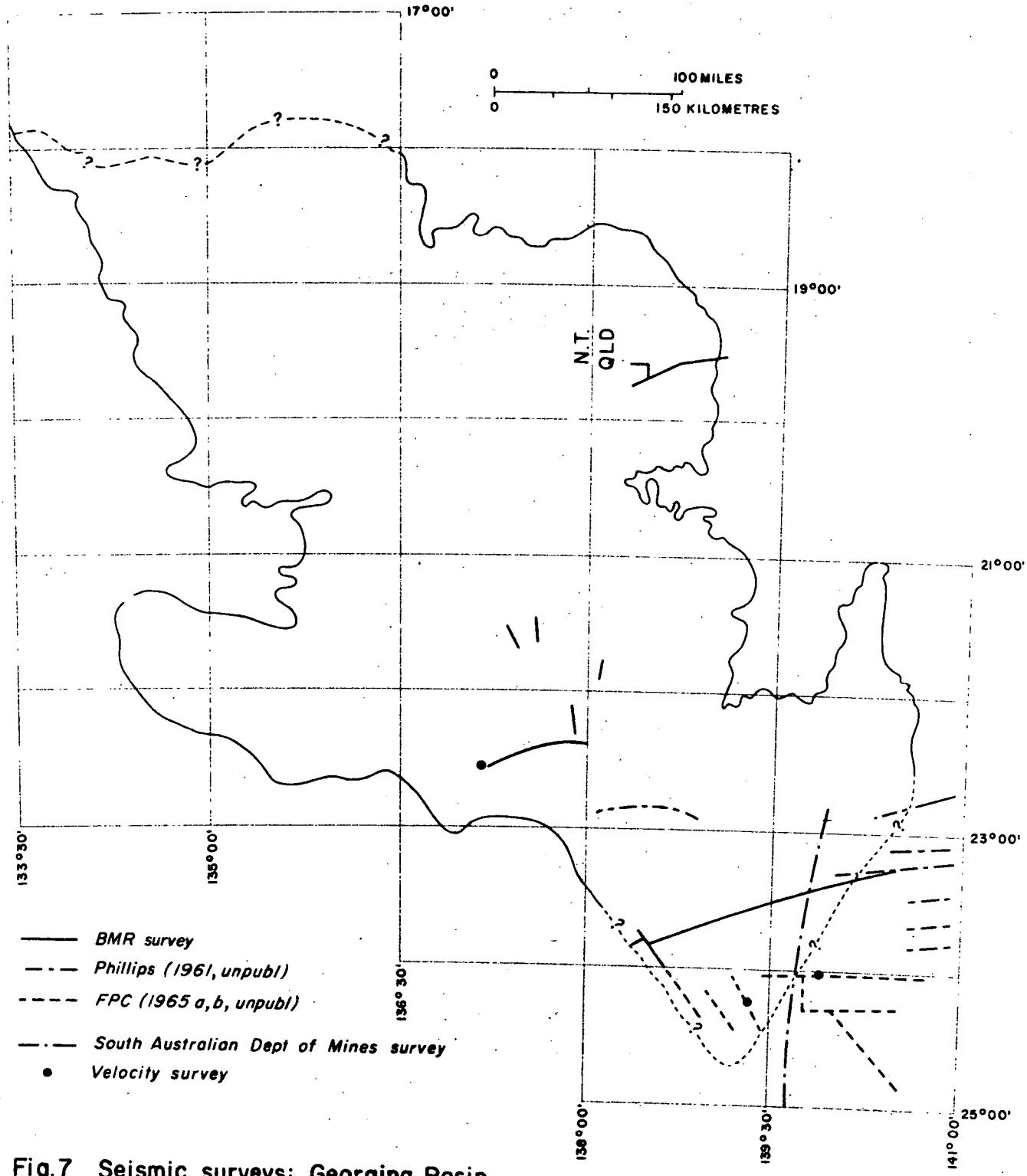

Fig.7 Seismic surveys: Georgina Basin

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Nautiloids. Nautiloids are extremely abundant in the Middle Ordovician Nora Formation and are also present in the Lower Ordovician Ninmaroo Formation and the Middle Ordovician Coolibah Formation. No detailed study has appeared but they have been illustrated in Hill et al. (1969). The fauna appears to be varied, and species known from other parts of the world are present.

Brachiopods. Published work on the Cambrian and Ordovician branchiopod faunas of the Georgina Basin is negligible. For the past four years, however, Dr R.A. Henderson, James Cook University of North Queensland, has been collecting material and using existing BMR collections in order to expand understanding in this field of research.

Trilobites. Studies of the abundant trilobite faunas in the Cambrian have been carried out by Etheridge (1897), Whitehouse (1936, 1939, 1940, 1945), Opik (1961, 1963, 1967 inter alia) and Shergold (1971).

Trilobites are of common occurrence in inner detrital belt sandstones and sandy dolomites along the southern fringes of the Georgina Basin, and in the carbonates which occur mainly in open shelf environments along the outer (ocean-facing) margins of the carbonate belt, around the eastern periphery of the Basin (Burke River area). They are relatively uncommon within the dolomites and stromatolitic limestones which form the carbonate belt (sensu stricto) in the Glenormiston-Tobermory-Urandangi triangle, and this poses problems in correlating inner detrital and outer carbonate belt faunas within the limits of the Basin.

As part of his program to describe the late Cambrian trilobite faunas of central and northern Australia, Shergold has previously described trilobites from the Gola Beds (Shergold, 1971) and those from sections at Black Mountain, Mount Ninmaroo, Mount Datson, and Dribbling Bore, in the southern part of the Burke River Structural Belt (Shergold, in press). As a result of this work, seven zones are now recognized in rocks of Late Cambrian age along the eastern margin of the Georgina Basin.

Drilling (Fig. 8)

Thirteen wildcat wells have been drilled in the Basin, and BMR has drilled three stratigraphic holes (Milligan, 1963; Smith et al., 1967). Of these, nine reached Precambrian basement and four Adelaidean sediments.

The results showed that sedimentary cover is thin in the northern part of the basin (300-600 m) with thicknesses increasing to 2000 m in the south.

The results of the drilling showed the usefulness of subsurface information in determining the extent of units, especially in the areas of poor outcrop in the central and northern parts of the Basin.

Hydrology

The first detailed hydrogeological study of areas within the Georgina Basin was undertaken by BMR (Randal, 1967). This study, which was confined to the Barkly Tableland in the northern part of the basin, showed that at least two groundwater areas exist, one based on the Georgina drainage system and the other confined to the northwest part of the basin. Because of this study the depth to adequate supplies can be estimated, pump position calculated, a rough estimate of supply given, and the salinity estimated. Randal (in prep.) has conducted a similar study for the Queensland part of the Basin for the Queensland Geological Survey.

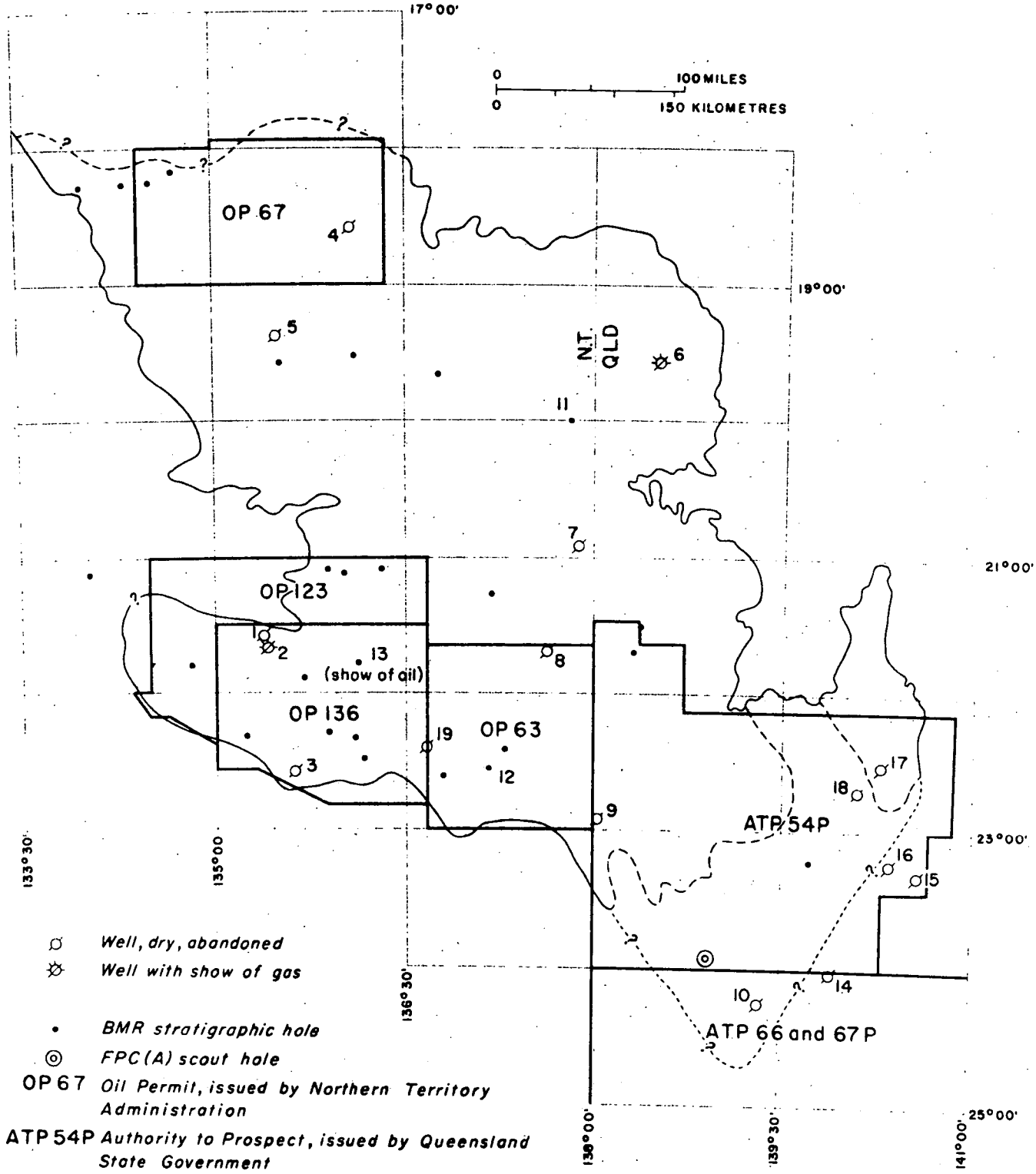
At present no detailed study of the hydrogeology of the southern and western parts of the basin has been published.

Mining

Phosphate. Rock phosphate was initially discovered by Broken Hill South in the Duchess area in the northeast part of the basin (Russell, 1967). Subsequently large phosphate deposits have been discovered on the northern and northeastern margins of the basin and in the region of the Alexandria-Wonarah Basement High. Distance from cheap transport has meant that the Lady Annie and Lady Jane deposits 95 km east of Camooweal will be mined before the much larger deposit at Duchess. A new port in the vicinity of Wellesley Islands in the Gulf of Carpentaria is planned.

The phosphate rock is Middle Cambrian and was deposited in a nearshore environment. The economics of transportation has concentrated the search in the northern part of the basin. However, high phosphate values have been obtained from the Middle Cambrian section in Black Mountain No. 1 and The Brothers No. 1 wells in the southeastern part of the basin (Fig. 8).

Lead-zinc deposits (Fig. 1). Three minor shows of lead and zinc are known: two in the east near Noranside (Casey, 1968) and Totts Creek (Blanchard & Hall, 1942) and the other in the southwest near Box Hole Bore (Woolley, 1961; Cons. Zinc, 1961). These deposits appear to be non-commercial, although leases have been taken out in the vicinity of both occurrences. The mineralization is in the Upper Cambrian Arrinthrunga Formation (Box Hole) and the Lower Ordovician Ninmaroo Formation (Noranside). High lead and zinc anomalies are also known from the Middle Cambrian sediments associated



1. Ammaroo No 1
2. Ammaroo No 2
3. Huckitta No 1
4. Brunette Downs No 1
5. Frewena No 1
6. Morstone No 1
7. Lake Nash No 1
8. Mulga No 1
9. Netting Fence No 1
10. The Brothers No 1
11. BMR 11 (Cattle Creek)
12. BMR 12 (Cockroach)
13. BMR 13 (Sandover)
14. Marduroo No 1
15. Elizabeth Springs No 1
16. Canary No 1
17. Black Mountain No 1
18. Beantree No 1
19. Lucy Creek No 1
20. Ethabuka No 1

Fig.8 Deep drill sites: Georgina Basin

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with the phosphorite deposits.

Other minerals. A small copper sulphide deposit is reported from Cambrian limestones 90 km ENE of Camooweal (Maxwell, pers. comm.). Minor manganese deposits have been recorded scattered through the basin (Smith, 1972). Pisolitic iron ore has been reported as a minor occurrence in the Huckitta area (Vine, 1959). Fluorine occurs in some waters in the Boulia area, especially in the area around the Black Mountain Fault (Casey, 1968).

Sedimentology

Previous sedimentological studies have been few. Brown (1961) described the sequence in the Burke River Structural Belt. His efforts were mainly descriptions of lithostratigraphic units of the Ninmaroo Formation. This study lacked diagenetic and geochemical information to substantiate his proposed model of depositional environments.

Records of descriptive petrology were produced by Nichols (1966) and Brown (1962, 1963). Both authors included samples from the Middle Cambrian sequence in the northeast part of the Basin. Nichols's work was on a regional scale, briefly covering the whole carbonate province of the basin.

De Keyser & Cook (1972) presented detailed petrologic, geochemical, and lithostratigraphic study of the phosphate deposits along the eastern limits of the basin.

3. OUTSTANDING PROBLEMS

Geological problems

Considerable work has been undertaken by BMR in the Georgina Basin. However, most of this work was of a regional nature, and many specialist tasks remain to be done, and local areas investigated in detail.

Regionally the Basin lacks a geochemical and a petrological study. Seismic surveys have all been local and seismic coverage is lacking in all but the southeastern part; however, past results from the area northwest of the Toko Syncline (Montecchi & Robertson, 1963) suggest that until techniques are developed which overcome the problem of poor records caused by cavernous and fractured limestone and methods are devised which prevent the strong reflections from the Early Ordovician Ninmaroo Formation masking reflections

originating in underlying rocks, there is little point in attempting a basin-wide seismic coverage.

Mapping by BMR in the Basin was originally of two types based on lithostratigraphy and biostratigraphy. Lithostratigraphic mapping concentrated on the Upper Cambrian and Ordovician units whereas the Middle Cambrian was mapped using biostratigraphic units in sequences of similar lithology.

The work of the Phosphate Group of BMR (de Keyser & Cook, 1972) showed that in the Middle Cambrian of the Duchess and Ardmore areas a workable lithostratigraphy can be recognized. They suggested that various lithologies interfinger and that the sediments could be grouped into six lithosomes. The Middle Cambrian sediments of the whole Basin should be critically re-examined, a viable lithostratigraphy erected and maps of those units produced.

Outstanding areas for further investigation because of the excellent outcrop are in the Burke River Structural Belt, the Toko Range area, the Glenormiston region, the Undilla embayment, and the Huckitta region. These sequences would produce reference sections covering the major intervals represented in the basin.

The results of detailed mapping could then be used to elucidate the geology of the more poorly exposed areas, in the central part of the basin, from the northern to the southern margin.

Detailed problems are:

a. The inception of widespread sedimentation in the Basin; Adelaidean or Middle Cambrian?

b. The facies relationships of the Middle Cambrian and the recognition of mappable lithological units.

c. The lithological divisions of the Upper Cambrian and the facies relationships, especially around the southern margin.

d. The relationship of the Lower Ordovician Ninmaroo Formation to the Tomahawk Beds and the underlying Arrinthrunga Formation.

e. The environment of deposition and former areal extent of the Middle Ordovician.

f. The former extent of marine transgressions, especially in the south-east, west, and northwest.

g. The nature of the southern margin.

h. The relation between the eastern margin of the Amadeus Basin and the southwestern part of the Georgina Basin.

i. The age and distribution of the late Precambrian units.

j. Correlation of the Adelaidean, especially the tillite horizons, with the Amadeus Basin.

k. The age and stratigraphic sequence of the Devonian Dulcie Sandstone and Cravens Peak Beds.

Biostratigraphic and palaeontological problems

Algae and Precambrian metazoans. Outstanding problems include:

a. The position within the Mopunga Group of the Precambrian/Cambrian boundary.

b. The age of the metazoan fauna of the Central Mount Stuart Beds.

c. The biostratigraphy of the algal floras in the Precambrian and Cambrian.

Conodonts. At present a detailed conodont zonation has been erected only for the Lower Ordovician (Tremadocian).

Recent studies in North America have shown that a workable zonation may be possible in the Upper Cambrian; this should be attempted in the Georgina Basin.

The late Lower and Middle Ordovician faunas are abundant and lend themselves to a detailed zonation. They also contain many unknown forms and forms similar to presently undescribed faunas from Arctic Canada.

Ecological control has been demonstrated in conodont faunas from the Devonian and Carboniferous, but, as yet, no detailed study of the relation between morphology and environment has been conducted in the Cambro-Ordovician.

Crustaceans. The recognition of the Bradoriida within the basin and their potential as biostratigraphic 'tools' means that a controlled collecting program is needed. This would enable a formal biostratigraphic zonation to be erected, which could complement the existing trilobite scale.

The knowledge of Ostracoda within the basin is minimal and they appear to be rare. However, a concerted search as part of the Bradoriida project could yield faunas which would be useful in determining palaeoecological conditions.

Fish. The relations between the Early, Middle, and Late Devonian faunas are still unknown. Work on the faunas in the Georgina Basin will aid in the interpretation of faunas from New South Wales.

Molluscs. The primitive mollusca appear to be useful environmental indicators, but detailed collections and a thorough taxonomic study will be necessary before this can be proven. These molluscs (ribeirioids) are probably ancestral to the Pelecypoda and related molluscan classes; detailed study would throw new light on the origins and evolution of some of the molluscan classes.

Nautiloids. A detailed study of the nautiloids could produce an important biostratigraphic zonation which could be compared to and used alongside the trilobite and conodont assemblage zones.

Brachiopods. Most of the limestones and many of the sandier intervals throughout the early Palaeozoic of the Georgina Basin contain brachiopods, and it is quite feasible to erect a brachiopod biostratigraphy which would complement, and at times implement, conodont and trilobite biostratigraphies already studied.

Trilobites. The majority of the fauna from the Cambrian and Ordovician of the Northern Territory is, as yet, undescribed. In the Queensland part of the basin Opik and Shergold have described much of the Cambrian fauna and have erected a trilobite zonation for most of the middle and Upper Cambrian.

The gap in the biostratigraphy, covering medial Upper Cambrian time, will be filled by work currently progressing on post-Idamean faunas from sections around Chatsworth homestead, again in the Burke River area. On the completion of this project, a reasonably complete sequence of trilobite faunas from carbonate and outer detrital belt environments will be available for the eastern margin of the basin.

4. AIMS AND OBJECTIVES

The project is intended to be a field-orientated analysis of the Georgina Basin. This basin is selected for this initial study because of its relatively simple structure, the varied and interfingering rock types, and abundant fossils that are relatively restricted in time.

An integrated palaeontological, sedimentological, and geochemical approach can be used in the analysis. Both sediments and fossils vary according to the depositional environment. Benthonic forms tend to vary with the sediment whereas variability in the planktonic and nektonic forms is often independent of substrate but closely related to the configuration of the depositional basin. The determination of the amount of ecological control faunal assemblages would probably alter the stratigraphy sufficiently to justify new editions of 1:250 000 maps; the Lawn Hill, Camooweal, Mount Isa, Urandangi, and Duchess Sheets would fall within this category. Furthermore, these sheets include all significant areas of Precambrian outcrop, so production of second editions or revised 1st editions demands co-operation between the Georgina Project and Metalliferous Section.

The major objective is to produce an integrated geological study of the basin; the data and interpretations are to be presented in the Map, Report, and Bulletin series of BMR. Apart from regional and 1:250 000 maps of the basin, largescale maps of selected areas would be produced. Other regional maps would show palaeoenvironments, palaeogeography, and isopach maps for selected intervals.

Oil and gas

Oil and gas prospecting has met with a singular lack of success in the basin. Very minor gas shows are known from Ammaroo No. 2 and Morstone No. 1. Asphalt and bituminous patches have been reported from Netting Fence No. 1 and in surface outcrops of the Arrinthrunga and Ninmaroo Formations.

The Arthur Creek Beds and the Ninmaroo Formation commonly have a petroliferous ordour; the Marqua Beds are richly fossiliferous, and appear to be good source rocks. The domal algal stromatolites in the Arrinthrunga Formation suggest a subtidal environment; this may indicate a sabkha environment to the south, which would be a possible source area.

The project would provide information on the environment of deposition; and on possible source, reservoir, and cap rocks. This additional information would be extremely important in helping to pinpoint the areas of likely oil accumulation in a basin which has up to now proved to be disappointing.

Mineral deposits

The environmental analysis maps will aid exploration for new phosphate deposits, especially in the unexplored southern part of the basin. This area has been neglected because of the high cost of transport but this

could change in future. The regional geochemical survey may enable detection of local areas of phosphate concentration.

The Georgina Basin is a geologically attractive area for lead-zinc mineralization of the Mississippi Valley type. This type of ore deposition depends on original presence of the elements (already proven), lithology, porosity and permeability, and basement structure; orebodies are often present in the region of basement highs. A basin-wide geochemical study together with an assessment of the depositional environment, basin structure, and geological history would greatly benefit the search for lead-zinc mineralization.

Hydrogeology

The recognition and the correlation of aquifers depends on an accurate and detailed stratigraphy. The erection of a detailed chronology and the elucidation of facies relations will greatly aid hydrogeological study in the southern part of the basin.

International and regional correlation

The Georgina Basin contains one of the most complete sequences of strata from the Middle Cambrian through to the Middle Ordovician known anywhere in the world. In addition it is one of the largest carbonate provinces known, comparable in size with the Red Sea and Persian Gulf areas of modern times, although both the Red Sea and Persian Gulf sediments have a much higher clastic:carbonate ratio.

The Georgina Basin is thus unique in providing all the elements necessary to produce a detailed stratigraphy of the Cambrian and Ordovician; thick sequences of one basic rock type (limestone), good exposure, abundant fossils, and wide areal extent. In addition the intertonguing of lithofacies at the basin margin will provide evidence for the contemporaneity of different faunas.

The basic framework of a chronostratigraphy with the additional benefit of the knowledge of faunal variation with respect to lithology will be readily applicable in the Amadeus, Wiso, and Daly River Basins. It will also enable accurate dating and detailed environmental interpretation of the limited outcrops of western New South Wales (Bancannia Trough) and the extensive but subsurface Ordovician rocks of the Canning Basin.

Conodonts and trilobites have already proved useful in correlating the rocks of the Georgina Basin with European, North American, and Asian

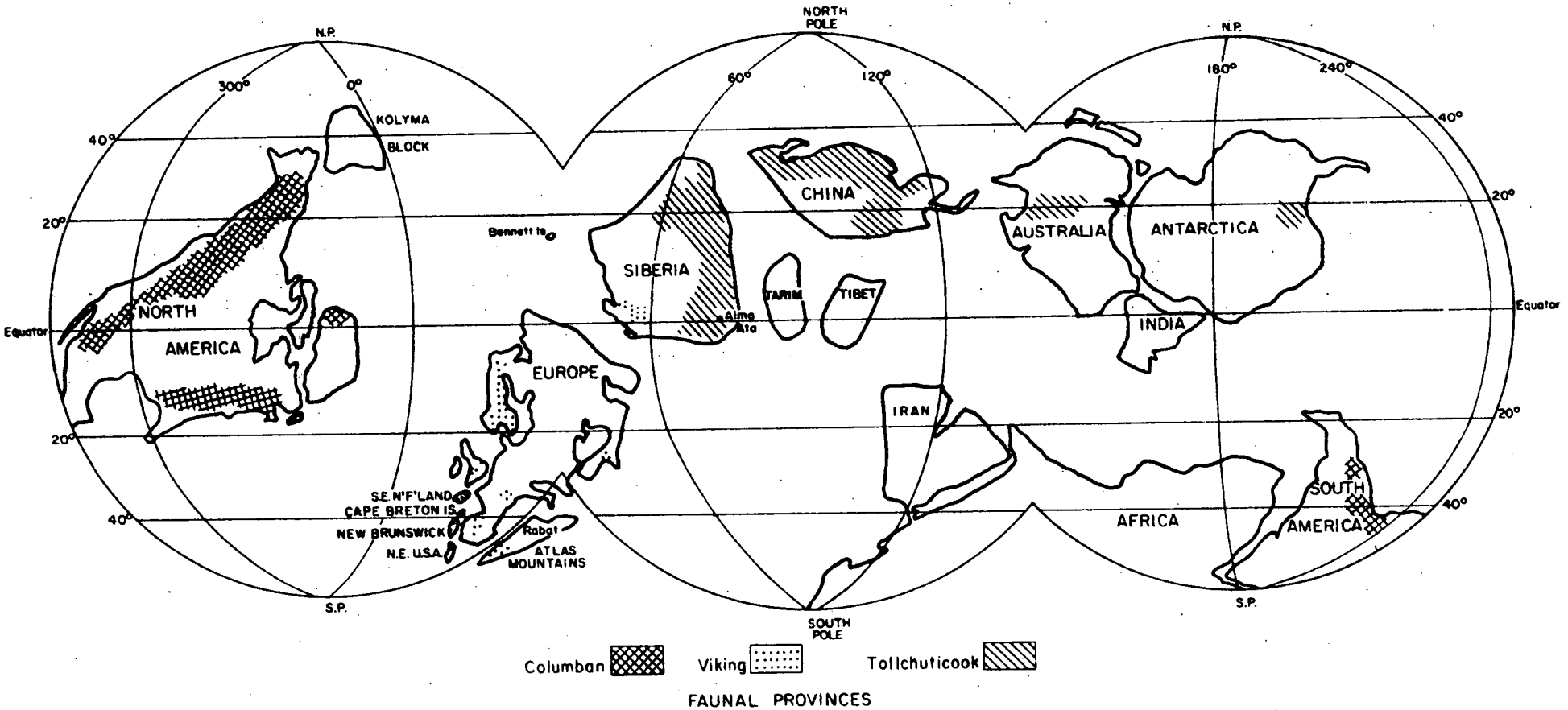

Fig.9 Middle Cambrian – Distribution of crustal fragments (after Jell), based on analysis of trilobite faunas.

To accompany Record 1974/44

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sequences. However, the Lower Cambrian, medial part of the Upper Cambrian, and late Lower and Middle Ordovician rocks still lack a detailed biostratigraphy. The completion of this will provide strong evidence for a worldwide correlation of Cambro-Ordovician sediments.

Further study of already discovered latest Precambrian to Early Cambrian fossils will aid in the establishment of an internationally acceptable Precambrian/Cambrian boundary.

Environmental analysis

In order to interpret correctly the environment of deposition it is necessary to have the maximum geological information for each rock body. This includes its size and geometry, the indications of benthonic and burrowing fauna, the nectonic fauna, the flora, and the type and nature of the sediment and sedimentary structures.

This project is directed towards collecting these data, and environmental analysis will be a natural outcome of the project. This analysis will be of further use in pinpointing areas of economic interest. The original environment of deposition plays an extremely important role in the formation and localization of hydrocarbons and sedimentary deposits of metallic and nonmetallic ores.

Finally it will aid in palaeocontinent reconstruction and give a further line of evidence to supplement palaeomagnetic and tectonic inferences.

Plate relationships in the early Palaeozoic (Figs. 9, 10)

Recent developments in geotectonics suggest that the Australian craton was not as stable during late Precambrian and early Palaeozoic as had hiherto been thought and may have been composed of more than one crustal block with junctions in central Australia. Study of the palaeontology and stratigraphy of the Georgina Basin may help to delineate the margins of these crustal blocks. The Toomba Structure running northwest along the eastern edge of the Tennant Creek Block, the line of plateau volcanics along the northern margin, and the faulted southwestern margin against the Arunta Complex have each been suggested as major geosutures.

On a broader scale the position of the constituent crustal fragments of the Cambrian and Ordovician Australian plate has considerable significance in palaeogeographic studies. Two recent studies of world palaeogeography have suggested very different relative situations of Australia, southeast

Asia, and China in the early Palaeozoic. Techniques are now being developed which employ palaeontological as well as palaeomagnetic and geotectonic data to outline palaeogeography, and this type of analysis may be particularly useful both internationally and regionally.

Plotting the routes of continental drift, siting plate collisions and breakups, and recognizing the consequent changes in sedimentary regimes is assuming considerable importance in assessment of the mineral or oil potential of any area.

Palaeogeography and palaeoclimatology

The palaeogeographic reconstructions of Smith (1972) are essentially maps of the present areal extent of major units and take no account of later stripping. A detailed study of the fauna, flora, and sediments will enable the position of shorelines to be estimated and a primitive bathymetric chart to be constructed. With this evidence true palaeogeographic maps of the Basin can be reconstructed and the relation to neighbouring basins determined. Some evidence for the climatic conditions can be obtained by considering the total nature of the fauna, its quantitative character, and the sediments and their cement.

5. PROPOSED WORK

The original mapping of the Georgina Basin in the period 1957-1965 was orientated to the production of 1:250 000 geological maps in an area which had lacked map coverage. The use of fossils in unravelling the history of the basin was recognized, and a detailed study of trilobites in the Middle and early Upper Cambrian sediments was undertaken by Opik (1961, 1963, 1966, 1967, 1970a, 1970b).

The results of the initial survey were that stratigraphic units were erected on strong palaeontological evidence and subordinate lithological evidence. The net result is a stratigraphy which is of limited use in detailed mapping. In order to produce a workable stratigraphy it is necessary to map lithological units and to understand their position within the time scale. We propose extensive field work, much of it in specific areas, to determine:

a. The thickness and distribution of major lithological units.

b. The sedimentology of these units.

c. The nature and variability of the faunas in these units.

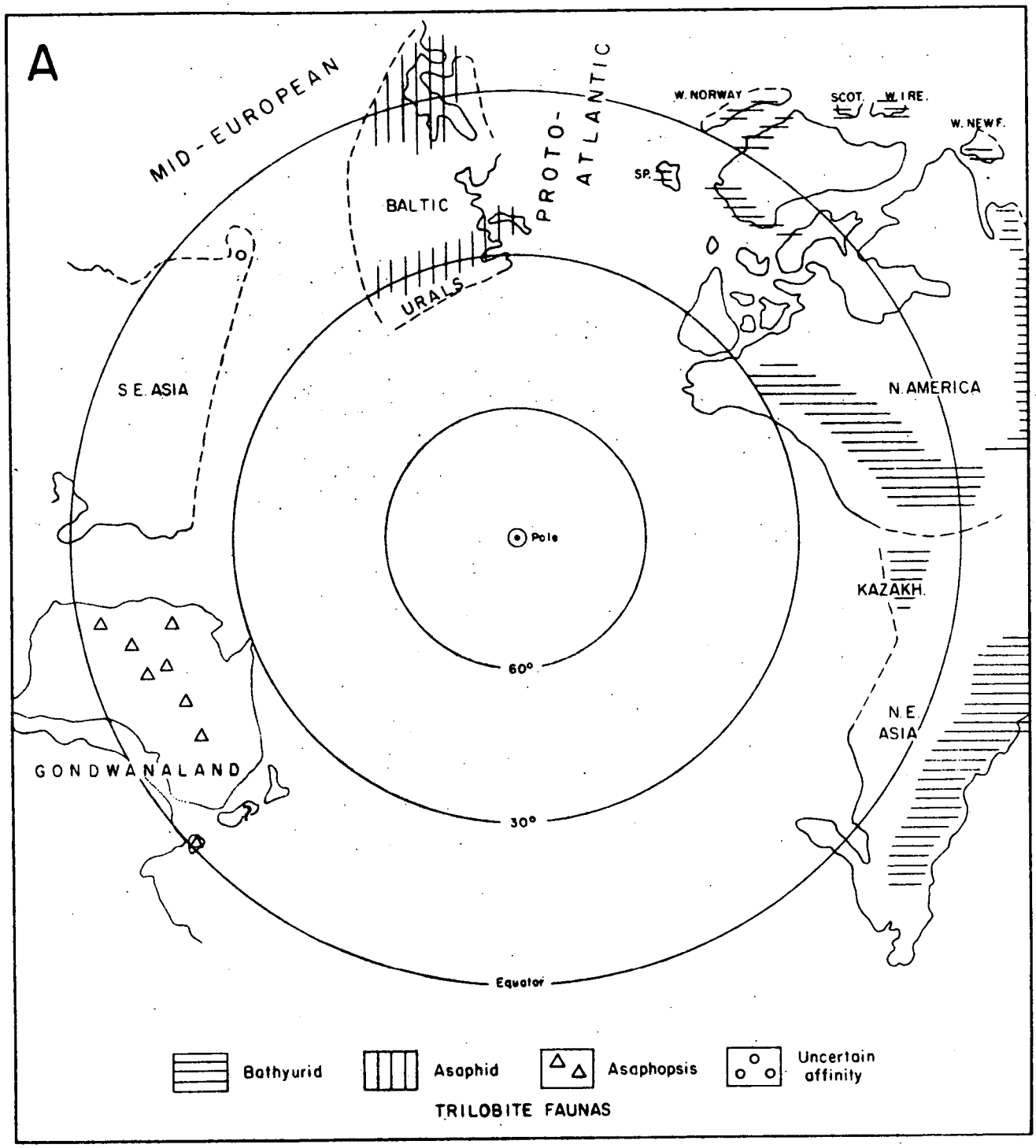

Fig. 10 Lower Ordovician (Arenig) — Distribution of crustal fragments (after Jell) based on trilobite faunas.

d. The sedimentary geochemistry and petrology of these units. The use of these data and their analysis is discussed under 'Aims and Objectives'.

Regional considerations

Mapping. The different philosophical approach to the mapping of the basin will perforce change the definition and hence the areal extent of existing formations. Others may be suppressed and new and formerly unrecognized units proposed. Thus for some areas amended 1:250 000 maps will be produced.

It is probable that many of the sheets covering areas of Middle Cambrian outcrop will be revised. Revisions to Sheets covering areas of Upper Cambrian/Lower Ordovician outcrops will depend on the results of a detailed study of the Chatsworth-Ninmaroo-Arrinthruga-Tomahawk sequence. Little change is envisaged in the interpretation of Middle Ordovician units.

Evolution and structure. The erection of a detailed stratigraphy will result in considerable environmental and palaeogeographic information. Much of this information can be presented pictorially as maps, and a sequence of maps illustrating the development of the basin will be presented.

Specialist considerations

Sedimentology. Previous sedimentologic studies have been descriptive and have provided general environmental conclusions. More detailed projects designed to accomplish specific problems are required. Five areas require this work:

(a) BURKE RIVER STRUCTURAL BELT. The projects are:

(i) Detailed mapping, petrography and geochemistry, environmental reconstructions of the Chatsworth and Ninmaroo Formations.

(ii) The regional analysis of lithofacies to indicate palaeobathymetric trends.

(b) TOKO SYNCLINE. Following the completion of (a), similar projects in the lateral facies of the formations previously studied would probably show:

(i) The nature of the basement highs to the east during sedimentation.

(ii) Variations in the sequence of sedimentation compared with the Burke River area. Comparisons of environments would follow.

(c) UNDILLA BASIN. The lithostratigraphy of the Middle Cambrian units exposed in this area is poorly understood. Base metal prospects for the area are promising. Detailed mapping, petrography, and geochemistry are essential to show stratigraphic and facies controls of the Pb-Zn mineralization.

(d) DULCIE SYNCLINE. On the western margin, where terrigenous sedimentation has been dominant, sedimentologic studies have yet to be initiated. Mapping and petrography are necessary for lithostratigraphic data which can be used to propose some model for this terrigenous sediment province.

(e) MIDDLE ORDOVICIAN. The Middle Ordovician sequence, which is dominantly clastic, is now preserved and partially exposed only in the Toko and Tarlton Ranges in the south and southeast. Detailed sedimentological and petrographic studies could help in determining both the former areal extent of Middle Ordovician seas and the sedimentary history at the termination of deposition within the basin.

Algae. Problems of general significance which a study of the Georgina Basin can help to solve include:

(a) The usefulness of stromatolites in late Precambrian biostratigraphy. Stromatolites are known from the Grant Bluff and Mount Baldwin Formations but have not been studied in detail.

(b) The nature of the late Precambrian biota. Metazoan body fossils and trace fossils are known from several Precambrian formations in the Georgina Basin, but trace fossils, in particular, have not been studied. Black cherts may contain microfossils which are, as yet, unknown in Australia.

(c) The reliability of the method of using tillites for time correlation.

Conodonts. Conodonts provide detailed stratigraphic control, especially in the Ordovician. The main emphasis will be on outcrops in the southern margin of the basin, from Black Mountain to Huckitta.

The erection of a zonation for the Upper Cambrian will require extensive work in the eastern margin area. The earliest reported conodonts are of Middle Cambrian age; they are known in the Georgina Basin (Jones, 1961), and although a detailed conodont stratigraphy will probably not eventuate because of poor recovery and simple morphology, some information on the early evolution and relationships of conodonts will be obtained by detailed collecting in the Glenormiston and Undilla areas.

Crustaceans. The collection of both Bradoriida and Ostracoda can be incorporated in the collection of other fossil groups. They can be extracted from bedding surfaces of rocks collected for macrofossils and also from crushed rock samples collected for microfossil work.

Fish. This study of fish remains will enable a vertebrate stratigraphy to be erected for the non-marine Devonian which will be useful in interpreting isolated localities in other areas. Detailed faunas will need to be collected from measured sections in the Dulcie Syncline. In the Toko Range the poorly outcropping Cravens Peak beds will need to be examined in detail and a drill-hole may be necessary to help elucidate the stratigraphy.

Molluscs. Thorough collecting will be necessary in the Chatsworth, Ninmaroo, and Kelly Creek Formations in the eastern part of the basin. In the south and southwestern areas faunas from the Tomahawk Beds and possibly the Arrinthrunga Formation should also be collected.

Nautiloids. Extensive collections have already been made from the Nora Formation. However, more collections from the Ninmaroo, Swift, Kelly Creek, and Coolibah Formations would be needed before a detailed biostratigraphy could be attempted. This means field work in the Burke River and Toko Range areas.

Brachiopods. Brachiopods are particularly valuable in the Middle and Upper Cambrian carbonate terrains where conodonts are not sufficiently differentiated morphologically to be utilized for of fine subdivision of biostratigraphical units. Full-scale studies on the evolution of brachiopod morphology in Cambrian rocks is progressing only in North America.

Trilobites. Further projects will be necessary to correlate the faunas of the inner detrital belt of the southern margin of the Basin with the reference sequence at Mount Unbunmaroo (Black Mountain). The following items require attention:

(a) Re-examination of the Georgina and Mungerebar Limestones of the Glenormiston area, and their relation with the Ninmaroo Formation.

(b) The collection of trilobites from the Upper Cambrian Tomahawk Beds and lateral equivalents (large collections made during the original mapping along the fringes of the Georgina Basin have never been described: much of the material and at least some of the locality information appear to have been mislaid).

(c) Some attention should be given to the sparse fauna of the Arrinthrunga Beds.

(d) The Middle Cambrian faunas from the Marqua and Sandover River Beds.

(e) The Middle Cambrian faunas from the Undilla area.

(f) The trilobite stratigraphy of the poorly exposed Middle Cambrian rocks in the northern part of the Basin.

Echinoids. Many calcareous intervals contain echinodermal debris, and pelmatozoan remains form significant proportions and carbonate deposits in the Burke River sequences. Known occurrences of fully articulated echinoderms, however, are quite limited. Henderson & Shergold (1972) have described a species of Cyclocystoides from the Middle Cambrian south of Mount Isa, and there is a documented occurrence of an eocystoid, similar to the Tremadocian Macrocystella, in the Upper Cambrian sequence at Lily Creek. Shergold is currently studying the fauna of this section. Echinoderms Peridionites and Cymbionites, described by Whitehouse (1941) from the Middle Cambrian of the Undilla Basin, require reinterpretation.

Chitinozoans. Chitinozoans are chitinous microfossils which occur abundantly in the lower Palaeozoic. They have proved to be useful biostratigraphic tools in Europe and North America. No work has been done on Australian faunas, but it is a logical outcome of acid-digestion work. The chitinozoans are concentrated in the fine residue, and only minor modifications to the acid-digestion techniques are necessary to retain the chitinozoan faunas.

Geochemistry. In order to determine the background geochemistry of the basin a pilot survey will be necessary. The sampling will be part of the normal sampling for lithology and palaeontology. The results of this survey will be useful in determining environment of deposition and may also reveal any anomolously high metal content. Following the pilot study, decisions can be made as to the need for, and use of, a regional study and further concentrated work on limited areas.

Additional professional support

Geophysical survey. Major problems which could be examined geophysically are:

(a) The nature of the southern margin and the type of faulting. Is the southern margin an overthrust burying Palaeozoic sediments beneath older crust?

(b) The relation between the Adelaidean and older Proterozoic rocks.

(c) Whether Cambro-Ordovician sediments underlie the Cretaceous in the vicinity of Middleton.

(d) Thickness and distribution of Precambrian sediments below the

Palaeozoic cover.

Drilling. Two different types of drilling will be necessary in the basin. Complementary drilling to augment well exposed sections and to examine interfingering contacts between various facies, and investigative drilling to provide continuous section in areas of poor outcrop. Locations for complementary drilling will become apparent as field work progresses. Most of these holes will be 70-100 m deep and could be drilled to advantage by BMR rigs. A short initial program is planned for 1974 with six holes being drilled in the Burke River Structural Belt (Appendix 2).

Investigative drilling would be to greater depths (500-1500 m) and would be necessary in the central parts of the basin. Although several holes (see Fig. 8) have been drilled, little material is available for biostratigraphic and petrological study. Another deep hole (up to 2000 m) may be needed to examine the post-Ordovician sediments of the Toko Syncline. A.O.D. Ethabuka No. 1 may provide the necessary information; on the other hand it may pose more questions than it answers, and another deep hole may be required. The investigative drilling would probably have to be done under contract, as the probable total depths exceed present BMR capability.

The complementary drilling program would take place in 1976 and/or 1977 and the investigative drilling in 1977 and/or 1979. Geophysical investigations proposed for 1977 may be necessary to determine drill sites for the 1979 drilling program.

Personnel

BMR employees. The successful completion of this project will depend on close co-operation between workers on different topics and careful supervision and co-ordination of the work at all stages.

For these reasons the maximum use of BMR personnel is recommended. Suggested personnel and their major areas of concern are as follows:

E.C. DRUCE — Party Leader Cambrian and Ordovician conodonts and carbonate petrology of selected sections; sedimentary geochemistry.

J.H. SHERGOLD — Upper Cambrian and Ordovician trilobites and carbonate petrology of selected sections.

B. RADKE — Detailed sedimentary petrology and geochemistry of Upper Cambrian and Lower Ordovician.

M. WALTER (part time)	The flora and fauna and petrology of the Adelaidean and Lower Cambrian; Cambro-Ordovician stromatolites.
P.J. JONES (part time)	Cambro-Ordovician ostracods and their ancestors (bradoriinids).
G. YOUNG (part time)	Siluro-Devonian vertebrate faunas and petrology.
J. DRAPER (part time)	Sedimentary petrology and sedimentology of the Middle Ordovician clastic sequence.

This leaves three major areas of study - the sedimentary petrology of the Middle Cambrian, the Middle Cambrian trilobite faunas, and Palaeozoic Chitinozoa, - unfilled by BMR personnel.

The Middle Cambrian problem is one of carbonate petrology and of palaeontology and, if undertaken by Bureau officers, then new appointments would probably be necessary.

Outside specialist. Many of the specialist fields of study, the results of which are necessary in a regional basinal analysis, cannot be provided by present BMR staff but can be provided by outside specialists.

Technical support staff. Technical support for the project falls into three areas: laboratory assistance, drafting, and office services.

The use of a field laboratory has proved to be extremely useful on previous projects, and a fully equipped mobile palaeontological laboratory is available. A petrological laboratory for the preparation of polished sections and peels is planned.

The provision of fully trained technical staff to operate and maintain the laboratories is essential. The minimum requirements would be a Technical Officer (in charge) and a Technical Assistant Grade 2. These officers should be trained in the preparation (mechanical and chemical) of fossils and the preparation of thin sections and peels.

These officers should be assigned permanently to the project to provide maximum efficiency and co-operation.

Drafting services would not be needed until the second field season after which the appointment of an officer from the Drafting Section to the project would be advantageous.

Office services would be considerable. In the early part of the project this would take the form of administering stores and equipment, and correspondence. Towards the end of the project the major emphasis would be in the typing and proofreading of scientific reports.

Field staff. The minimum number of professional officers in the field at any one time would be four. During most of the field season this would be augmented by one part-time officer and probably one visitor. The professional officers would be working in different areas and on different problems, and the provision of adequate field hands is vital. Proposed field staff is:

1 Mechanic

4 Field hands

1 Cook

The appointment of a Camp Manager would be a distinct advantage; if one was appointed then the field hand complement would be reduced by one.

Part-time staff. Depending on initial results several areas of investigation may need the help of additional BMR staff.

Geophysics:	If sufficient geophysical coverage is obtained the help of a geophysicist in interpreting the results would be necessary.
Petroleum Technology:	Porosity and permeability studies of various lithologies could be necessary. Also chemical analysis of any hydrocarbon-rich samples.
Geohydrology:	The presence of a field party in the area would provide logistic support in the southern part of the Georgina Basin within the Northern Territory. This is the major area not covered by a geophydrological survey. Personnel could be provided either by BMR or the Water Resources Branch of the N.T. Administration.
Tertiary Units:	Tertiary lacustrine deposits occur within the geographic confines of the basin. They could be areas of potential uranium mineralization. The geologic mapping of these units should be considered a separate problem, but our field facilities in the area could be used.
Photography:	The eastern part of the basin will be visited during a ten-day field trip connected with the International Geological Congress in 1976. The production of a guidebook will be necessary, and in order to illustrate it adequately, the services of the BMR photographer would be deservable in the 1974 field season.

Isotopic Dating: There are no useful isotopic data on the Precambrian sediments. Sampling of important sequences could take place in 1975 and the facilities of the Age Dating Laboratory would be required.

Logistics

Field program (Figs 11-13)

Year	Area of Operation	Ancillary services
1974	Eastern, southeastern margin	Light plane hire, Drilling
1975	Central area	I.G.C. field trip; Drilling
1976	No field work	
1977	Central and Southwestern area	Seismic survey ?
1978	No field work	?Drilling program
1979	Central and northern areas	Helicopter hire

Office program. The office program will consist of two phases: in the period 1974-77 it will mainly be concerned with the preparation of samples and gathering of data; the period 1977-80 will be taken up with preparation of maps and final reports.

Some publications will be forthcoming in the period 1974-77, mainly concerned with easily isolated topics. Some of these may be in the Bulletin series; map production would be large-scale maps of selected areas.

The major output would be concentrated in the period 1977-80, especially in the Bulletin series and updated 1:250 000 maps.

Integration of I.G.C. program. The International Geological Congress will be held in Australia in 1976. The eastern part of the Georgina Basin is a logical place to run a field excursion for those interested in early Palaeozoic biostratigraphy.

A proposal for a ten-day excursion has been proposed to the Queensland Field Trip Committee (Appendix I); if accepted it would entail:

1. Preparation of excursion guide.
2. A short visit by the BMR photographer in the 1974 field season.
3. A 'dry run', possibly with senior BMR officers, questionably in 1975.

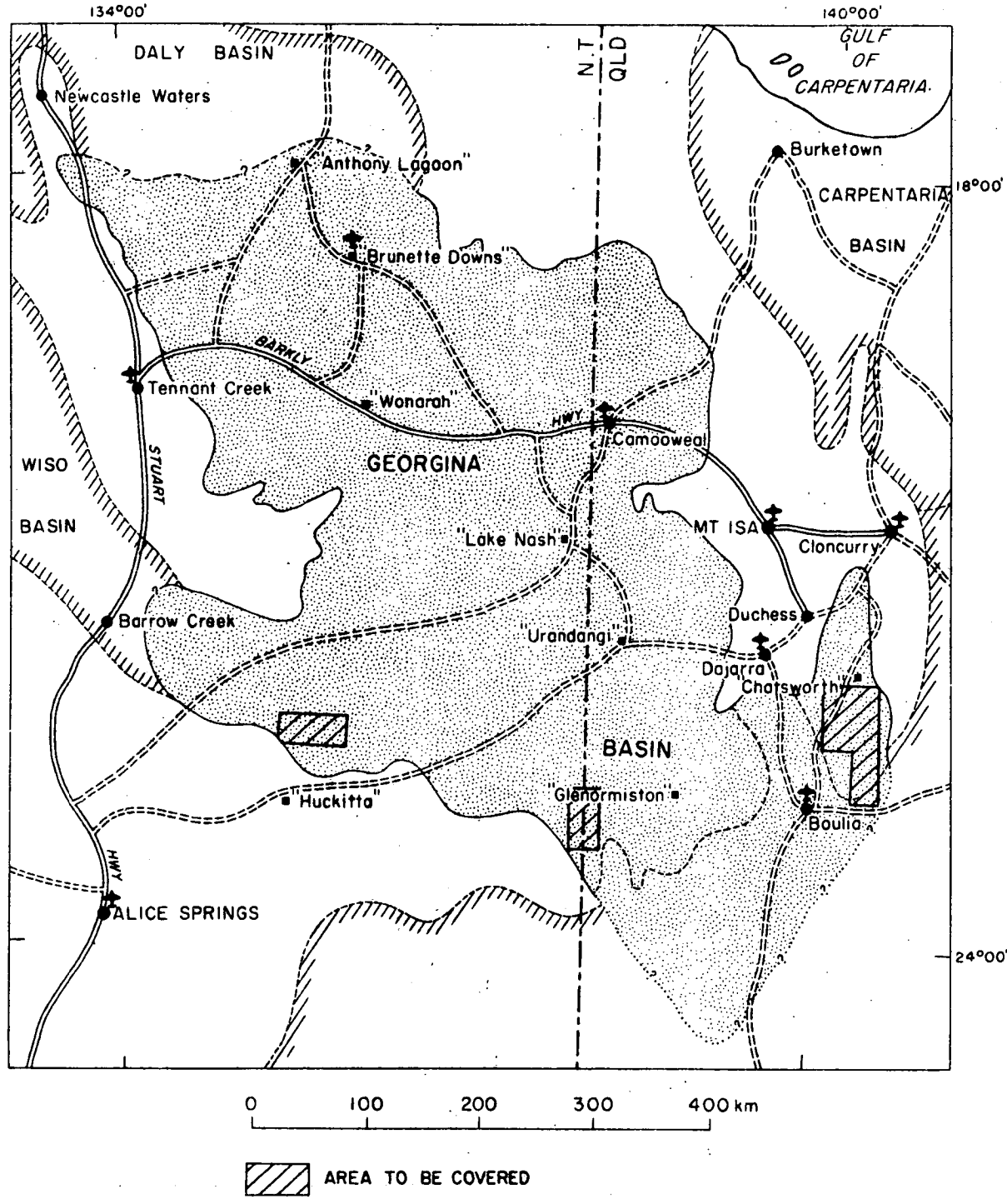

Fig. 11 1974 field program: Georgina Basin

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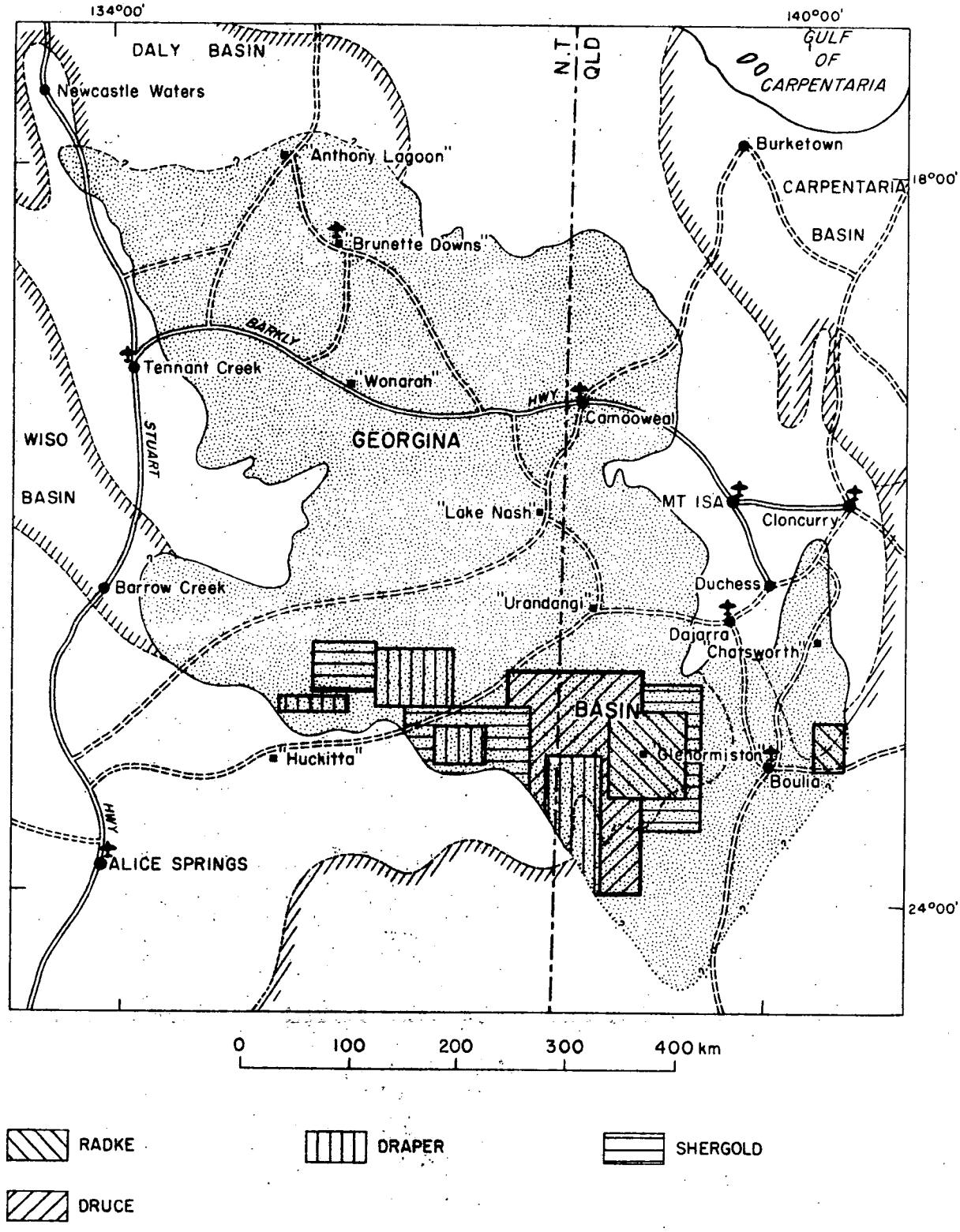

Fig. 12 1975 field program: Georgina Basin

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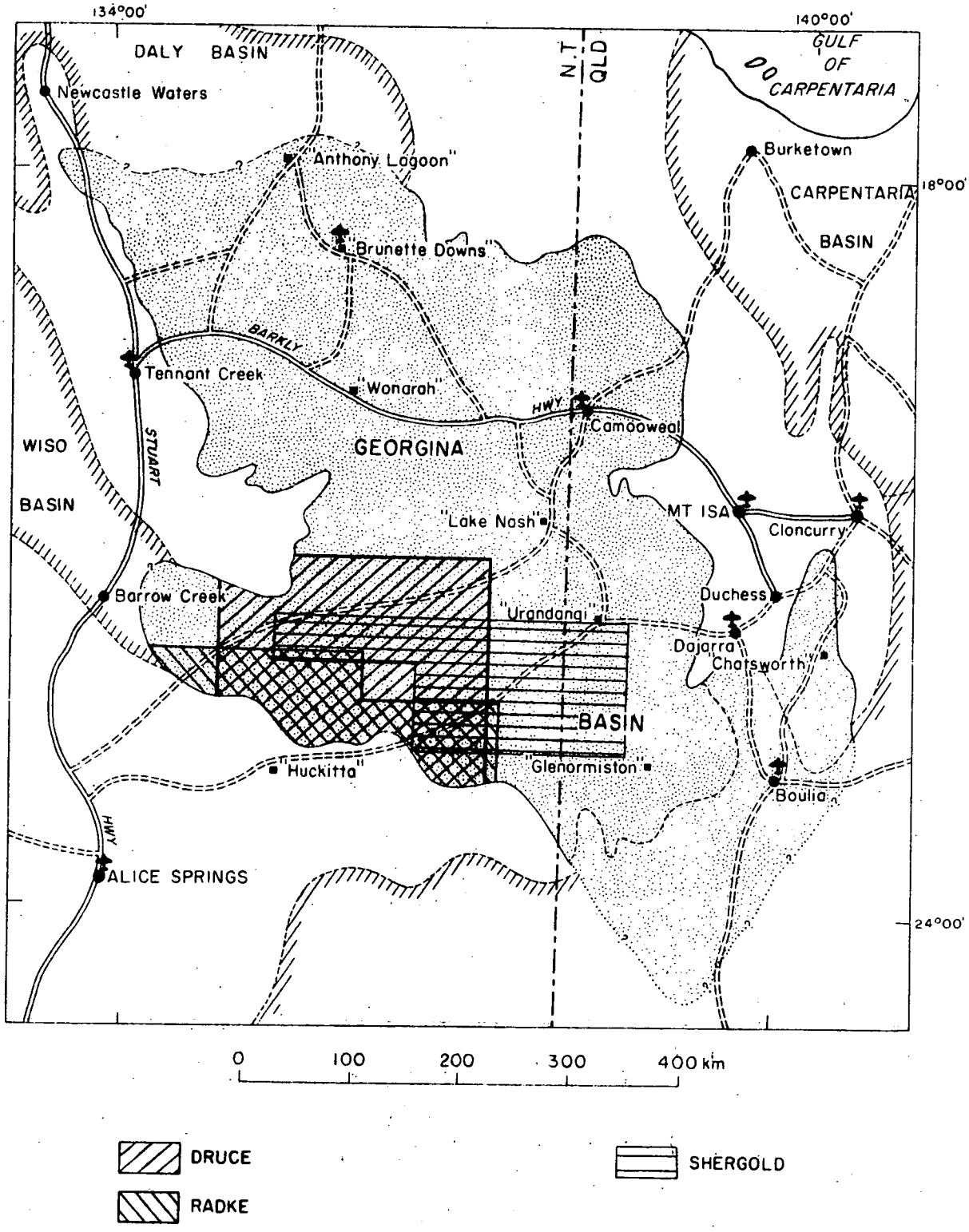

Fig. 13 1977 Field program : Georgina Basin

To accompany Record 1974/44

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4. Interruption of the 1976 season during August in order for BMR officers to attend the conference meetings and to lead the excursion(s).

5. Provision of extra vehicles, equipment, and possibly manpower during the 1976 field season.

Training and co-operation

Co-worker conferences. The biostratigraphical study of the evolution of a basin will need workers from both inside and outside BMR. Close co-operation is essential to obtain the maximum benefit from all the different viewpoints. This will become of greater importance towards the end of the project and also in the off field season years. Up to three conferences will probably be needed; the venue could be either Canberra or Brisbane.

Co-operating agencies. The project will extend from Queensland into the Northern Territory. Possible co-operating agencies would be the Queensland Geological Survey, the Northern Territory Geological Survey, and the Water Resources Branch of the Northern Territory Administration.

Regional co-operation. The stratigraphic history and sequence of faunas found in central Australia are closely comparable with those of Asia (Indo-Chinese region and parts of Malaya), China (People's Republic), and Korea. It is probable that all these regions were geographically much closer to Australia than at present.

The results of this project will be readily applicable to these areas; conversely information from these areas could be of considerable help in unravelling the history of the Georgina Basin. Close co-operation between BMR personnel and workers in these areas will be necessary.

Studies of the Cambrian and Ordovician faunas of the Georgina Basin have already led to several co-operative projects. Dr R.A. Cooper of the New Zealand Geological Survey is studying the Middle Cambrian faunas of New Zealand and has found comparison of his material with that of the Georgina Basin essential. Dr S.H. Chuang, University of Singapore, is studying the inarticulate brachiopods from the Sino-Australian area with Dr Henderson. Dr Shah (Jammu State University) and Dr Gupta (Punjab University) have been studying faunas from Kashmir which appear to be very similar. Dr Miller (University of Utah) has been studying the Upper Cambrian conodonts of North America which appear to be virtually identical to those from the Georgina Basin. The Middle Ordovician conodont faunas are closely comparable to material from Arctic Canada which are being studied by Dr C. Barnes (Waterloo, Canada).

Future extensions of work

The biostratigraphic framework set up as a result of this project will be readily applicable in the adjacent Australian Basins of the same age. The Amadeus, like the Georgina, has good exposures but differs in having a greater quantity of clastics in the stratigraphic column. The sequence in the Wiso and Daly River Basins is poorly exposed but contains rocks of comparable age which have yielded both trilobites and conodonts similar to those in the Georgina Basin. The mapping of these basins will be a much easier accomplishment after a biostratigraphic standard has been erected in the Georgina Basin.

Study of these basins, and the limited exposures in the Bonaparte Gulf Basin and the Bancannia Trough in western New South Wales, need not necessarily wait until the completion of the Georgina study.

Subsurface studies in the Canning Basin will also be helped; analysis of cores from future deep wells in this basin will be greatly aided by the information gathered in the Georgina project.

Finally the integration of this essentially shelf sequence with that of the Tasman geosyncline will be important.

6. PRESENTATION OF RESULTS

Maps and Explanatory Notes (Fig. 14)

Because the basin history is being approached from a detailed integrated study of the sediments, the fauna, and possibly the geochemistry, the stratigraphic divisions proposed will necessarily be a late phase of the study. Furthermore, it is difficult to know at this stage how sweeping the changes will be.

It appears that the greatest changes may occur in the stratigraphy of the Middle Cambrian; thus sheets in the northern and northeastern parts of the basin are most likely to need major revision. Several of these, - Lawn Hill, Camooweal, Mount Isa, Urandangi, and Duchess - also cover large areas of Precambrian outcrop. They have also been extensively restudied by the Phosphate Group. Production of revised 1:250 000 maps for these areas would be integrated with the program for the Cloncurry Party of the Metalliferous Section.

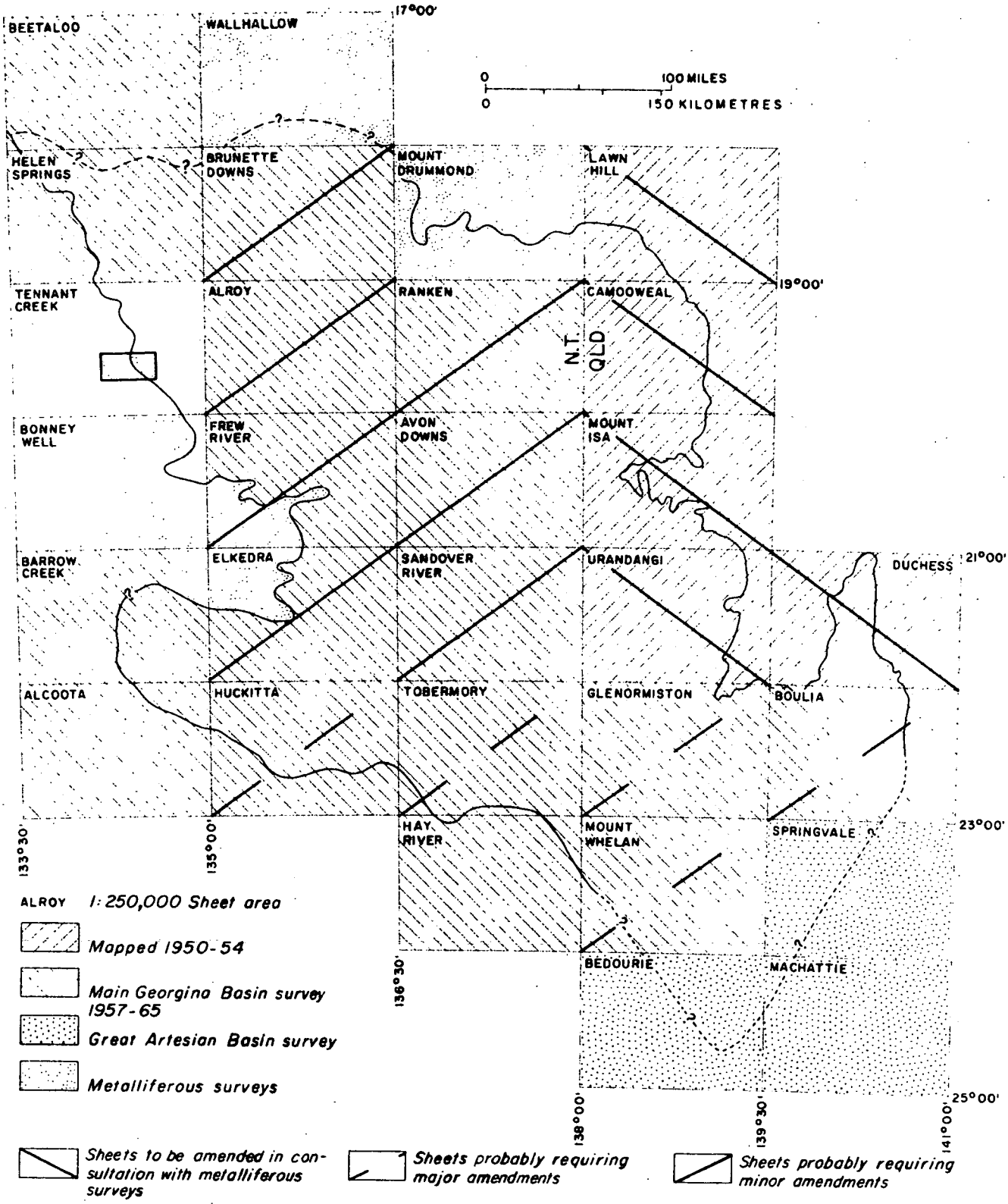

Fig. 14 1:250,000 Geological Sheet areas, showing mapping history

To accompany Record 1974/44

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The sheets which cover areas of mainly Middle Cambrian sediments are Brunette Downs, Alroy, Ranken, Avon Downs, and Frew River. These sheets would probably be revised, but, because of the poor outcrop, only after an extensive drilling program.

The areas of uppermost Cambrian and Ordovician outcrop appear less likely to be amended, these sheets include Boulia, Glenormiston, Tobermory, Sandover River, Huckitta, and Mount Whelan.

Finally some sheets contain small areas of Georgina sediments; amendments to these would probably be carried out by other projects with information supplied from the Georgina Basin project. They include Hay River, Alcoota, Barrow Creek, Tennant Creek, Helen Springs, Wallhollow, and Mount Drummond.

Where major amendments occurred to maps, updated Explanatory Notes would be produced.

Bulletins

The major results of this project would be presented in the Bulletin series of BMR. Each specialist would produce more than one Bulletin in his own area. These may be divided either by time (Cambrian faunas..., Ordovician faunas..., etc.) or by area, depending on the major emphasis of the work. Outside specialists should be encouraged to publish their studies in the Bulletin series.

The final phase of the project would be the production of one or more Bulletins on the geology, evolutionary history, and structure of the basin.

Reports

A few of the individual studies within the project will be suitable for publication in the report series, for example the sedimentary geochemistry and geophysical work.

Records

Records will be necessary for the drilling program and for the presentation of raw data gathered by external contracts, and by the project staff.

Outside publications

The major publication effort will be within the Bulletin series of BMR. However, syntheses of individual projects and the overall project should be presented in outside journals. The considerable insight into the problems of the Cambrian and Ordovician gained in this project will be of considerable interest to other workers in this field. Consideration should be given to the presentation of results, ideas, and views at relevant international symposia and the publication of these in symposium volumes.

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APPENDIX 1

INTERNATIONAL GEOLOGICAL CONGRESS 1976
ITINERARY FOR PROPOSED GEORGINA BASIN EXCURSION

Area: Eastern Georgina Basin

Leaders: E.C. Druce & J.H. Shergold

Length: 1300 miles; 11 days

Cost: approx. $150-00

Numbers: Participants 20 or 25

Mode of transport: 4 Wheel Drive vehicles with 600 mile overflight on last day

GEORGINA BASIN

Personnel: Leaders (3)
Technical Officer (1)
Mechanic (1)
Field Hand (1) (doubles as Cook's offsider)
Cook (1)

Visitors 20 Total 27

Vehicles: 4 Station Wagon Landrovers
1 International 1500
1 LWB Landrover (will require lunch gear to carry)
1 2 wheel trailer
1 Water trailer

All field equipment and vehicles arranged or provided for by BMR

DAY	ITINERARY	ROUTE	MILEAGE Indiv.	MILEAGE Accum	TIMING Stop	TIMING Go	NIGHT STOP	LOGISTICS	COST Indiv.	COST Accum	ACTION
PRE-DAY	Meet Mt Isa		0	0			Barkly Hotel		18.00		1 Check whether accomod. at MIM
DAY 1	am 1 Visit Mt Isa Mines		0	0	all a.m. leave 1330		Duchess Hotel Dinner 18.30		10.00	28.00	1 Book in Duchess Hotel
	pm 2 Drive Duchess and unload	S. on Duchess Rd on Cloncurry Rd	60	60	0.5	2.5					
	3 Visit Selwyn Range Lst	10 miles Station track	20	80	0.5	0.5					
				80		0.5					
DAY 2	1. Roaring Bore	E on Cloncurry Rd	25	25	leave 0730	1.0	BHS Camp	Tucker Waggon	5.00		1. Arrange booking with BHS if possible
		W on Dejarra Rd			2.0			Duchess -			
		S on Pilgrim Ck Rd	55	80		2.0	or	Lunch Stop - BHS Camp			
					Lunch						
					3.0		Fly Camp				
	2. Inca Shale etc. Monasby Ck		20	100		1.0					
				180						33.00	
DAY 3	1. N End Enginal Hill (riberoids)	S on Station track	15	15	leave 0730	0.5		Tucker Waggon straight to Chatsworth (lunch)	3.00		
					0.5						
	2. Pomegranite Lst	E across Pomegranite Ck	30	45		1.0					
					0.5						
	3. Chatsworth Lst	S thro' Chatsworth Hstd	30	75		1.0		then to Black Mt.			
					2.0		Black Mt.				
	4. Digby Peaks	SN on Boulia Rd	20	95	Lunch						
						1.0					
					1.0						
	5. To Black Mt via Fort William	SW on Boulia Rd				3.0					
		E to Ft William	70								
				165	Dinner at 7						
				345						36.00	

DAY	ITINERARY	ROUTE	MILEAGE Indiv.	MILEAGE Accum	TIMING Stop	TIMING Go	NIGHT STOP	LOGISTICS	COST Indiv.	COST Accum	ACTION
DAY 4	1. Black Mt section				all day to 1530			Packed lunch Vehicles to N of Black Mt			
	2. To Mt Datson	S to Cazna E to Granton	40	40		2.0	Mt Datson	Tucker waggon to Mt Datson	4.00		
				385						40.00	
DAY 5	1. Mt Datson section		10	10	Start 0730 2.00			Tucker waggon to Boulia for supplies then to Glenormiston	5.00		
	2. Dribbling Bore	S on Station track			0.5						
	3. via Hamilton Hotel to Boulia	E on Winton Rd (Ham)	20	30	Lunch at Hamilton	0.5					
		W on Boulia Rd (Boul)	50	80		1.0	Glenormiston				
	REFUEL			465	1.0						
	4. To Glenormiston		90	170		3.0				45.00	
				555							
DAY 6	1. Sun Hill	SE on Station track	15	15	Start 0730	0.5			4.00		
	2. Georgina Lst	W cross country	20	35	1.0	0.5		Tucker waggon straight to Mithaka			
	3. Mt Idamea	W cross country	0	35	1.0	0.5					
					Lunch		Mithaka				
	4. Kelly Ck & Coolibah	N & W on Station track	60	95	1.0	3.0	Waterhole				
	5. Mithaka	W on Station track	30	125		1.5					
				680						49.00	

DAY	ITINERARY	ROUTE	MILEAGE Indiv.	MILEAGE Accum	TIMING Stop	TIMING Go	NIGHT STOP	LOGISTICS	COST Indiv.	COST Accum	ACTION
DAY 7	1. Craven's Pk Beds	S on Station track	10	10	Start 0730			Tucker waggon straight to Gap Hole Ck.	4.00		
	2. Toomba Bore	S on Station track	20	30	0.5	0.5					
	3. Erlthera Soak	Thro Toomba Gorge	20	50	1.0	1.5	Gap Hole Creek				
					Lunch	(1.0)					
	4. Gap Hole Ck	via Toomba Bore and Black Stump	35	85	1.0	2.0					
				765	1.0					53.00	
DAY 8	1. Marqua Beds (Old Morqua)	Criagie Dam track	50	50	Lv 0730	3.0			4.00		1. Arrange showers Tobermory
	2. Coolibah Fm No. 8 Dam	NE Station track	30	80	1.0			Tucker waggon straight to Tobermory			
					Lunch	1.5	Tobermory				
	3. Tobermory (Coolibah-Nora on way)	N Station track	50	130	1.0						
				895	1.0	2.0				57.00	
DAY 9	1. Urandangie (Camooweal dolomite Ninmaroo Fm) REFUEL		60	60	Lv 0800	2.5	Old Morstone Homestead	Tucker waggon to Urandangie then Camooweal (supplies)	12.00		1. Arrange acc. at Camooweal
				960	1.0						
	2. Camooweal		130	190	Lunch						
					1.0	4.5					
			50	240						69.00	
				1135							
DAY 10	1. Thorntonia (various stops)	NE on Thorntonia Rd	35	35	Lv 0800	3.5			5.00		
					1.0		S of Thorntonia	Tucker waggon with convoy			
					Lunch	1.5					
	2. Middle Cambrian S of Thorntonia	S on Station track	30	65	3.0						
				1200						74.00	
	1. To Mt. Isa via Yelvertoft	S on Station track W on Barkly Highway	100	100	Lv 0730				5.00		1. Arrange charter, Twin Otter?
				1300	2.00	2.5		Tucker waggon to			
					Lunch						2. Acc at Barkly
	2. Overflight. Toko's Boulia-Black Mt Duchess Refuel Boulia (350 m) (600 miles)						Barkly Hotel Brisbane plane leaves	Mt. Isa 120 miles 1300	40.00	120.00	
								Ferry vehicles to Mt. Isa			

APPENDIX 2

DRILLING BY PETROLEUM TECHNOLOGY SECTION IN THE GEORGINA BASIN IN 1974

Geologist in charge: E.C. Druce

Number of Holes: 6

Locations: All on BOULIA 1:250 000 Sheet

Hole 1. 139°38'E 22°08'

Geology (inferred):
- 2 m sand
- 10 m Cretaceous sandstone
- 50 m O'Hara Shale (shale, chert, sandstone)
- 50 m+ Pomegranite Limestone

Coring: Continuous after base of Cretaceous reached

Drilling Conditions: Fair, some thin chert beds. (Some water at 10 m?)

Hole 2. 140°02'E 22°04'S

Geology (inferred):
- 1 m silicified crust
- 20 m Swift Formation (shale, limestone and sandstone, all silicified).
- 50 m+ Ninmaroo Formation (calcarenite, dolomite).

Coring: Complete hole to about 80m

Drilling conditions: Hard, becoming fair. (Water unlikely, possibly cabernous).

Hole 3. 140°20'E 22°01'S

Geology (inferred) 2 m sand, soil

80 m + Chatsworth Limestone

Coring Complete Hole to about 80 m

Drilling Conditions: Fair to good (water at 15 m?)

Hole 4. 140°16'E 22°02'S

Geology (inferred) 10 m Ninmaroo Formation (limestone)

80 m Chatsworth Limestone (limestone)

Coring Complete Hole to about 80 m

Drilling conditions: Fair to good (? no water)

Hole 5. 140°24'E 22°52'S

Geology (inferred) 3 m sand

7 m Noranside Limestone (limestone, chert)

30 m Ninmaroo Formation (limestone, dolomite)

30 m+ Chatsworth Limestone (limestone)

Coring Continuous after base of Noranside limestone.

Drilling conditions: Hard (upper 10 m) to Fair. (?water at 10 m)

Hole 6. 140°30' 22°30'S

Geology (inferred) 3 m sand

20 m Wilgunya Formation + Longsight Sandstone

50 m + Gola Beds (limestone)

Coring Continuous after base of Longsight

Drilling conditions: Good (?Water at 25 m)

Total Expected Footage: 1600' (490m)

Total Coring (440m)

Convenient Dates: June - August 1974

Holes ranked in order of preference 3, 2, 6, 4, 5, 1.

Access

This varies considerably. Excellent access is available for Holes 1 and 5, reasonable access on two-wheel tracks is available to Hole 6.

There is poor access to Holes 2, 3, and 4. Hole 4 is about 1 mile off a track and uphill but no massive rock outcrops. Hole 3 is across a deep creek, the crossing on which may be washed out. Access is the same for Hole 4 as for 3 with about 6 km of spinifex country to traverse. It is reasonably flat but there are low limestone ridges.

Special Considerations

1. Packing of core

1974 is an extremely inconvenient time for a drilling program to be conducted in the Georgina Basin. Help will only be given in locating the drill site and in access. Labelling, packing and shipment of core will have to be undertaken by the drill crew.

2. Radio contact

Because of the above consideration it will be essential for daily radio contact to be maintained. This will enable the quick solution to drilling problems caused by geological features.