DEPARTMENT OF
MINERALS AND ENERGY

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/78

# THE NGALIA BASIN NORTHERN TERRITORY



By

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ILLUSTRATIONS



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June, 1973

## Regional Setting

The Ngalia Basin is an isolated accumulation of shallow marine, glacial, and continental sediments of Adelaidean, Cambrian, Ordovician, and Carboniferous age that unconformably overlie and are completely surrounded by Precambrian metamorphic and igneous basement rocks. It covers about 16 000 $km^2$ and lies in the southern part of the Northern Territory between latitudes 22°00' and 23°00' south and longitudes 129°00' to 133°45' east (Fig. 1). The basin is about 420 km long and has a maximum width of about 72 km. It is asymmetrical in north-south cross section with the greatest thickness of sediments preserved near the faulted northern margin. The basin is divided into two lobes separated by a median basement ridge. The western lobe is the deeper and contains a sedimentary pile close to 5000 m thick.

## Exploration History and Important Previous Literature

Before 1967 there had been no systematic regional geological coverage of the Ngalia Basin. Tindale (1933) proposed the name Ngalia Trough for the unmetamorphosed sediments. A brief unpublished report on the Ngalia Basin was prepared by Pacific American Oil Co. (PAOC) (1963), the former permit holders, and geophysical surveys on behalf of PAOC were conducted over their lease area; a regional aeromagnetic survey covered practically the whole of the basin (Hartman, 1963) and a seismic survey was carried out over the eastern lobe (Hudson & Campbell, 1965); a discussion of concurrent regional gravity observations is given by Nettleton (1965).

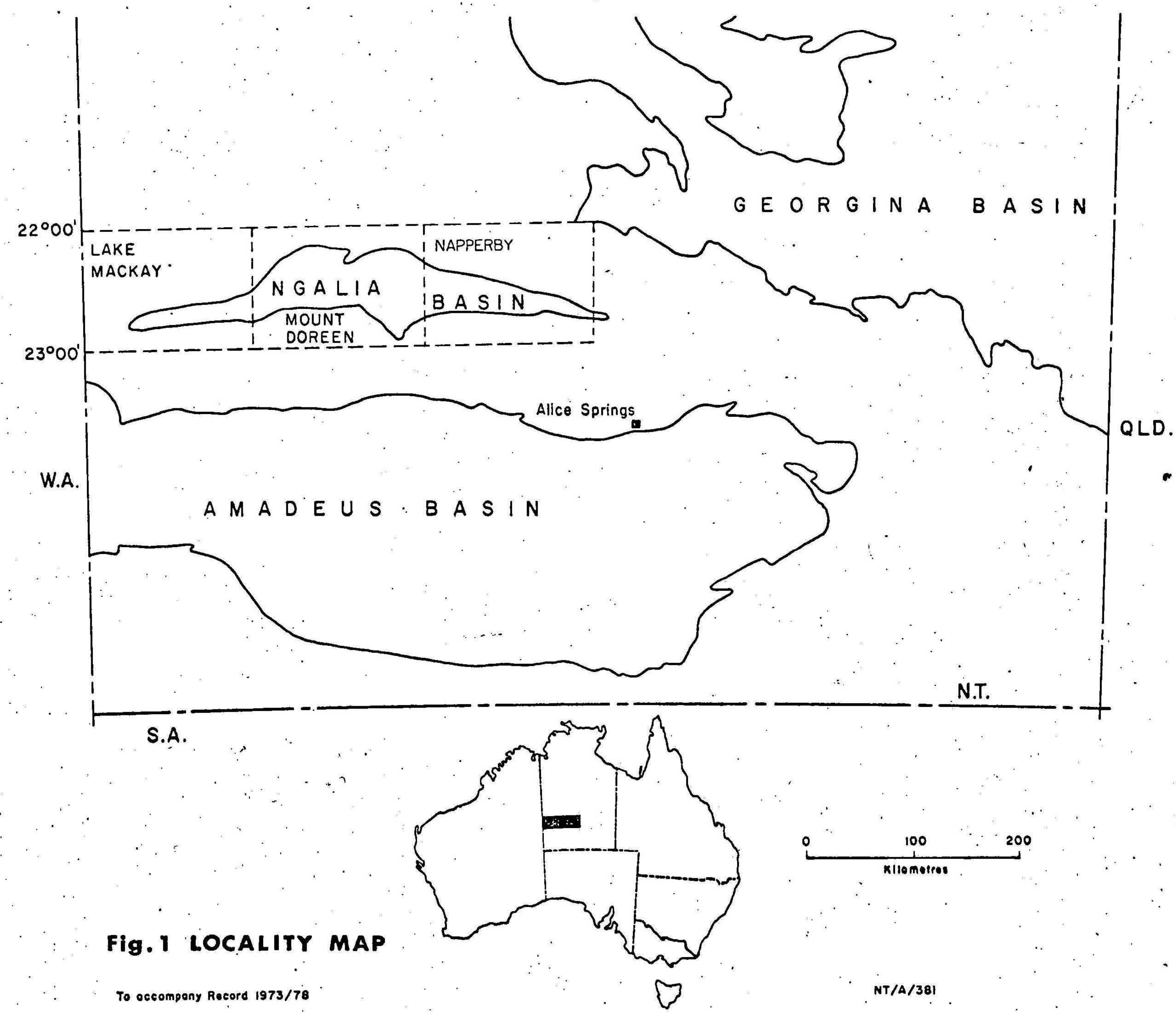


**Fig. 1 LOCALITY MAP**

To accompany Record 1973/78

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The geology of the Yuendumu Native Reserve, which covers part of the central northern margin of the Ngalia Basin, was described by Cook (1963) and after additional field work he published a brief regional report on the whole basin (Cook & Scott, 1968).

A photointerpretation by Rivereau (1965) was followed by systematic regional geological mapping of the Lake Mackay, Mount Doreen, and Napperby Sheet areas in 1967 and 1968. (Wells, Evans, & Nicholas, 1968; Nicholas, 1969; Evans & Glikson, 1969). The results of shallow stratigraphic drilling in the basin is discussed by Evans & Nicholas (1970).

Geophysical surveys for Magellan Petroleum (1972), the present permit holders, continued after the Bureau's surveys and were mostly concentrated in the western basin lobe. As well as adding further interconnecting lines with the Bureau's work, it also provided a link with the original PAOC surveys in the east.

Geological maps at a scale of 1:250 000 have been issued by BMR, and each is accompanied by a set of explanatory notes (Lake Mackay - Nicholas, 1972; Mount Doreen - Wells, 1973; Napperby - Evans, 1972).

The most recent published papers on the Ngalia Basin are those of Cooper, Wells, & Nicholas (1971), who discuss the regional geology and age determinations on the Vaughan Springs Quartzite, and Wells, Moss, & Sabitay (1972) who give a regional summary of the geology and discuss the results of the most recent geophysical work.

## Stratigraphy

Marine and continental sediments of Adelaidean, Cambrian, Ordovician, and Carboniferous age form the sedimentary pile of arenaceous rocks which are predominant in outcrop. The basal formations rest unconformably on Precambrian crystalline basement rocks or, in a few places, on Precambrian metasediments.

Eight formations are present, with an aggregate maximum thickness of 7000 m (Table 1). The thickest section of sediments (5000 m) is in the western lobe of the basin.

The base of the sedimentary sequence in the Ngalia Basin is placed at the base of the Vaughan Springs Quartzite, and the Precambrian rocks unconformably below will be referred to as basement. Most of the formations are separated by unconformities, and a complete sequence is not present in any one area. The geological succession exposed at selected places along the central northern margin of the basin is illustrated in Figure 2, and a condensed version of the stratigraphic table is given below:

TABLE 1 - STRATIGRAPHY OF THE NGALIA BASIN

| AGE | FORMATION | MAXIMUM THICKNESS (metres) | LITHOLOGY AND ENVIRONMENT |
|---|---|---|---|
| CARBONIFEROUS | MOUNT ECLIPSE SANDSTONE | 2100-2400 | Sandstone and subgreywacke, coarse-grained, poorly sorted, cross-bedded. Interbeds of cobble and boulder conglomerate and red micaceous siltstone. Plant fossils in upper part. Continental, fluviatile and piedmont. |

Table 1 (Cont.)

| AGE | FORMATION | MAXIMUM THICKNESS (metres) | LITHOLOGY AND ENVIRONMENT |
|---|---|---|---|
| ORDOVICIAN | KERRIDY SANDSTONE | 700 | Sandstone and subgreywacke, medium and coarse-grained, silty and in part calcareous and arkosic. Siltstone interbeds. Probably fluviatile. |
| | DJAGAMARA FORMATION | 320+ | Sandstone, medium-grained, glauconitic and with abundant clay pellets in part. Thick intervals of green siltstone in western outcrops. Shallow marine. |
| CAMBRIAN | BLOODWOOD FORMATION | 200+ | Siltstone, thin bedded, and sandstone, red, both in part richly micaceous. Abundant trace fossils and rare macrofossils of probable Lower Cambrian age. Shallow marine. |
| | WALBIRI DOLOMITE | 430± | Dolomite, thick bedded, and in part glauconitic, oolitic, stromatolitic and pelletal; interbeds of siltstone, micaceous in part; minor coarse-grained well sorted and rounded sandstone, in part with dolomitic matrix. Abundant fragmentary marine macrofossils. Shallow marine. |
| | YUENDUMU SANDSTONE | 700+ | Sandstone, fine and medium-grained, moderately well sorted, cross-bedded and slumped in part. Shallow marine, near shore. |
| ADELAIDEAN | MOUNT DOREEN FORMATION | 340 | Siltstone, green, upper part with abundant striated erratics of various rock types up to 4 m across. Pink laminated dolomite and red shale at top of the formation and green siltstone at the base. Dolomite with black chert is predominant at some localities in the west. Fluvioglacial and partly marine. |

Table 1 (Cont.)

| AGE | FORMATION | MAXIMUM THICKNESS (metres) | LITHOLOGY AND ENVIRONMENT |
|---|---|---|---|
| | VAUGHAN SPRINGS QUARTZITE | 2400 ± | Sandstone, silicified, closely jointed, thick bedded to massive, generally with basal coarse-grained and pebbly hematitic sandstone and granule conglomerate. Shallow marine. |
| ADELAIDEAN | TREUER MEMBER | 1400± | Sandstone, thin to medium bedded, cross-bedded, micaceous and glauconitic in part and rich in small clay pellets. Interbedded grey siltstone which is predominant in many sections. Member occurs in lower half of the Vaughan Springs Quartzite. May contain interbedded evaporites. Shallow marine. |

Most of the sequence is unfossiliferous, and the age of two of the formations was obtained by dating of glauconite using Rb/Sr and K/Ar measurements (Cooper, Wells, & Nicholas, 1971). The minimum age calculated for the Treuer Member, which was deposited soon after sedimentation started, was 1280 m.y. A single sample of the Djagamara Formation yielded an age of about 450 m.y. or mid-Ordovician, which was in general agreement with the broad time range assigned to the formation from fossil evidence in bounding formations.

## Structure

A simplified structure map with solid geology is shown in Figure 3. The structure in the sediments and distribution of outcrops in the basin indicate an asymmetrical cross-section with the thicker and more strongly deformed rocks occurring in a belt along the northern margin. A typical cross-section of the

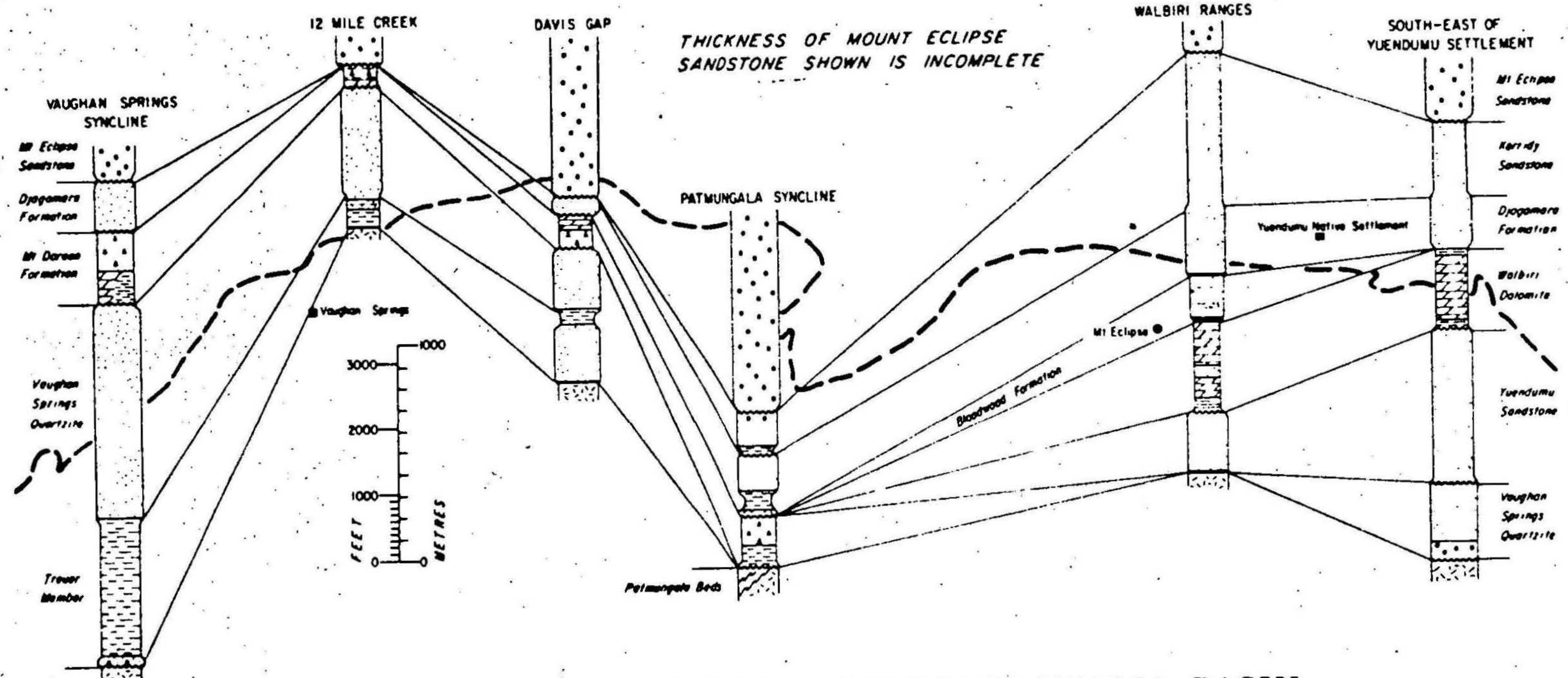


**Fig. 2 CENTRAL NORTHERN MARGIN OF NGALIA BASIN, SELECTED STRATIGRAPHIC SECTIONS**

To accompany Record 1973/78

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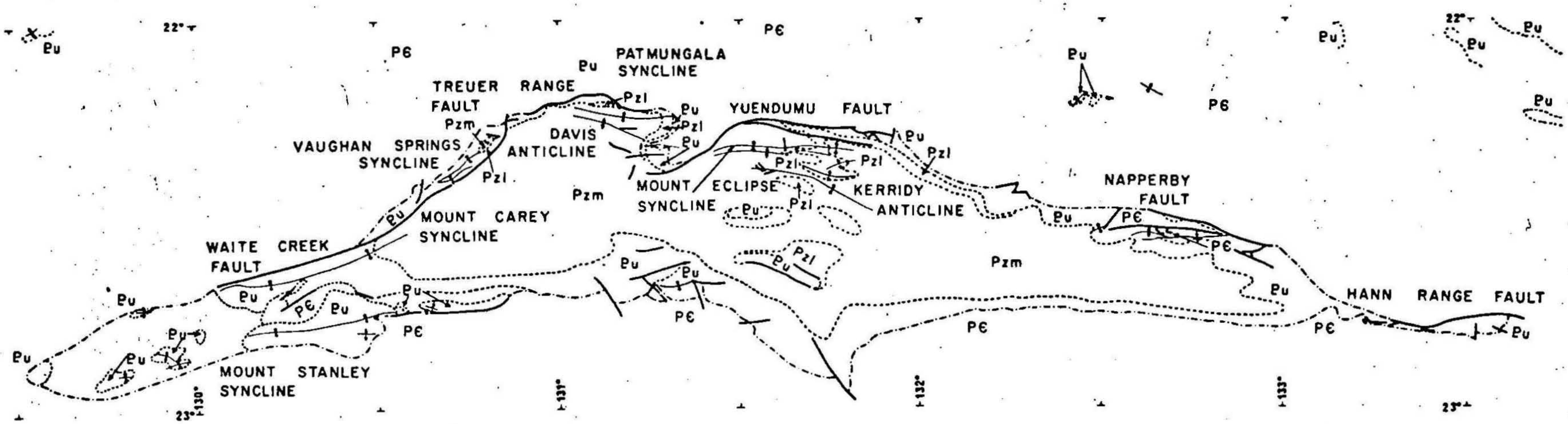


**REFERENCE**

| AGE | SYMBOL | ROCK UNIT |
|---|---|---|
| CARBONIFEROUS | Pzm | Mount Eclipse Sandstone |
| ORDOVICIAN<br>CAMBRIAN | Pzl | Kerridy Sandstone<br>Djagamara Formation<br>Bloodwood Formation<br>Walbiri Dolomite |

| AGE | SYMBOL | ROCK UNIT |
|---|---|---|
| ADELAIDEAN | Pu | Yuendumu Sandstone<br>Mount Doreen Formation<br>Vaughan Springs Quartzite |
| PRECAMBRIAN | PЄ | Patmungala Beds, metamorphic and igneous rocks of the basement |

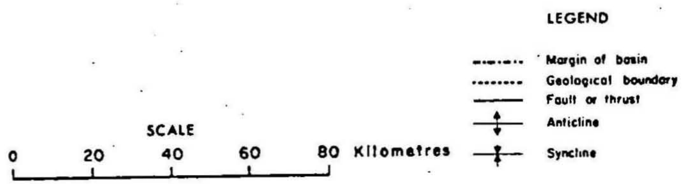


**Fig.3 STRUCTURE AND SOLID GEOLOGY — NGALIA BASIN**

To accompany Record 1973/78

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basin is best illustrated by seismic section NS (Figs. 4 and 7).

The folds in the sediments mostly trend westerly and are commonly doubly plunging. The mostly asymmetrical folds exposed in the strongly deformed northern belt generally have a wavelength of about 3 km. Both the wavelength and amplitude of the folds decrease markedly towards the south, where they are also more symmetrical. Along the eastern half of the southern margin the basal quartzite dips at moderate angles northwards. In the west the structure is more complex, as the quartzite is broken into large blocks which have assumed various attitudes by differential tilting. The basin/basement relationship is in most places an unconformable contact between the Vaughan Springs Quartzite and crystalline basement. Faults are mostly parallel to the fold axes and displacement is generally north-side-up except where a reversal has been caused by later movements.

Along the northern margin of the basin the sedimentary rocks are in most places in fault contact with crystalline basement rocks. Geophysical surveys have shown that some of the faults are low-angle thrusts. Large slices of basement rocks and some of the overlying sediments have been transported southwards several kilometres over the main wedge of basin sediment. Complex fault systems appear to be present in the eastern part of the basin, but faulting is less severe in the west. Several low-angle thrusts appear to transect the sediments in both areas, and major structural highs are apparently associated with them.

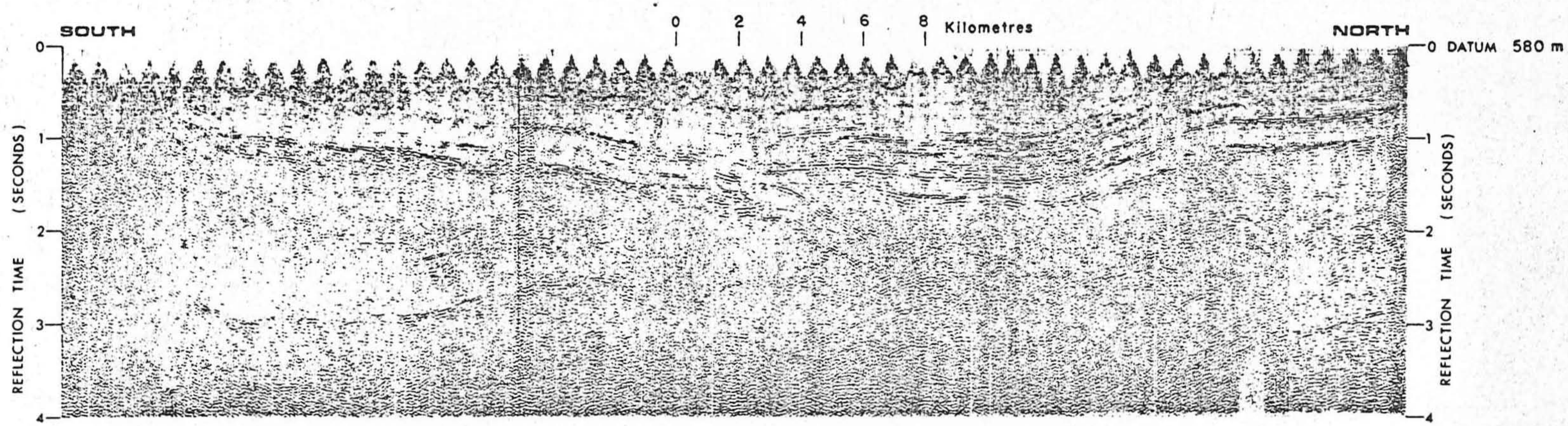


**Fig. 4 SEISMIC REFLECTION CROSS-SECTION — LINE NS**

To accompany Record 1973/78

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The thrusts are either high-angle large-throw reverse faults or low-angle thrusts and imbricate structures. The formation of the imbricate structures possibly occurred by development of a decollement surface utilizing possible Proterozoic evaporites as a gliding plane. Thin thrust sheets were stacked above the surface and the less competant sediments at shallower depth yielded by folding.

Geophysics

Aeromagnetic surveys indicate that the basin consists of two deep lobes containing 5000 to 6000 m of sediments over magnetic basement, separated by a north-trending ridge (Fig. 5). The lobes are asymmetrical, with their deepest part closest to the northern margin.

The dominant feature of the regional gravity data is the Yuendumu Regional Gravity Low (Fig. 6), which has a similar shape but lies well north of the median line. Overthrusting of basement over thick sediments as well as intrabasement variations may be primarily responsible for the position of the gravity low. A detailed study of residual gravity data may be used to further delineate structural trends.

There is regional seismic coverage of most of the basin (Fig. 7), and the most recent surveys by Magellan Petroleum (1972) were designed to further define structural leads indicated by the earlier surveys. The seismic work confirmed the overall pattern suggested by the aeromagnetic interpretation and outlined major structural features.

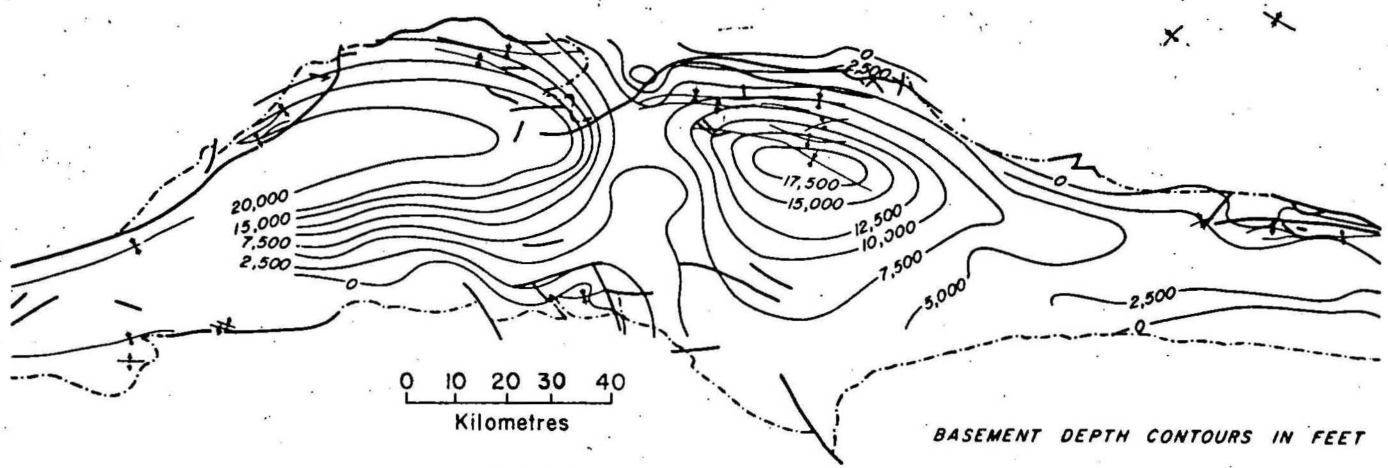


**Fig. 5 MAGNETIC BASEMENT CONTOURS**

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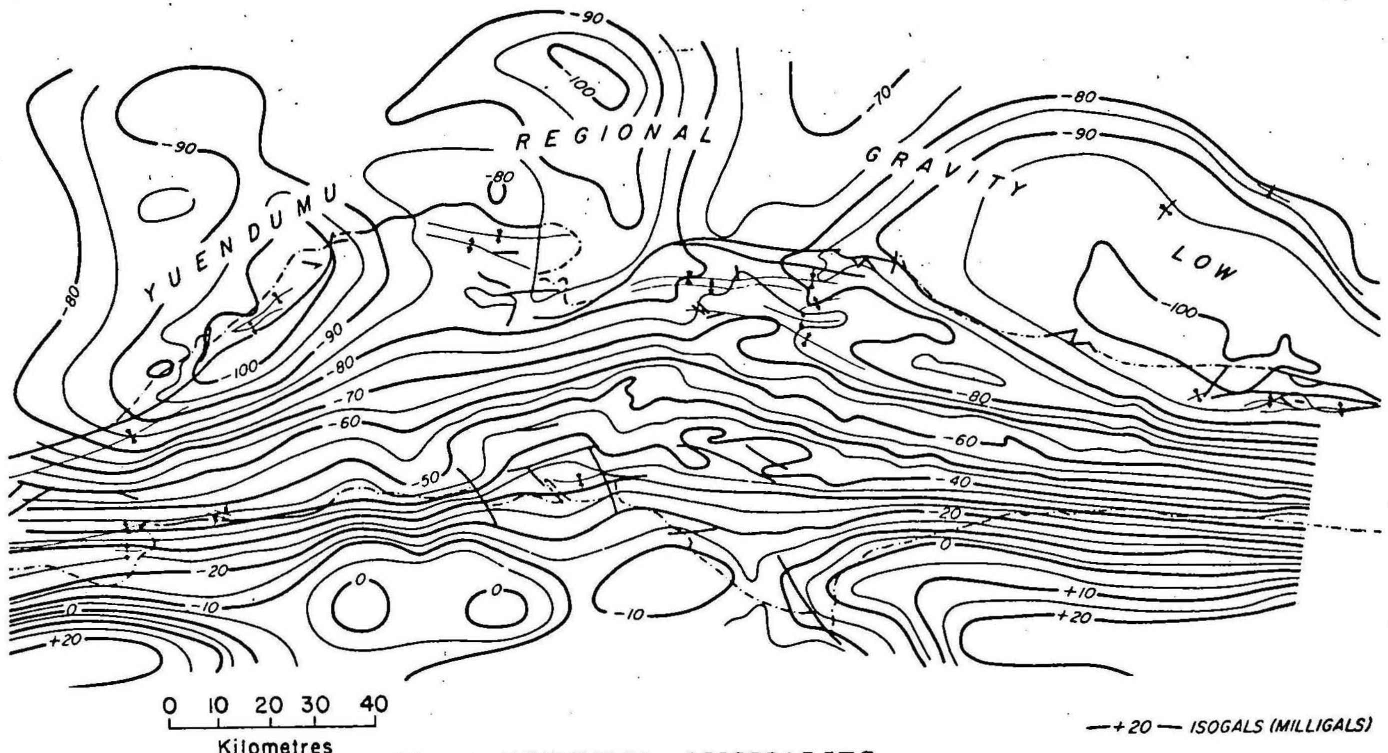


**Fig.6 BOUGUER ANOMALIES**

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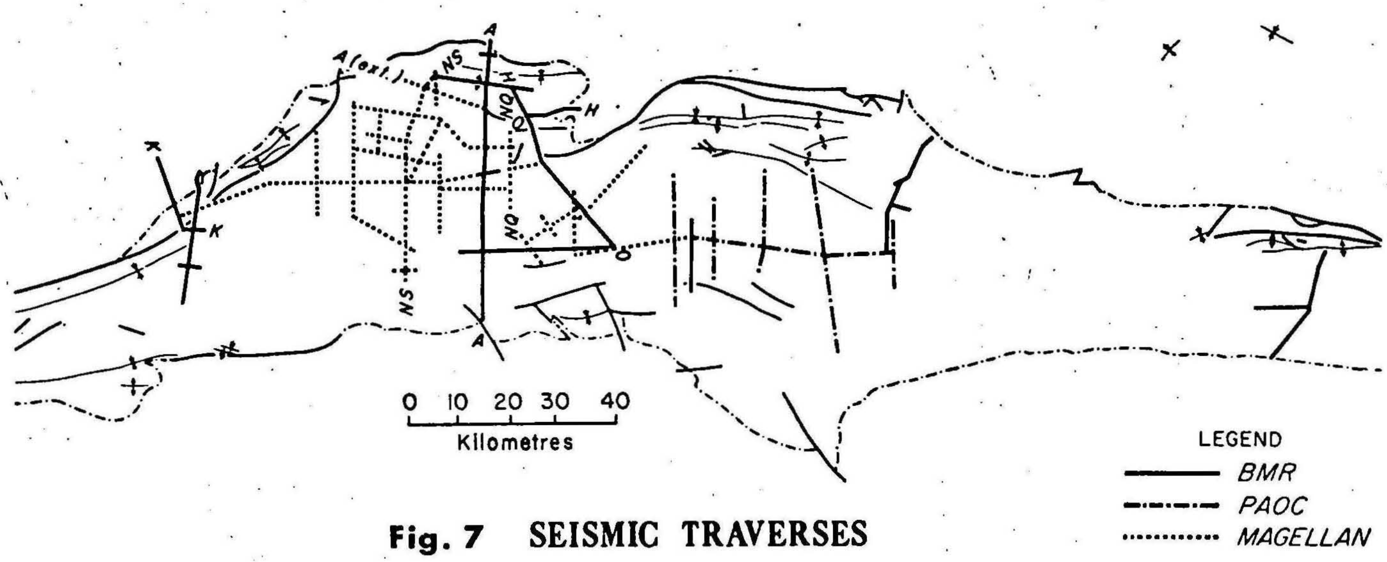


**Fig. 7 SEISMIC TRAVERSES**

To accompany Record 1973/78

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Tectonic Framework and Regional Correlations

The tectonic framework of the Ngalia Basin must evitably be compared with that of the neighbouring Amadeus Basin to the south, because of the similar tectonic evolution of the two provinces, and the obvious correlations that are possible between the sedimentary sequences. An integrated study enables a clearer picture to be obtained of the regional tectonic framework. The stratigraphic correlations between the two basins are shown in Figure 8. The sequence in the Ngalia Basin is very much thinner and incomplete than that in the Amadeus Basin, and many more tectonic events have affected it, as is shown by the much greater number of unconformities.

However, although the Ngalia Basin was much more unstable than the Amadeus, it is still possible to correlate some of the major tectonic events. In particular the Upper Palaeozoic Alice Springs Orogeny, which impressed the major folds, faults, and thrusts on the sediments of the Amadeus Basin, probably correlates with the last major orogeny in the Ngalia Basin.

Other movements that probably coincided occurred in pre-Adelaidean times and caused the unconformity at the base of the sedimentary sequence; late Adelaidean movements before and after the glacial episodes; and an early Palaeozoic (probably late Ordovician or Silurian) movement. The main difference between the two regions concerns the early Cambrian or late Adelaidean Orogeny which caused major uplifts of basement along the southern part of the Amadeus Basin and recumbent folding of the Adelaidean sedimentary wedge.

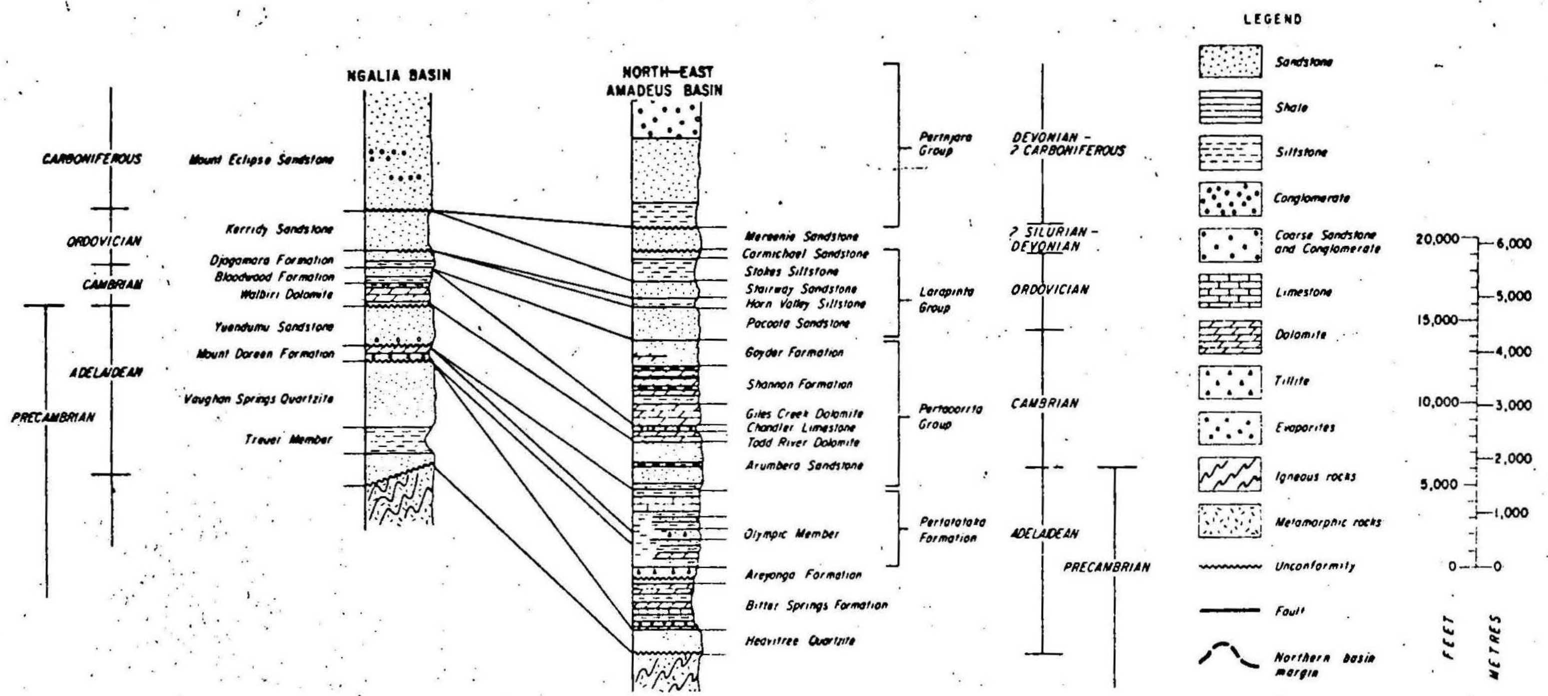


**Fig. 8 CORRELATIONS OF FORMATIONS BETWEEN NGALIA AND AMADEUS BASINS**

To accompany Record 1973/78

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The effects of this orogeny do not appear to have reached the Ngalia Basin. Any local movements at this time are either of only minor consequence or are missing from the record.

The net effect of these movements and the last major orogeny has been to impress a similar structural style on the two basins; although their histories are different in detail the regional aspects are similar. The northern margins of both basins are strongly deformed and in many places are faulted, overthrust, and recumbently folded. The fold pattern and asymmetrical cross-sections of the two are similar and both are bounded to the north and south by Precambrian metamorphic and igneous basement complexes. In both basins the basement has been reactivated in thrusts and folds in the marginal areas.

Petroleum Potential and Prospects

There are no known occurrences of hydrocarbons in the basin and there has been no deep exploratory drilling. However the Lower Cambrian and Ordovician rocks contain potential source beds and the Ordovician has potential reservoirs of porous and permeable sands. This considerably upgrades the petroleum potential of the Ngalia Basin in view of the abundant hydrocarbons present in similar Ordovician rocks of the Amadeus Basin. The most promising drilling objective in the Ngalia Basin therefore is the Ordovician Djagamara Formation. The formation is probably preserved under thick cover rocks in the western lobe. Seismic surveys have indicated a number of buried closed structures there, the most important of which are anticlines commonly developed above sole thrusts. Seismic cross-sections show strong angular discordances in the formations and in a few sections concealed sequences of unknown lithology are possibly present in some of the troughs beneath the unconformities. Shallow stratigraphic drilling in the basin has shown the existence of thick black siltstone of possible Cambrian age which appear to have good source-rock potential and is not known in outcrop. This discovery further substantiated the interpretation of seismic records that additional section may occur on the flanks of some structures.

The unconformities also further emphasize that the Ngalia Basin was subject to many structural modifications throughout its history. Development of structure soon after deposition, or supratenuous folding such as that already demonstrated in the Amadeus Basin, would increase the probability of early entrapment by hydrocarbons and considerably enhance the prospects of the area.

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Acknowledgements

The ideas expressed in this paper are largely based on those given in a lecture presented at the 1972 APEA Conference and published in a paper by A.T. Wells, F.J. Moss & A. Sabitay in the APEA Journal, 1972, Volume 12, Part I.