GS89/007

# NORTHERN TERRITORY GEOLOGICAL SURVEY
# PETROLEUM BASIN STUDY

# — WISO BASIN —

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# 1.0 INTRODUCTION

The following report is a review of the petroleum potential of the Wiso Basin in central Northern Territory. The review was undertaken by Questa Australia Pty Ltd for the Geological Survey of the Department of Mines and Energy of the Northern Territory of Australia.

The object of the report is to address the hydrocarbon potential of the basin in order to encourage explorers to become involved in petroleum exploration in the area. Much of the discussion which follows is based on the findings of Kennewell *et al.* published by the Bureau of Mineral Resources (BMR) between 1977 and 1980.

The Department offers onshore areas for exploration under the guidelines of the Petroleum Act, October 1984 (summarised in Appendix 1). The maximum size of an area that can be applied for is 200 five minute blocks (approx. 16000 km$^2$). Awarded permits carry a five year term and two five year renewal periods with a 50% relinquishment at the end of each period. Permits are granted subject to specific work commitments which must be completed on a year by year basis.

Upon commercial discovery a production licence valid for 21 years can be applied for. Maximum size for a production licence is 12 blocks (80 km$^2$) but several licences can be granted. These licences may be renewed for further 21 year periods.

If a discovery is made but deemed to be non-commercial at the time, a retention licence can be held over an area of 12 blocks (80 km$^2$) with the initial and renewable term lengths being five years. More than one licence can be granted and these can latter be changed into production licences when the discovery becomes commercial.

The Northern Territory Government wishes to promote petroleum exploration and development and will do everything in their power to assist those groups who may be interested in pursuing opportunities in the Territory.

# 2.0 EXECUTIVE SUMMARY

The Wiso Basin in its entirety, is a large (160,000 km$^2$) structural downwarp situated in the central northwestern Northern Territory. Approximately eighty percent of the basin contains generally less than 300m of sediment and is therefore considered non prospective for hydrocarbons. The Lander Trough in the extreme southern position of the basin, occupies some 30,000 km$^2$ and is considered prospective for oil and gas. The entire basin remains virtually unexplored.

There has been no petroleum exploration in the Wiso Basin since 1967 and to date no petroleum exploration wells have been drilled. BMR investigations were carried out from 1962 to 1975 during which period twenty two shallow stratigraphic bores with an average penetration of 100m were drilled. Existing geophysical data over the Lander Trough consists of one seismic survey (5 fold, 1967), two aeromagnetic surveys processed as one (1967) and one regional gravity survey (1965). Assessment of the hydrocarbon prospectively of the basin therefore remains speculative.

The Lander Trough contains approximately 2000–3000m of Cambrian to Ordovician sediments. Much of this sequence is not present along the exposed margins of the basin and lithofacies must therefore be postulated. Deposition of carbonates and clastics took place in shallow marine to fluviatile environments. The lower and upper limits of the sequence are defined by unconformity surfaces, the former reflecting the Petermann Ranges Orogeny and the later the Alice Springs Orogeny. Two additional unconformities are recognised within the basin sequence.

Postulated hydrocarbon potential is considered moderate. Maturation modelling and qualitative geochemistry suggest, however, that the Middle Cambrian Montejinni Limestone and the Ordovician Hanson River beds (Unit 3) will be moderately to optimumly mature and of fair source rock quality within the Lander Trough. The Hanson River beds (Unit 2) and the Montejinni Limestone provide the most important reservoir potential and a postulated basal coarse clastics unit would provide additional reservoir potential if present.

The Wiso Basin evolved with a similar tectonic and depositional history to the Amadeus and Ngalia basins and future drilling in the Lander Trough is therefore expected to identify additional reservoir objectives and source rock units.

No closed structures have been found in the Lander Trough but only 200 km of regional seismic has been acquired. Closed structures are certain to be present but additional seismic programme is required to locate them. The Hanson River Seismic programme indicates a reactivated bounding fault system with slight dip reversal of overlying sediments indicating that the trough has been deformed.

Stratigraphic trapping of hydrocarbons within carbonates of the Montejinni Limestone and within the 'basal coarse clastics' provide additional exploration potential. The only reported hydrocarbon show in the basin is a 'tarry residue' reported within the basal dolomite of the Montejinni Limestone at a depth of 72m in BMR Green Swamp Well 1 but the BMR stratigraphic wells were not drilled on closed features.

The Wiso Basin should have all of the prerequisites of an important hydrocarbon province but given an almost complete lack of geological and geophysical data, a full assessment of the true hydrocarbon potential of the basin cannot be presented. A minimum exploration programme would answer many questions regarding the prospectivity of the basin. Modern multifold seismic data should be acquired over the northwestern Lander Trough, tying older vintage data and crossing a cross axial high which has been defined on the basis of gravity and magnetics data. In addition, a deep stratigraphic (?exploration) well should be drilled to basement in the Lander Trough to determine the stratigraphy within the trough and to address reservoir and source rock potential.

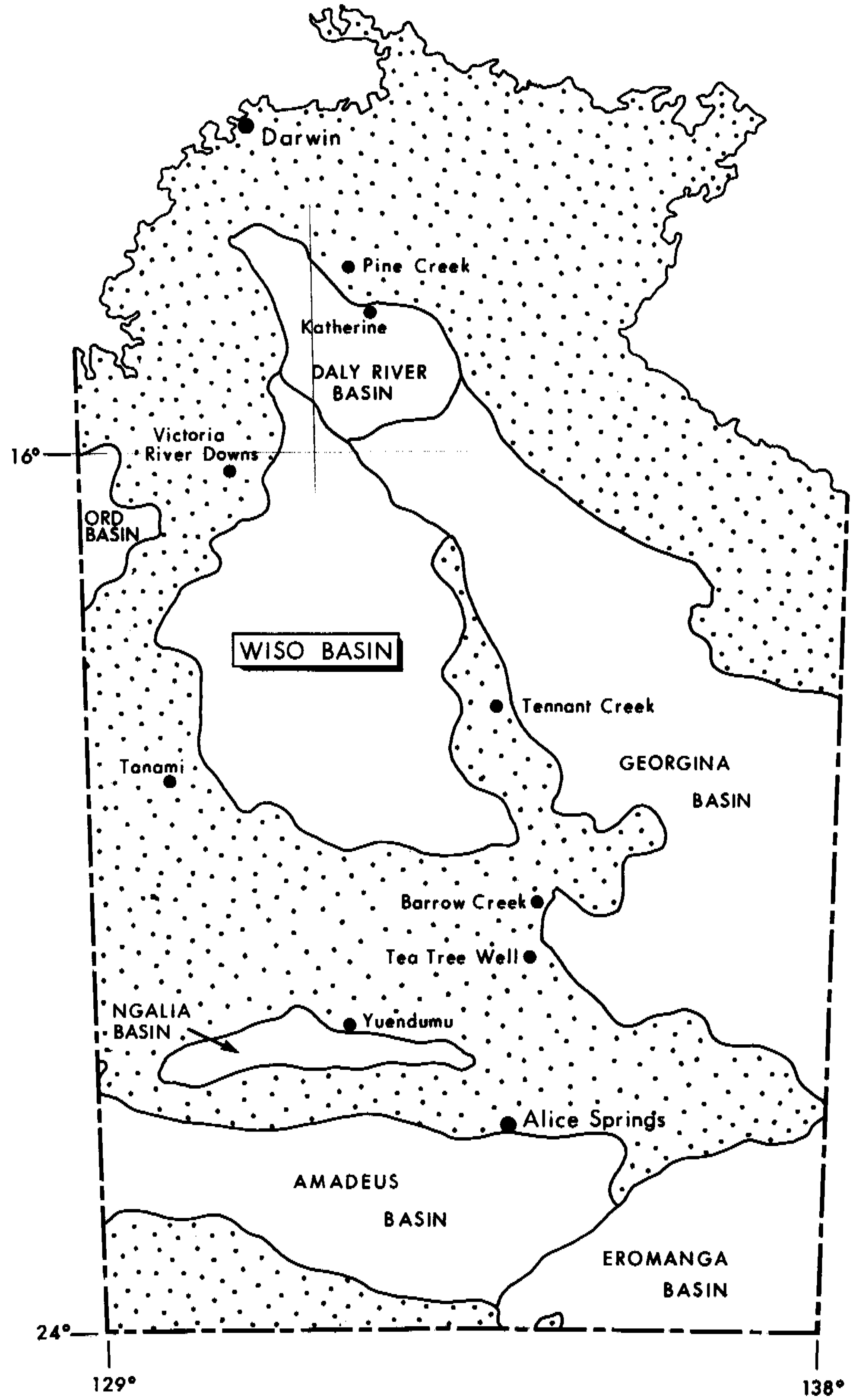
## 3.0 BASIN LOCATION

The Wiso Basin is a Palaeozoic structural downwarp in the central northwestern portion of the Northern Territory between Victoria River Downs and Tennant Creek. It underlies an area of approximately 160,000 square kilometres and covers nearly nineteen 1:250,000 sheet areas, bounded by latitudes 15°00' and 22°00' south and longitudes 129°00' and 135°00' east (Figure 1).

Access to the basin is poor. The sealed Stuart Highway, which runs from Darwin to Adelaide, provides access to the general area but does not enter the basin proper. Several dry weather tracks run west from small settlements along the highway into the region but only station tracks in the far north and in the south around the Hanson River actually traverse the basin. Service centres are Tennant Creek to the east and Katherine to the north.

A flat plateau known as the Main Plateau occupies most of the Wiso Basin area. This plateau slopes northward from an elevation of 400m in the south towards a 290m ridge in the north with a shallow, central basin depression. Sand covers much of the interior basin and in the south, west northwest trending dunes are up to 20m high and 10km long. In the northern part of the basin, black soil and basalt plains cover most of the region.

Temperatures across the basin range from about 38°C (max) to 23°C (min) during the summer months of October through April and 29°C (max) to 11°C (min) during the winter months. July is usually the coldest month of the year. In the northern part of the basin rainfall is monsoonal with upwards of 250mm falling on an average of 15 days during January. There is virtually no winter rainfall. The southern part of the basin receives considerably less of the monsoonal rains. The most pleasant period for field operations lies between June and August when temperatures are relatively cool and rainfall unexpected.




# LOCATION MAP

**WISO BASIN**

FIGURE 1

# 4.0 GEOLOGICAL SETTING

## 4.1 BASIN STRUCTURE

The Wiso Basin is a broad, intracratonic depression which comprises an east southeast trending trough, known as the Lander Trough, in the south and an extensive, shallow shelf to the north. The early Wiso Basin formed as a large southward dipping half graben faulted on the south against Proterozoic basement. The central Australian craton was uplifted during Silurian time and the basin took on its present form with the downwarping of the Lander Trough.

The Wiso Basin sequence was deposited on a basement of deformed Proterozoic rocks, the Granites-Tanami Block in the west, the Arunta Block in the south and the Tennant Creek Block in the east. The flat lying Lower Cambrian extrusives of the Antrim Plateau Volcanics underlie much of the northwestern basin area.

The basin is continuous with the Daly River Basin and the Georgina Basin in the north and east and with the Dulcie Syncline of the Georgina Basin in the southeast.

Landsat imagery indicates the major lineaments to have a southeast trend with 60° to 90° conjugate trends.

Evaluation of existing seismic data and outcrop exposures indicate that the Wiso Basin consists of three distinct tectonostratigraphic sequences each confined by unconformity surfaces.

Earliest Wiso Basin deposition appears to have taken place in response to the early pulses of the Petermann Ranges Orogeny, a period of compressive structural deformation that was most intense along the southern margin of the Amadeus Basin. The first significant pulse of this orogeny is referred to as the Yuendumu Movement in the Ngalia Basin and is here applied to the Wiso Basin. This compressive phase was in response to a reversal in rotation of the Australian Craton and consequent collision with the Pacific Plate. Subsequent to the movement, the Wiso Basin began to subside and to receive the first sediment input. The sedimentary sequence deposited across the unconformity surface was essentially a gently, southward dipping wedge.

A second pulse of the Petermann Ranges Orogeny (second Yuendumu Movement) further rejuvenated existing faults in the basin but overall deformation was very mild. The basin continued to subside along the faulted southern margin but the structural dip of the basin floor remained gentle with only a slight increase of dip into what is now the Lander Trough.

The basin remained tectonically quiescent until Silurian time when the entire central Australian Craton was elevated. In response to the uplift, a hingeline formed longitudinally across the southern basin and the Lander Trough was formed as a permanent basin depression. The uplift was initiated through several pulses of the Alice Springs Orogeny, an intense period of structural deformation which affected much of the Australian Craton. Large slump structures indicate structural disturbance during sediment deposition. Downwarping preserved the basin sediments in the Lander Trough but erosion removed considerable sediment from the northern part of the basin and all of the Palaeozoic sediments from the Arunta Complex, south of the present basin margin.

Late Palaeozoic and Early Mesozoic time was for the most part a period of erosion without further deformation. A mild uplift in the Late Cretaceous and Early Tertiary provided a renewed sediment source which led to deposition of sands and gravels in a fluvial environment. Renewed compression on the continent's northeastern margin led to further deformation but the affect of this on the Wiso Basin was minimal.

By Mid Triassic time, the basin, as part of the Australian continent, began to tilt northwards in response to doming associated with the breakup of Australia and Antarctica. As a result of the tilting Mesozoic and younger sedimentation was restricted to the northern part of the basin.

Structuring in the basin is not intense. Photogeology suggests the presence of shallow, large scale folds in the northwestern part of the basin. Supratenuous folding of early Palaeozoic sediments over basement highs and Cretaceous sediments over highs induced by the Alice Springs Orogeny will probably prove to be the most significant structural form. A prominent cross axial high is interpreted from gravity and magnetic data within the Lander Trough.

The most significant faulting recognised in the basin is along the southern margin of the Lander Trough. Here, a series of parallel, east southeast trending faults with an overall displacement in excess of 2000m places sediments of the Wiso Basin against the crystalline rocks of the Arunta Complex. These faults are interpreted as being reactivated normal faults which have overthrust with continued compression and uplift.

Surface cover conceals the underlying prospective sediments but having a good impression of the structural history of the basin, it is difficult to conceive that the Lander Trough would not have closed structures, either faulted or unfaulted, suitable for the trapping of hydrocarbons. These would most likely occur along the southern margin and in the vicinity of the cross axial high.

### 4.1.1 Magnetic Features

The depth to magnetic basement map (Enclosure 1) has been prepared integrating the results of the Tanami and Tanami/Barrow Creek aeromagnetic surveys (Appendix 2). Two additional surveys are indicated in Appendix 2 but these are in the far north of the basin and only cover an extremely small part of it. The Tanami and Tanami/Barrow Creek surveys were processed as one survey and hence are treated as such. The main feature of the interpretation is a large trough trending northwest in the south of the basin. The trough appears to be fault bounded to the south, perhaps under the present Arunta Complex outcrop, thus indicating a high angle reverse fault. The trough appears to have two depocentres, en echelon to each other, separated by a cross axial high. Depths of 3000m and 4500m have been interpreted for the eastern and western depocentres respectively. Basement highs are indicated in the southeast adjacent to the Georgina Basin and on a northwestern trend on the northeastern edge of the basin. Additionally, two north northeasterly trending highs are interpreted in the central part of the basin, separating two shallower (2000m) depressions which are uncontrolled in the north.

The features must be viewed with some interpretational concern. There is an abundance of shallow magnetic bodies over almost the entire basin area, most probably lavas and basic igneous intrusions (eg. Antrim Plateau Volcanics). This makes it difficult to distinguish between areas where weakly magnetic basement is near the surface and areas where non-magnetic sediments (with deeper basement) have been intruded. In addition, much of the outcropping basement in the basin is weakly magnetic to non-magnetic and thus areas of apparently deep basement may in fact be areas of very weakly magnetic basement and not as deep as interpreted. With this in mind, four interpretation methods (half-slope, dipping dyke, characteristic curve and half-width) were used along with comparison with structures or outcrops on geological maps in order that the most realistic interpretation could be developed. The depth estimates are thus subject to a 10–15% accuracy.

### 4.1.2 Gravity Features

BMR reconnaissance gravity surveys acquired during the 1970's covered the entire Wiso Basin (Appendix 2) and the Bouguer anomalies are presented on Enclosure 2. There are two main provinces indicated from the interpreted data.

The Buchanan Regional Gravity Platform occupies the area north of 19°S and is characterised by small gravity gradients. The high anomaly level of the province suggests that it corresponds to an area of relatively shallow Proterozoic basement.

The Lander Regional Gravity Low is a west northwesterly trending gravity trough, 300km long by 100km wide, bounded by a steep gradient in the south and a gentler gradient in the north. Analysis of the gravity anomalies shows that the total anomaly cannot be accounted for by just the Lander Trough sediments and hence it is concluded (Mathur, 1976) that, similar to the other central Australian gravity lows (Officer, Amadeus and Ngalia) the Lander is an area of crustal downwarping and the anomaly is due to preservation of sedimentary rocks and the total crustal movement and not simply internal crustal thinning (Figure 2). The main gravity low includes both of the major depositional lows established by aeromagnetic data and thus reaffirms their existence.

### 4.1.3 Seismic Features

Only one seismic survey has been recorded in the Wiso Basin and this covers only a part of the southwestern depocentre of the Lander Trough. The survey was acquired in 1967 over the area in which gravity and aeromagnetic data indicated a significant sedimentary basin sequence. Six lines were recorded as both five fold reflection data and one way refraction data (Appendix 2). Initial interpretation by Ray Geopyhysics suggested a southwesterly dipping half graben with sediments up to 2150m thick near sp 212, line R-1. In 1977 Kennewell *et al* reinterpreted the data and concluded that basement was only a little more than 1000m deep at the same location. Apart from this discrepancy in maximum depth to basement, the conclusions drawn by the two interpreters are similar.

The Lander Trough is described as a crustal downwarp bounded on the southwest by an en echelon thrust fault system. The fault system's major reactivation is interpreted to be post Ordovician in age and most likely contemporaneous with the Alice Springs Orogeny.

The upper reflector (C) / refractor (A), shown in Figure 3, can be correlated into the BMR stratigraphic wells on strike as the base of the Lake Surprise Sandstone. Kennewell concluded that the reflector (D) / refractor (B) interface is the base of the Wiso Basin and that reflector E was most likely the interface between the Adelaidean Central Mount Stuart Formation overlying the Proterozoic Hatches Creek Group.

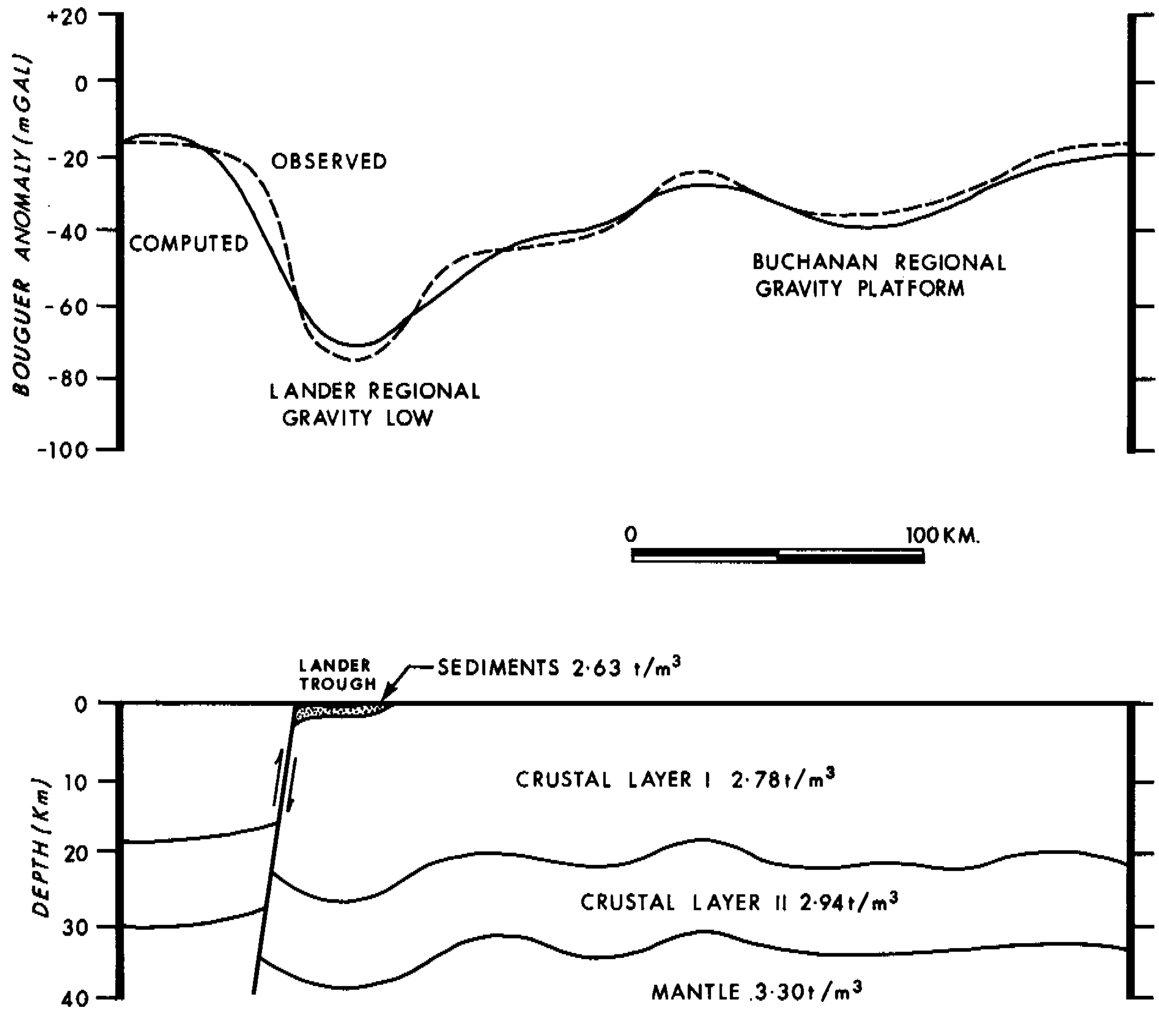
Recent post stack processing of line R-4 (Figure 4) has considerably improved event definition. This line had previously not been interpreted due to unreliable data. Horizon 3 is interpreted to be the base basin unconformity as the underlying events have greater dip suggestive of Proterozoic basement. This interpretation is slightly different to that of Kennewell et al in that it places basement deeper in the trough, similar to the Ray Geophysics interpretation. The various horizons are postulated to be:

I –base Lake Surprise Sandstone

II –base Point Wakefield beds

III –base Montejinni Limestone (base Wiso Basin)

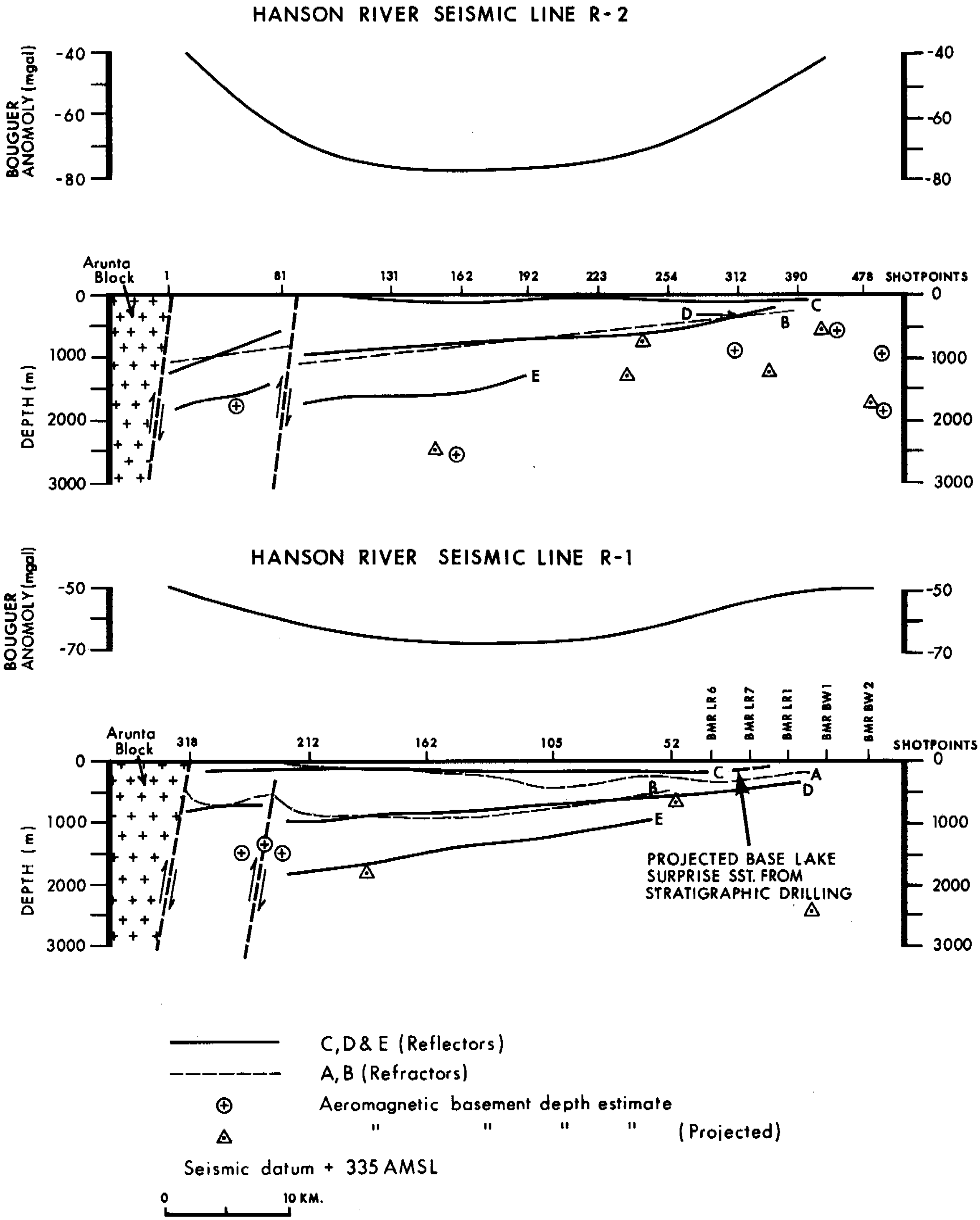
The aeromagnetic data shown in Figure 3 and Enclosure 1 may also be used to demonstrate that basement is deeper than that suggested by the 1977 interpretation. The gravity data is unable to quantify this result as the total anomaly is more related to the crust than to the sedimentary sequence.




**INTERPRETED CRUSTAL STRUCTURE**
**FROM REGIONAL GRAVITY PROFILES**
**Wiso Basin**

AFTER KENNEWELL ET AL (1977)

FIGURE 2



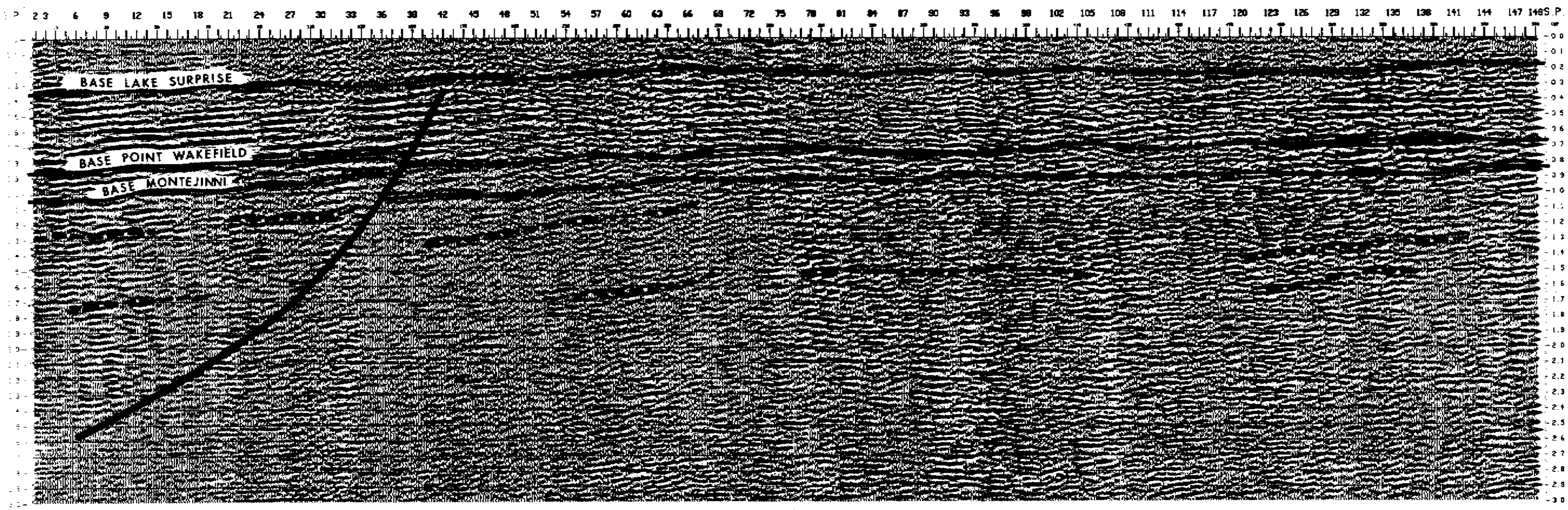

## HANSON RIVER SEISMIC SURVEY
**Seismic Horizon Interpretation with Gravity and Magnetic Data**

AFTER KENNEWELL ET AL (1977)

FIGURE 3

RECORDED 1967
PRESTACK PROCESSING: 1967
POSTSTACK PROCESSING: 1988
SHOT POINT INTERVAL: 183m

SOURCE: WEIGHT DROP
FOLD: FIVE
HORIZONTAL SCALE: 1:80,000




HANSON RIVER LINE R4 (migrated)

0 5km

FIGURE 4

Integration of magnetics, gravity and seismic data, including their respective error bands, leads to the conclusion that the Wiso Basin sediments in the Lander Trough are between 2000m and 3000m thick.

Source and reservoir units identified in outcrop and from stratigraphic drilling should be well developed in the trough. The stratigraphy of the basin remains largely unknown and it is expected that much of the sediment present in the deeper parts of the Lander Trough has not been seen in outcrop.

### 4.1.4 Structural Elements

The Wiso Basin can be divided into a northern and a southern province. A metamorphic ridge which dips northwestwards, as indicated on the Bouguer Gravity map, separates the two provinces. This ridge appears to be a subsurface extension of the Tennant Creek Block. North of this hinge line, sediments of the basin are less than 300m thick and have very little structure. The structure which does exist comprises drape over basement features and erosional features associated with the total stripping of Late Cambrian through Ordovician sediments that took place during the Early Carboniferous Orogeny.

The Lander Trough constitutes the southern basin province. The trough originated as an half graben, fault bounded to the south. It is 300km in length, 100km in width and approximately 2000–3000m in depth. The trough comprises two depocentres separated by a cross-axial high. Dip into the trough from the north is gentle and uninterrupted.

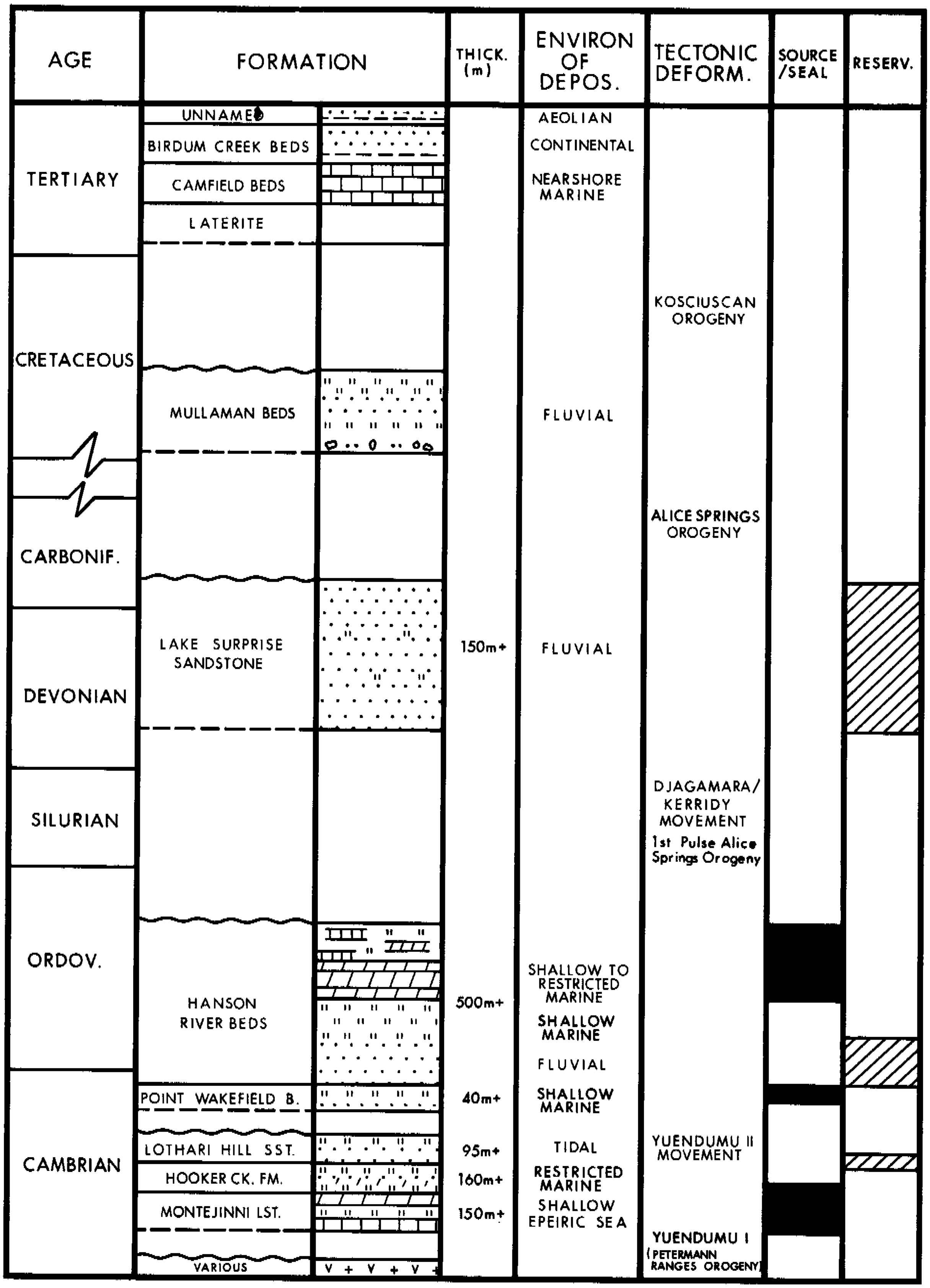
There are several shallow magnetic anomalies in the southern basin most likely generated from the presence of volcanics in the sedimentary sequence and by the various basement complexes underlying the sedimentary sequence which constitutes the Wiso Basin. The basin has not been studied in detail and therefore the precise make-up of the structural provinces is unclear.

## 4.2 STRATIGRAPHY

The stratigraphy of the Wiso Basin sequence is summarized in Figure 5. The sequence consists of shallow marine and carbonate Palaeozoic sedimentary rocks which have been divided into six formations and which together form three sequences, each separated by an unconformity surface (Figures 6 and 7). There is little surface exposure of Wiso Basin sediments with most of the basin being overlain by Mesozoic and younger rocks. The relative stratigraphic positions of the various formations has been determined from that outcrop which does exist and from shallow stratigraphic bore holes which have been drilled in the region. There are no deep bores in the Lander Trough where the full Wiso Basin sequence is interpreted to be present. The well data that is available is listed in Appendix 3.

Basement varies from high grade metamorphic rocks of the Early to Middle Proterozoic Arunta Complex to gently folded Adelaidean sediments of the Victoria River Basin. The inferred subcrop of basement rocks is shown on Figure 8.

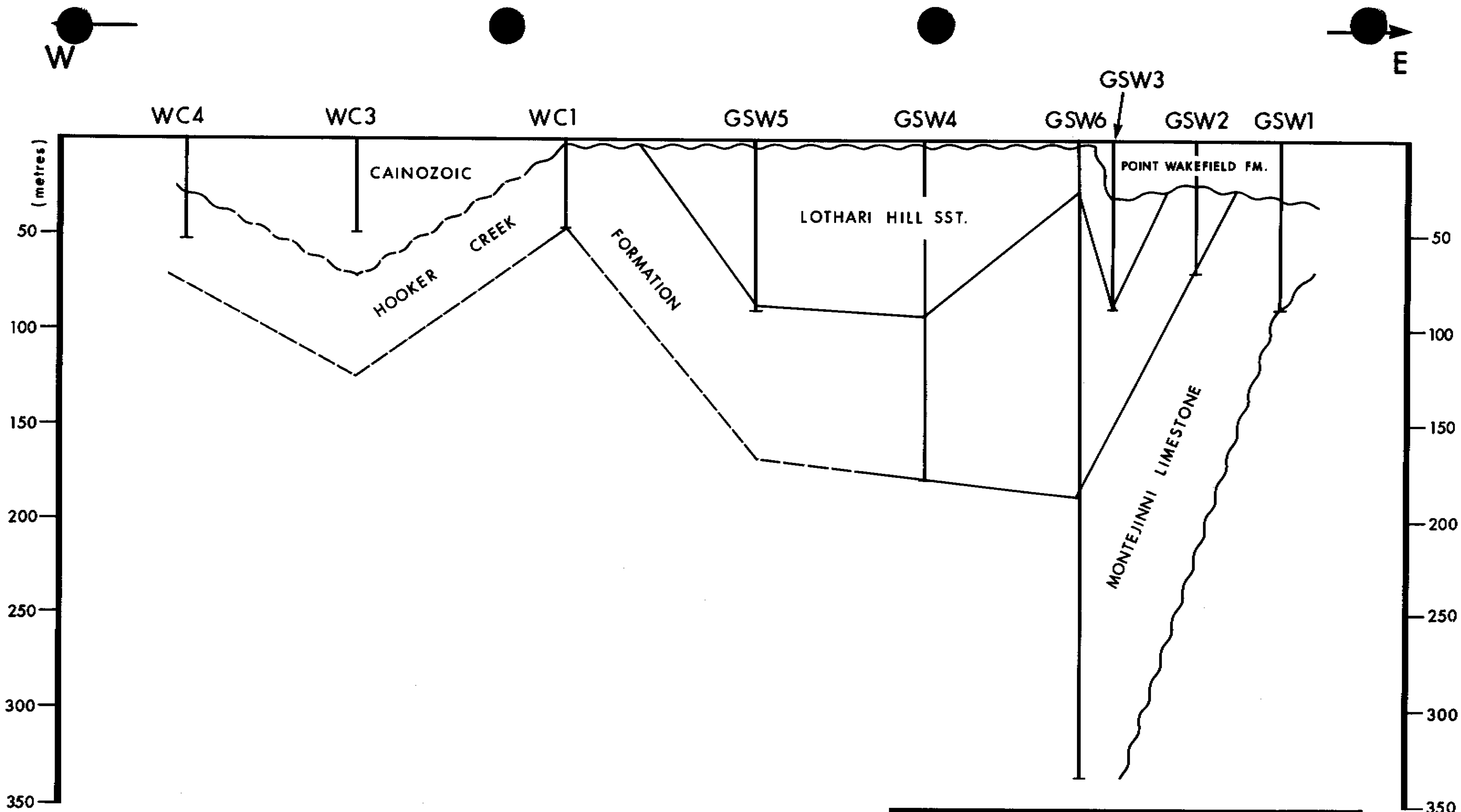
The Arunta Complex forms basement to the basin on its southern margin and consists predominantly of high grade metamorphic, Early to Middle Proterozoic sediments which have been heavily intruded. In the western and southwestern parts of the basin, the Granites — Tanami Block comprise intensely folded and metamorphosed sedimentary rocks with acid and basic tuffs and lavas and gabbroic rocks. The northwestern part of the basin is underlain by gently folded and, in part, prospective sediments of the Victoria River Basin. Much of the basement complex which underlies the Wiso Basin is overlain by Adelaidean and Early Cambrian volcanics which have been assigned to several different formations.




**Generalized Stratigraphy**

**WISO BASIN**

FIGURE 5



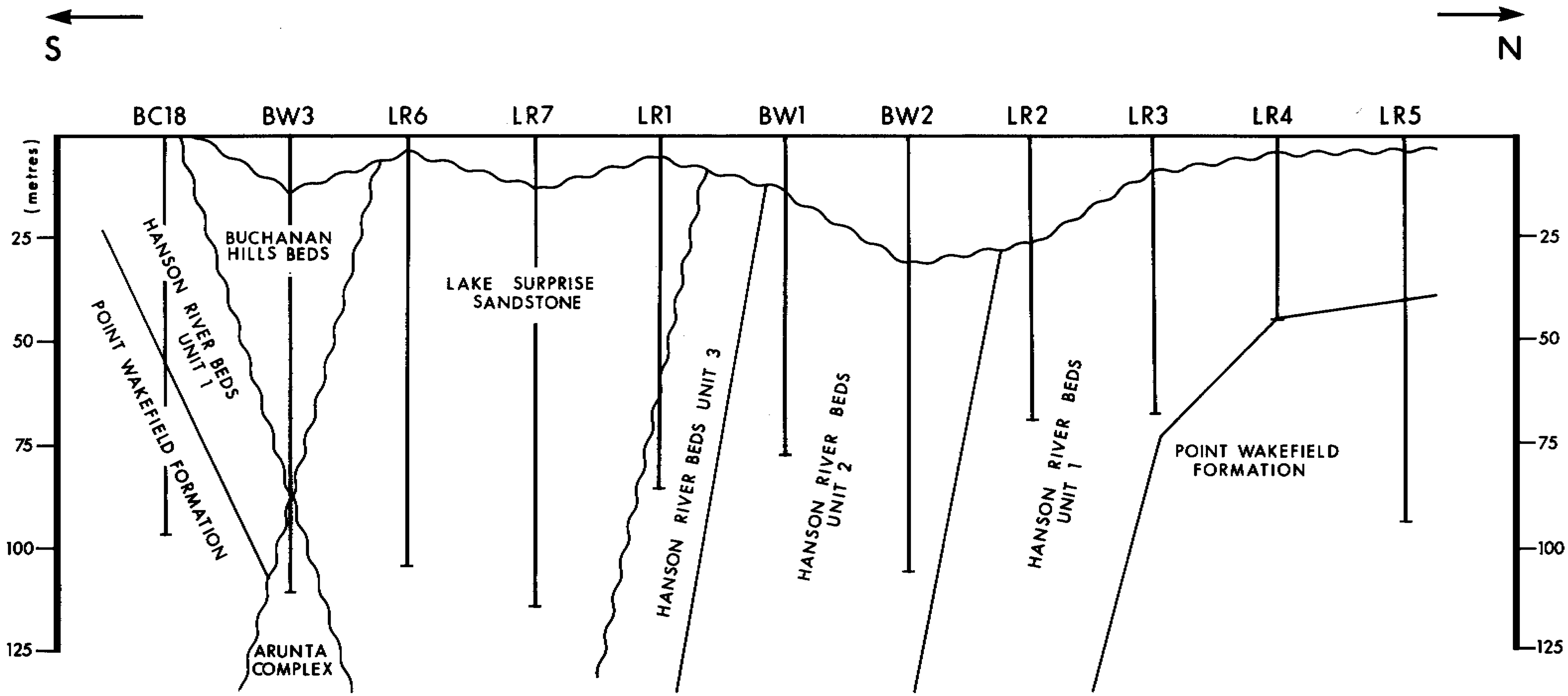

Horizontal Scale: 1:1,000,000
Vertical Scale: 1:2,000
Vertical Exagg.: 500×

REFER FIGURE 8 FOR LINE OF SECTION

**Wiso Basin**

**EAST-WEST GEOLOGICAL CROSS-SECTION along Tennant Creek/Hooker Creek Road**

FIGURE 6



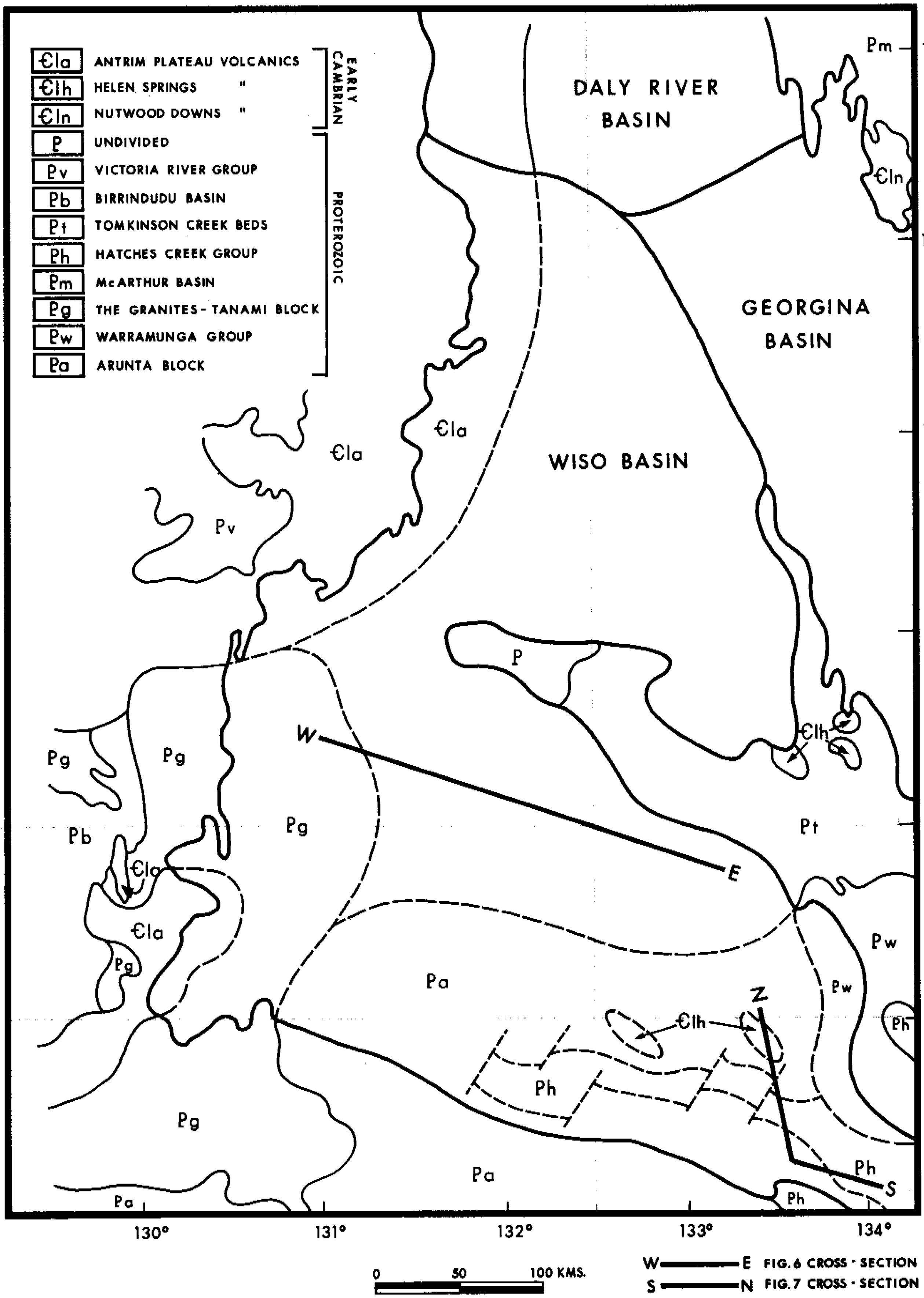

Horizontal Scale: diagrammatic
Vertical Scale: 1:1,000

Wiso Basin

NORTH–SOUTH GEOLOGICAL CROSS–SECTION
Lander Trough

REFER FIG. 8 FOR LINE OF SECTION

FIGURE 7




INFERRED SUBCROP OF BASEMENT ROCKS

FIGURE 8

### 4.2.1 Montejinni Limestone

The Montejinni Limestone is continuous across the entire Wiso Basin, often outcropping as rugged mesas or ridges and sinkholes. The formation doesn't outcrop in the southern half of the basin as it is covered by younger Palaeozoic and Mesozoic sediments.

In the northern half of the basin, the Montejinni Limestone consists of dolostone, limestone, dolomitic limestone and calcareous mudstone and siltstone, often with abundant chert nodules. Dolostone, dolomitic siltstone and chert interbeds appear to be more representative of the formation in the central part of the basin.

In the northwestern part of the basin, the formation reaches a maximum thickness of about 58m and has been divided into three recognisable units. These units are not necessarily representative of the entire basin. Where seen in outcrop the basal unit consists of mottled to microcrystalline limestone, dark grey to brownish in colour, stromatolitic in part, particularly at the base of the unit, with minor dolostone windows and chert. The middle unit is a red-brown to yellow-buff, calcareous siltstone which grades to mudstone. In places it is thin bedded and laminated. The upper unit is described as a dark grey to black, in places foetid, limestone, grading to a calcilutite, often thick bedded and containing chert nodules.

The sequence thickens towards the south, reaching a thickness of 151m in BMR Green Swamp Well 6, which was drilled in the central part of the basin. The sequence is interpreted to be considerably thicker in the Lander Trough. BMR Green Swamp Well 6 encountered the three units described from the northwestern part of the basin. The corresponding units in both the northern and central parts of the basin are similar but dolostone is the primary lithology in units 1 and 3 in the central basin well and there is a relatively high percentage of gypsum, suggesting perhaps, that a relatively thick sequence of evaporites may be present in the Lander Trough. The formation is interpreted as a sequence which grades from evaporites in the southern trough to dolostones and then limestones towards the basin's northern margin. This provides an ideal source rock environment with numerous possibilities for reservoir development.

The Montejinni Limestone was deposited in a shallow epeiric sea which covered large portions of the Northern Territory. Several regressions probably took place during the deposition of the formation. Fossils indicate the Montejinni Limestone is time correlatable with the base of the Giles Creek Dolomite of the Amadeus Basin. The formation is also equivalent to the Gum Ridge Formation of the western Georgina Basin and the Tindall Limestone of the Daly River Basin.

The Montejinni Limestone forms the basal unit of the known Wiso Basin sequence. In the north, the formation unconformably underlies the Mullaman beds where an eroded contact indicates the present formation thickness to be less than the original depositional thickness. The Montejinni Limestone constitutes the entire preserved Wiso Basin sequence in the north. Throughout much of the central and southern parts of the basin, the contact of the Montejinni Limestone with the overlying Hooker Creek Formation is gradational. On the eastern basin margins, the Montejinni Limestone is unconformably overlain by the Point Wakefield beds.

### 4.2.2 Hooker Creek Formation

The formation outcrops as low rises along the central western basin margin. The thickest recorded section of the Hooker Creek Formation is 161.5m in BMR Green Swamp Well 6, its type section. The formation is tentatively dated as early Middle Cambrian in age on the basis of trilobites and brachiopods and may in part be a lateral equivalent of the Montijinni Limestone.

In its type section the formation consists of interbedded dolostone, siltstone and shale with dolostone becoming more abundant towards the base of the formation. In outcrop a red-brown colour is prominent, due to weathering and ferruginisation. Where present, the dolostone is fine grained to crystalline. The uppermost beds of the formation include fine grained, quartzose, in part dolomitic, sandstone with abundant clay. It may be expected that these sands will provide considerably better reservoir quality in the central and southern parts of the basin where they may prove to be coarser grained with better sorting and where they would not be weathered.

The Hooker Creek Formation was deposited in a restricted marine environment. Wide coastal lagoons along the eastern basin margin would have been inundated by the sea during transgressions and left to dry out during regressions, providing an ideal source rock environment. The formation appears to thicken towards the south into the Lander Trough where fine grained clastics and evaporites might be expected.

The formation's contacts with the underlying Montejinni Limestone and overlying Lothari Hill Sandstone are both gradational and conformable. The formation is regionally contemporaneous with the Giles Creek Dolomite of the Amadeus Basin and with the Wonarah beds of the Georgina Basin.

### 4.2.3 Lothari Hill Sandstone

The Lothari Hill Sandstone is exposed in outcrop throughout the entire central basin and as far south as the hingeline which defines the northern margin of the Lander Trough. Its presence in the Lander Trough is unknown but the formation is expected to thicken into the trough. The formation is not present in the northern part of the basin, probably due to erosion.

Where observed in outcrop, the Lothari Hill Sandstone is reddish brown to white, fine grained, poorly sorted and often dolomitic or micaceous. The sandstone is typically thick bedded and even textured but low angle cross bedding has been observed in some outcrops. Rare interbeds of tight, clayey siltstone and silty chert are also present in the formation.

Polygonal mud cracks, worm burrows, low angle cross bedding and symmetrical ripple marks are indicative of deposition in a tidal environment.

A lack of fossils and its red colouration are probably indicative of an intermittently desiccated environment. Better sand (and therefore reservoir) development is expected in the deeper parts of the basin, towards the Lander Trough.

No fossils have been recorded from the formation and its age must therefore be determined on the basis of its gradational contact with the underlying Hooker Creek Formation.

### 4.2.4 Point Wakefield beds

The Point Wakefield beds are poorly exposed and limited in outcrop to the central basin area. The formation is absent from the northern basin and, although concealed in the southern basin, probably thickens into the Lander Trough.

The formation where seen in outcrop consists predominantly of brown and white siltstone which is calcareous and/or silty in part and which includes a few chert beds. In the central basin, it appears that the formation can be divided into two subunits, a lower, calcareous rock subunit and an upper, arenaceous and lutaceous rock subunit. The maximum recorded thickness for the formation is 41.1m, encountered in BMR Barrow Creek 18 on the ridge between the Lander Trough and the Dulcie Syncline.

Because of poor outcrop, it is difficult to determine the depositional environment of the formation. The two subunits appear to have been deposited under shallow marine conditions. The presence of stromatolites indicates restricted, quiet water deposition but the presence of well sorted sandstone suggests high energy deposition.

On the basis of its stratigraphic position between the Hanson River beds and the Lothari Hill Sandstone, the Point Wakefield beds have been assigned a post Templetonian age. A more precise age assignment cannot be made at this time. No diagnostic fossils have been recorded from the formation.

The lower contact of the Point Wakefield beds is considered unconformable whilst the upper contact appears to be gradational, but neither is stratigraphically conclusive.

### 4.2.5 Hanson River beds

The Hanson River beds occupy only the southern basin area, adjacent to and within the Lander Trough. Surface exposure is poor.

The Hanson River beds form the thickest sequence in the Wiso Basin. Maximum thickness is uncertain but seismic data suggests the formation to be in the order of 350m to 800m in the southwestern Lander Trough. No continuous section of the formation has been encountered but the Hanson River beds appear to be divisible, at least in the area of their surface exposure, into four discrete subunits. Seismic evidence suggests that there may be additional, younger units in the central Lander Trough.

Subunit 1, the basal unit, overlies the Point Wakefield beds with an undefined but probably gradational contact. The subunit consists of fine to medium grained, rounded to angular, moderately sorted sandstone, interbedded with orange, brown and green, slightly fissile, slightly micaceous claystone and siltstone, which were deposited in a continental fluvial environment.

Subunit 2 comprises a fine grained, well rounded, well sorted sandstone and an angular, poorly sorted sandstone. Tracks and burrows are abundant and in places the subunit contains fissile claystone and some glauconite grains. Evidence suggests that the subunit was deposited in a shallow marine environment and is a time and facies equivalent of the Pacoota Sandstone in the Amadeus Basin from which oil and gas are now being commercially produced towards an ever expanding market.

Subunit 3 is a white, crystalline, laminated limestone which has been partly replaced by dolomite along joints and laminae. Interbeds and laminae of dark brown to dark grey, bioturbated mudstone are common. The subunit is equivalent to the Horn Valley Siltstone of the Amadeus Basin which is considered an excellent source rock and to the Nora Formation of the Georgina Basin.

The upper subunit, Subunit 4, is a coarsely crystalline dolostone with white, hard, micaeous claystone and well sorted, subrounded sandstone interbeds. Fossils of molluscs, brachiopods and trilobites are common and indicate a correlation with the Stokes Siltstone and Stairway Sandstone in the Amadeus Basin and the Carlo Sandstone and Mithaka Formation in the Georgina Basin.

Conodonts and other fossils indicate an Early to Middle Ordovician age for the Hanson River beds.

### 4.2.6 Lake Surprise Sandstone

The youngest formation of the Wiso Basin sequence, the Lake Surprise Sandstone, is a white, grading to dark brown, very fine to medium grained, well sorted, well rounded, sandstone. Low angle cross bedding is common. Its distribution is centred over the Lander Trough where it unconformably overlies the Hanson River beds. The formation was deposited in response to the Alice Springs Orogeny during which time the Lander Trough was structurally downwarped.

Evidence suggests the Lake Surprise Sandstone was deposited by streams and as fans from a provenance which comprised already well rounded, well sorted sandstone. Although there is no evidence of a fining upward sequence which may be expected in a fluvial environment, it does not seem probable that the formation was deposited under shallow marine conditions. A braided stream environment is postulated.

Seismic data indicates the sandstone is approximately 150m to 250m thick in the centre of the trough. South of the fault bounded Lander Trough, the formation overlies the Arunta Complex.

Barren of fossils, the Lake Surprise Sandstone, cannot be dated by biostratigraphic methods. The formation appears to be equivalent to the Mereenie Sandstone in the Amadeus Basin, the Mount Eclipse Sandstone in the Ngalia Basin and the Cravens Peak beds and the Dulcie Sandstone in the Georgina Basin, and is therefore assigned a Devonian to Carboniferous age.

In these other basins, deposition resulting from the Alice Springs Orogeny provided the sedimentary load necessary to bring immature source rocks into a generative state and to promote hydrocarbon migration from source rocks to reservoirs.

### 4.2.7 Formations Overlying the Wiso Basin Sequence

Unconformably overlying the northern Wiso Basin are several Albian/Aptian fluvial sandstone/siltstone sequences known as the Mullaman beds. These are continuous in the northwest with the Mullaman beds of the Bonaparte Basin.

Unconformably overlying the Mullaman beds are a series of Tertiary sequences of restricted distribution. These consist of a) a deep weathering laterite profile over most of the basin; b) the Camfield beds (limestone); c) a dark grey Miocene limestone which is present over the northern area; d) the Birdum Creek beds, white nodular fossiliferous limestone distributed again in the extreme north of the basin; and e) the ubiquitous calcretes, alluvium, aeolian sands and gravels of broad, intracratonic depressions.

## 5.0 BASIN HISTORY

In Proterozoic time, the Australian Craton occupied only the central and western part of the present day continent. Adelaidean and earliest Phanerozoic time saw the inception of the eastern (Pacific) and the northwestern (Tethyan) margins of Australia by plate divergence. Failed arms (aulacogens) of triple junctions penetrated deep into the interior of both the Tethyan (Bonaparte Basin) and Pacific (Officer, Amadeus, Ngalia and Polda Basins) margins. These aulacogens allowed an inland seaway to readily encroach the existing craton and the central Australian basins were covered by shallow, epicontinental seas throughout much of the early stages of their depositional history. These areas were tectonically very active from pre-Adelaidean through Carboniferous time and numerous tectonic movements, with two orogenies, are recorded in the rock record.

Throughout much of their earliest depositional history, the central Australian basins together formed an extensive sedimentary province. At times the inland sea occupied the entire central craton. During times of tectonic disturbance when large portions of the central land mass were elevated, the sea entered the now segregated basins via the aulacogens from an eastern sea. The rifts allowed the seaway to enter each of the basins simultaneously and likewise, to regress from each of the basins simultaneously. The depositional history of each of central Australia's intracratonic basins is therefore very similar.

The Wiso Basin formed part of this central Australian tectono-depositional province but during Adelaidean time appears to have been more stable than the basins to the south. Basins such as the Amadeus and Ngalia have a long and complex Adelaidean history and much of the subsequent Phanerozoic history of these basins was controlled by Adelaidean events. The Adelaidean sequence in these basins offers considerable exploration potential.

Little is known about the Adelaidean sequence which underlies the Wiso Basin. Adelaidean sediments appear to be thin and in the north constitute part of the Victoria River Basin. These sediments are concealed and have not been penetrated in the deeper portions of the Wiso Basin where they might be preserved. They are not expected to be of significant thickness, however, even in the deepest part of what is now the Lander Trough.

Although Proterozoic sediments which underlie the Wiso Basin sequence have been severely deformed, Adelaidean diastrophism does not appear to have been as severe as that seen to the south. The proto-Wiso Basin appears to have remained as a gentle depression, relatively unfaulted and with a gently undulating topography. The basin was active tectonically in the sense of volcanic activity and, volcanic sequences underlie much of the Wiso Basin sequence but movements which disturbed the southern basins were probably no more than tremors in the Wiso Basin.

The Wiso Basin was probably initiated in early Cambrian time in response to initial pulses of the Petermann Ranges Orogeny which severely affected the southern margins of the Amadeus Basin. The intensity of this orogeny decreased towards the north but its effect on the Wiso Basin is seen in that the basin began to subside and acquire sediment and the faulting which places the southern margin of the Lander Trough against Proterozoic basement (Arunta Complex) was probably initiated, allowing the Wiso to develop as a half graben. Earliest Cambrian sediments, other than volcanics, have not been found in the Wiso Basin but they may be preserved in the Lander Trough.

The known Wiso Basin sequence commenced with deposition of limestones, dolostone and siltstone of the Montejinni Limestone during Middle Cambrian (Ordian) time. Deposition was across the entire basin and it is likely that coarser clastics would have formed in southern depocentres during periods of marine transgressions while evaporites would have been deposited during regressions. Restricted marine conditions would have existed along the basin margins with silty dolostones and possibly shallow basin evaporites being deposited.

The sea regressed in response to gentle uplift of the basin margins. Uplift and erosion emphasized the Tennant Creek Block, separating the Wiso Basin from the Georgina Basin. The regression probably also resulted in erosion of the Montejinni Limestone in the northern Wiso Basin.

As seas again transgressed the central basin during Middle Cambrian (Templetonian) time, sands and silts of the Lothari Hill Sandstone and calcareous silts and sands of the Point Wakefield beds were deposited in the central basin area. The northern depositional extent of these formations is unknown but the shallow inland sea probably occupied the entire northern basin during times of maximum transgression. It may be postulated that a thick shale sequence would have formed in the southern depocentre along the faulted Arunta Complex but at the same time, coarse clastics would have been shed from the emergent basement granites and metramorphics.

Uplift of the northern margin of the basin in late Cambrian time once more interrupted sedimentation but in response to continued uplift and a retreating sea, fluvial sands of the lower Hanson River beds were deposited in the central and southern parts of the basin. The northern basin probably remained emergent.

A marine transgression in probable Early Ordovician time submerged much of the basin and resulted in deposition of near shore marine sands and shallow water carbonates of the upper Hanson River beds. Shale and limestone could be expected in the southern trough. There were probably several changes in relative sea level during the deposition of the Hanson River beds and these would be reflected in the lithofacies.

The inland sea began to retreat from the Central Australian basins for the last time in response to Late Ordovician through Middle Devonian movement. Sedimentation in response to these movements has not been identified in the Wiso Basin but representative sediments may be present in the Lander Trough. The full effect of the movements on the Wiso Basin is unknown. It appears the entire central continent began to rise during these early pulses of the Alice Springs Orogeny. Crustal downwarping of the southern Wiso Basin was in response to this uplift and the Lander Trough became a prominent physiographic feature. Braided streams brought well sorted clastics of the Lake Surprise Sandstone into the newly depressed trough. Erosion removed much of the remaining Palaeozoic sequence from the northern basin area and from the margins of the basin.

The Wiso Basin escaped the full intensity of the Alice Springs Orogeny which severely deformed Palaeozoic and Proterozoic sediments in the southern basins.

Erosion which persisted into the early Mesozoic led to deposition of fluvial sands and gravels (Mullaman beds — Unit A) across the northern Wiso Basin. In Late Jurassic and Cretaceous time an inland sea transgressed the northern continent from the north and deposited clays, silts and glauconitic sands of the upper Mullaman beds.

A period of relative tectonic quiescence with very little sedimentation ensued until Holocene time. Minor local movement in the early Cainozoic had only a small effect on the deposition of thin lacustrine and fluvial sediments in local, small scale depressions. Uplift and erosion in response to the Kosciuscan Orogeny, which was centred on the northeastern margin of Australia, gave the basin its present topographical expression. Laterites formed on the Main Plateau while scarps formed in the northwest. Below the scarps, depressions were filled with limestones and calcareous silts.

Recent time has seen the deposition of alluvial and aeolian sands in the southern basin and calcretes and erosional sands and gravels in the northern basin.

# 6.0 PREVIOUS EXPLORATION HISTORY

Systematic study of the geology and geophysics of the Wiso Basin was confined to the late 1960's and 1970's, although exploration of the area dates back to the turn of the century.

The first attempt at stratigraphic correlation was in 1909 by Chewings (1931) when he was commissioned to sink a series of water bores for stock routes.

Geological mapping for the Bureau of Mineral Resources 1:250,000 sheets covering the basin was commenced in 1961 by Mackay (Barkclay, 1965) and was not completed until 1978.

Stratigraphic drilling was undertaken by the BMR in three phases. BMR Barrow Creek 18 was drilled in 1962 as a part of the Georgina Basin programme on the Proterozoic ridge separating the two basins and established that Palaeozoic rocks extended across it. In 1965 a series of wells were drilled on the track between Tennant Creek and Hooker Creek. These showed the northward thinning of Wiso Basin sediments. The final phase, in 1974 and 1975, saw the drilling of a line of wells northward out of the Lander Trough and one well (BMR Green Swamp Well 6) on the northern margin of the trough.

Petroleum exploration occupied a three year period from 1964 to 1967. In 1964 Aero Service Ltd (1964a) flew an aeromagnetic survey over the southern basin for Exoil Oil Co. Pty Ltd and the subsequent interpretation indicated the presence of the Lander Trough. To the north, two small scale aeromagnetic surveys were undertaken, the first by Aero Service (1964b) for Bakley Oil Co. Pty Ltd in the Dry River/Sandy Creek area and the second by Compagnie Generale de Geophysique (1966) for Mercure International Petroleum Ltd in the Daly Waters area. Neither lead to further petroleum investigations.

In 1965 the BMR contracted Wongela Geophysical to carry out a regional gravity survey of the basin. This was completed in 1967 (Flavelle, 1965; Fraser, Darby and Vale, 1977; Whitworth, 1970).

American Overseas Petroleum Ltd was attracted to the area in 1967 and carried out an aeromagnetic survey of the southern basin (Adastra Hunting, 1967), following it up with a reflection and refraction seismic survey over the southeastern Lander Trough (Ray Geophysics, 1967). No further work was undertaken.

At the conclusion of their stratigraphic drilling and geological mapping in 1977, the BMR compiled all relevant data into Bulletin 205, "The Geology of the Wiso Basin" which was published in 1980. Since then, no work other than some geochemical sampling and analyses by AMDEL, (AMDEL, 1987), of samples from two stratigraphic bores for CRA Exploration, has been undertaken in the basin.

# 7.0 HYDROCARBON POTENTIAL

With the minimal amount of data available for the Wiso Basin, an assessment of the hydrocarbon potential must be left to conjecture. Sediments exposed in surface outcrop have been highly weathered and therefore are not indicative of the subsurface. With only shallow BMR stratigraphic wells having penetrated the subsurface, the more prospective parts of the basin remain unevaluated. With sediment thicknesses of less than 300m over almost of the entire northern Wiso Basin, the hydrocarbon potential is considered negligible for that area. The Lander Trough, however, contains up to 3000m of largely marine clastics and carbonates and therefore offers excellent hydrocarbon potential.

## 7.1 HYDROCARBON SHOWS

The Wiso Basin has been only poorly explored and no petroleum exploration wells have been drilled. A 'tarry residue' has been reported at a depth of 72m in BMR Green Swamp Well 1 within the basal dolostones of the Montejinni Limestone (Appendix 4), but no other hydrocarbon shows have been reported. Twenty two stratigraphic wells were drilled on the northern margin of the Lander Trough but as these were very shallow and not drilled on the basis of closure, hydrocarbon shows would not be expected.

## 7.2 SOURCE ROCK QUALITY

The total sedimentary sequence in the Lander Trough has not been penetrated and therefore its stratigraphy remains unknown. The basin, on the basis of its tectonic and stratigraphic history, should contain effective source rock horizons, but without deep well penetration, the presence of such intervals can only be postulated.

There are three known potential source rock sequences in the basin, all of which were deposited under shallow and restricted marine conditions, the Montejinni Limestone/ Hooker Creek Formation, the Point Wakefield beds and the upper units of the Hanson River beds. Deeper basin (Lander Trough) facies equivalents should also prove to be ideal source rock units.

CRA Exploration, as part of their Georgina and Daly River Basin exploration programme, sampled the Montejinni Limestone in BMR Green Swamp Wells 1 and 6 on the northern flank of the Lander Trough. Subsequent analysis by AMDEL (1987) for Total Organic Carbon (TOC) and Rock-Eval Pyrolysis indicated the formation to be organically lean with TOC values ranging from 0.10% to 0.76%. Analysis of the Arthur Creek Formation, an equivalent sequence in the Georgina Basin, indicates that there are two lithofacies in the limestone, an anaerobic lithofacies having TOC values as high as 10% and an aerobic lithofacies with TOC's in the 0.25% to 0.85% range, the latter similar to the Wiso Basin samples. In comparing the two basins and the relative positions of the two sets of samples it is postulated that the organically rich anaerobic lithofacies seen in the Georgina Basin will be present in the Lander Trough of the Wiso Basin.

Silts and clays (shales) of the Point Wakefield beds provide additional source rock potential for the basin. Where sampled in outcrop, the formation has been leached and organic material has been removed. Source rock quality is expected to improve basinwards where the formation would not have been weathered and where a thicker, more organically rich sequence, would have been deposited.

The upper units of the Hanson River beds, in particular Unit 3, comprise shallow marine carbonates and clays. Unit 3 is described as consisting in part of, dark brown to dark grey, laminated mudstones. The unit is a time and facies equivalent of the Horn Valley Siltstone, which is believed to be the primary source of the oil and gas contained in the Mereenie and Palm Valley fields of the Amadeus Basin (Kurylowicz *et al.*, 1976). Although no analysis has been undertaken, the Hanson River beds are considered to have good source rock potential.

Outcrop and well bore information indicates the possible presence of evaporitic sequences within the Lander Trough. The association of evaporites with petroleum has been well documented, in particular by Kirkland and Evans (1980) and Warren (1986). Evaporites overlie carbonates that contain probably half of the world's reserves of petroleum and nearly half of the world's major petroleum producing provinces show a significant association between evaporites and petroleum reserves. Most of the world's giant oil and gas fields are associated with evaporites, the organic material within the evaporite sequence providing the major hydrocarbon charge.

In present day basins, marine embayments in which gypsum and halite are being deposited frequently, demonstrate excellent source potential:

1) Great quantities of organic material are produced in high saline, restricted environments. Few species can exist but those that do, commonly exist in great profusion.

2) Because stratification of brine may occur and reducing conditions may be associated with the bottom waters, much of the organic matter produced can be preserved.

3) Upon maturation, the result may be a rich carbonate source rock.

4) Organic material associated with meso-saline environments is predominantly oil prone.

5) Migration of produced hydrocarbons from evaporitic sequences would be facilitated by salt solution. Organic material would originally form part of the cyclic, evaporitic sequence and solution of enclosing salts, after organic material had yielded hydrocarbons, would allow hydrocarbons to escape. The migration process is far easier to explain than that from shale sequences.

It is therefore argued here that evaporitic sequences within the Wiso Basin sequence should be regarded as potentially rich, oil prone source rocks.

## 7.3 MATURATION

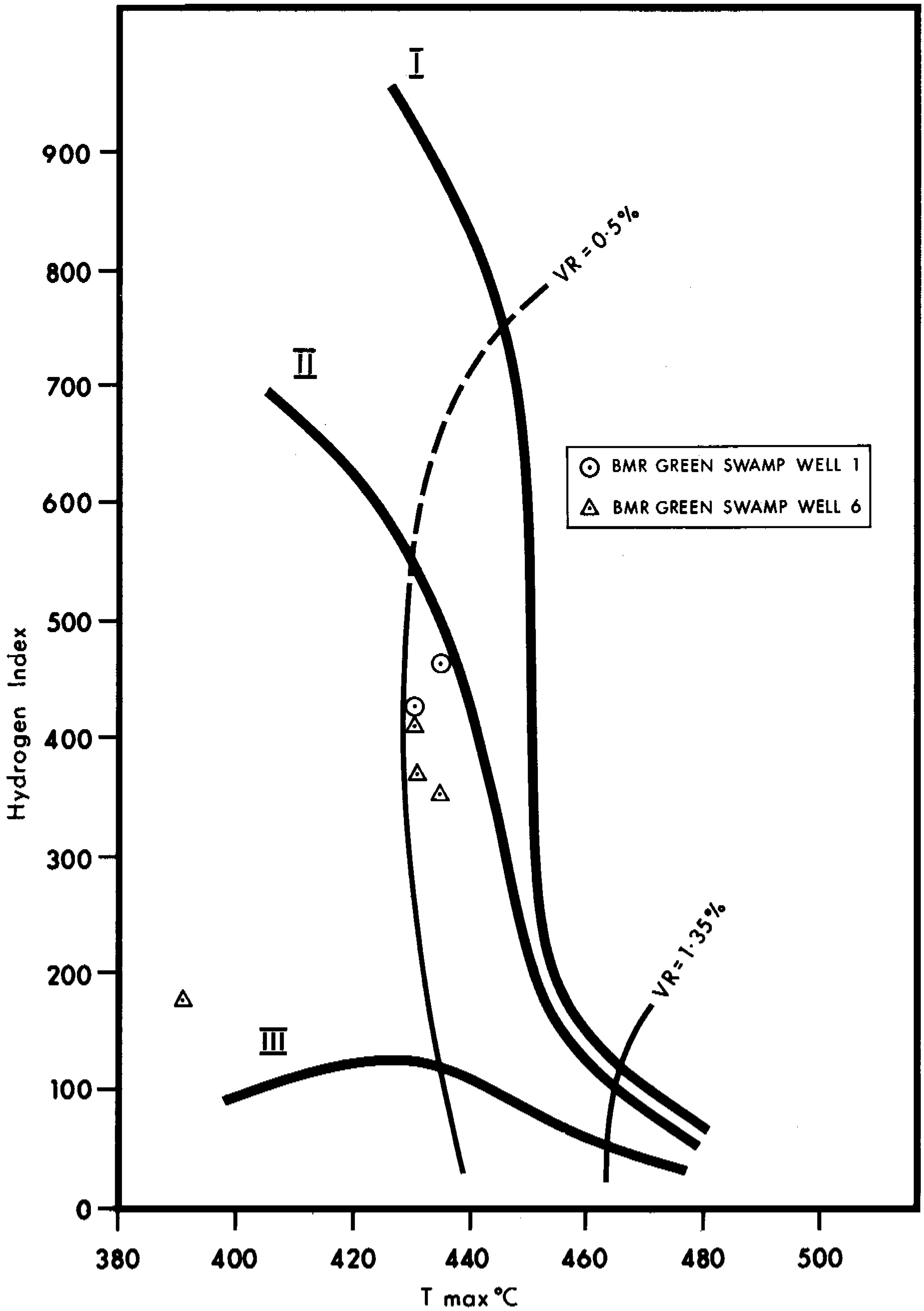
Samples from Green Swamp Well 1 and 6, drilled on the northern flank of the Lander Trough, were submitted to AMDEL for geochemical analysis. These are the only samples from the Wiso Basin that have been geochemically analysed. Figure 9 is a cross plot of Hydrogen Index with T max (both of which are indicators of maturity and kerogen type) for the Montejinni Limestone. The results indicate that the limestone sampled contains a marginally mature type II kerogen with oil and wet gas potential. The AMDEL samples were taken from depths of 220m to 330m and maturation would be expected to improve into the Lander Trough where the Montejinni Limestone has been buried an additional 2000m.

There are no qualitative data available on the organic maturity of other potential source rock intervals in the basin. In order to assess the thermal maturation history of the basin, burial history plots were constructed and maturation modelling applied based on the methods first described by Lopatin in 1971 (Waples, 1980).

### 7.3.1 Lopatin Modelling

The construction of burial history curves requires a detailed knowledge of the depositional history of a basin. As absolute ages, depositional rates and even formation thicknesses of Wiso Basin assigned rock units are unknown, an accurate reconstruction of the basin's depositional history is not possible. The application of the Lopatin maturation model requires a knowledge of the basin's geothermal history. Even the recent geothermal history of the Wiso Basin remains unknown and it is not certain the application of an Amadeus Basin (a more fully explored basin) model is valid.

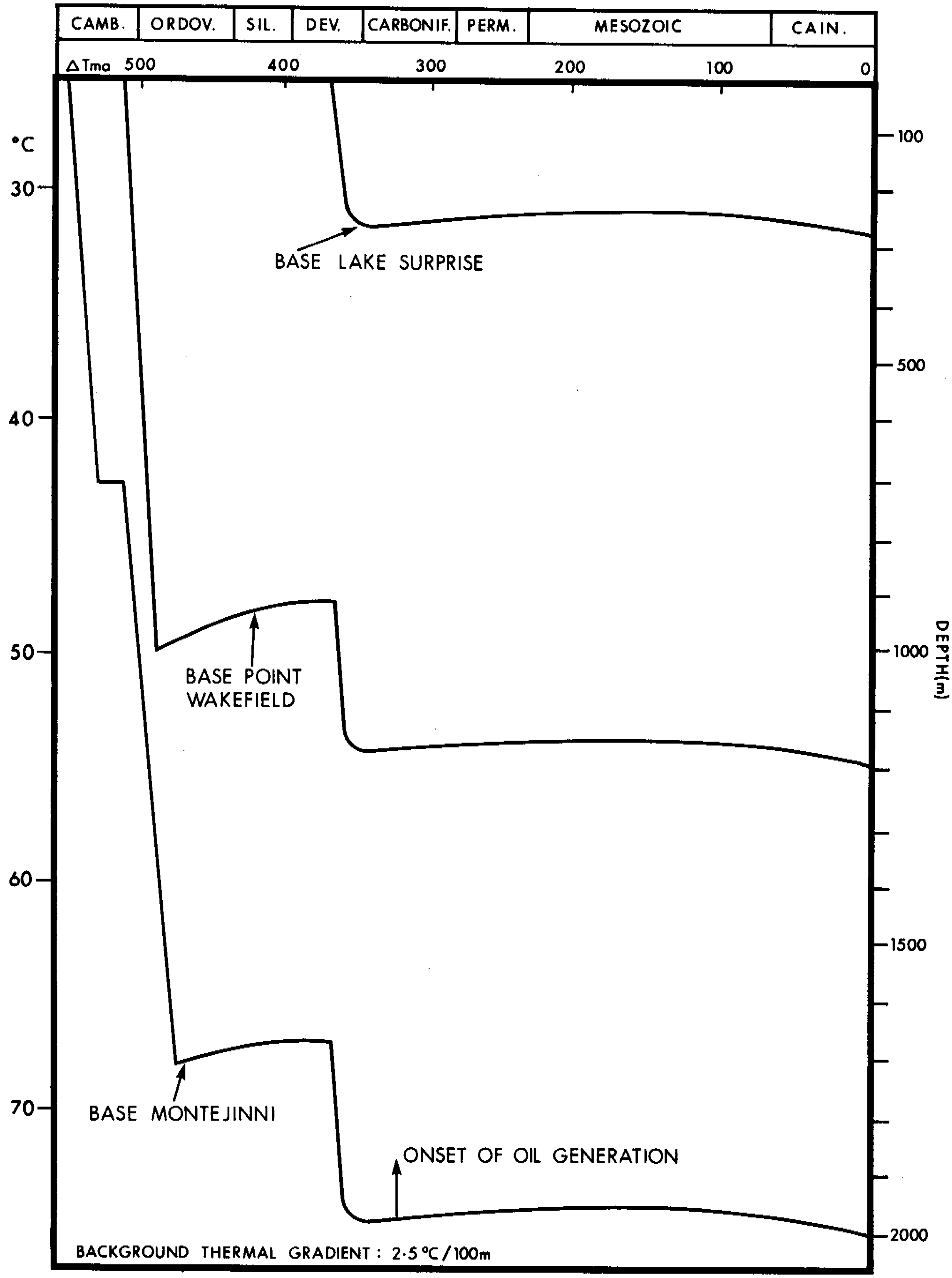
Nevertheless, a good insight into the maturation history of the basin can be obtained by using interpreted seismic data and by applying a range of possible geothermal gradients representing the maximum and minimum gradients that the basin might have experienced.




# Source Rock Maturation

Montejinni Limestone

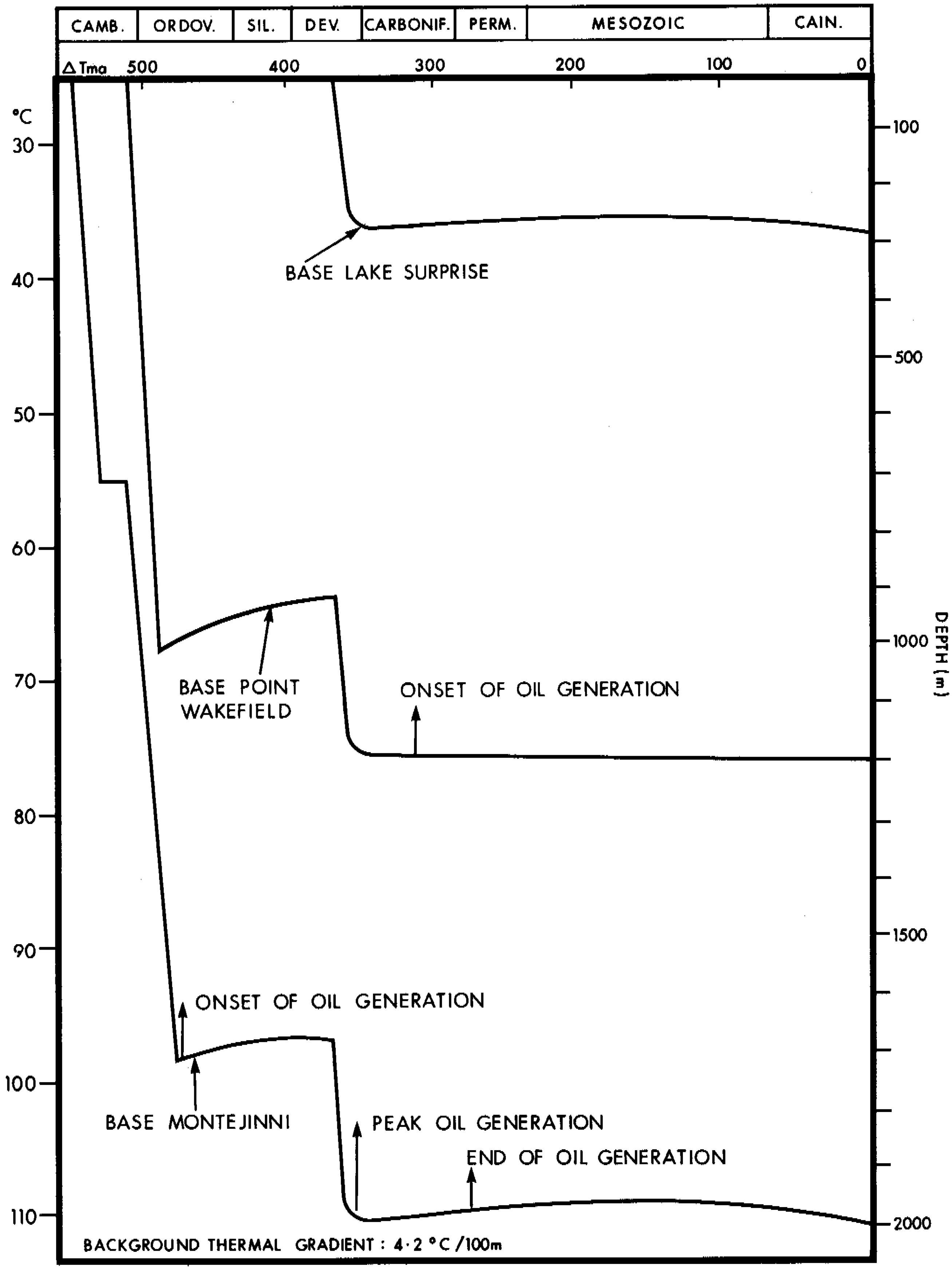
FIGURE 9




**LOPATIN MODEL**

**SOUTHEASTERN LANDER TROUGH**

FIGURE 10




# LOPATIN MODEL

## SOUTHEASTERN LANDER TROUGH

FIGURE 11

Present day geothermal gradients in the Amadeus (Jackson, McKirdy and Deckleman, 1984) and Ngalia basins are in the order of 1.5 to 3.5°C/100m. This approximates the world mean gradient of 2.5°C/100m and is considered the minimum geothermal gradient that the Wiso Basin would have been subjected to. A constant gradient of 4.2°C/100m is believed to be the maximum that the Wiso Basin would have witnessed. This is the value used by Morris (1986) for a study of the Dulcie Syncline (en echelon to the Lander Trough) in the northwestern Georgina Basin. Maturation modelling was therefore undertaken by applying these two 'end member' gradients and assuming that the surface temperature remained unchanged at 25°C and that the individual gradients did not vary within the sedimentary sequences.

The results of the modelling (Figures 10 and 11) indicate that, at minimum, the basal Wiso Basin sediments would have entered the oil generation phase by the end of the Alice Springs Orogeny but would not yet have reached peak oil generation. Ordovician source rocks are postulated, on the basis of the model, to continue to remain immature for significant hydrocarbon generation.

If geothermal gradients in the order of 4.2°C/100m existed in the Wiso Basin during the Palaeozoic, lower Cambrian source rocks would have passed from peak oil to wet gas generation at the end of Permian time and Ordovician source rocks would be in an early generative stage.

Qualitative maturation measurements of material from the Montejinni Limestone at a depth of 300m suggests the onset of oil generation was achieved at a very shallow depth implying that geothermal gradients were considerably higher than they are today. Evidence suggests therefore, that early Palaeozoic rocks in the Lander Trough will be ideally mature and that significant volumes of oil and gas would have been generated. It is unlikely that significant hydrocarbons would have been generated from Wiso Basin sediments prior to the final period of basin deformation.

Aeromagnetic data indicates a thicker sediment package in the northwestern depocentre of the Lander Trough than that modelled and therefore maturation of potential source rocks could prove to have progressed further.

## 7.4 RESERVOIR/SEAL

All of the potential reservoir units in the Wiso Basin, with the exception, perhaps, of the Lake Surprise Sandstone which is exposed at surface, either underlie effective sealing strata or contain intraformational seals.

The lower two units of the Hanson River beds provide the best reservoir potential in the basin. The units comprise porous, fine grained sandstones and are capped by claystones and limestones of the upper two units. The lower units of the Hanson River beds are stratigraphically similar to and a time equivalent of the Pacoota Sandstone reservoirs of the Mereenie and Palm Valley fields in the Amadeus Basin. The Pacoota Sandstone in the Mereenie Field of the Amadeus Basin is estimated to contain 34,700 megalitres (218 million barrels) of in-place oil reserves and 14 billion cubic metres (500 billion cubic feet) of in-place gas reserves (Jackson *et al*, 1984). Test rates were in the order of 24–117 kilolitres (150–735 barrels) of oil per day per well and the better wells are currently producing at rates in excess of 200 BOPD.

Estimates indicate that in excess of 28 billion cubic metres (1 trillion cubic feet) of gas is present at Palm Valley. Test rates from the fractured Pacoota reservoir are up to 2 million cubic metres (70 million cubic feet) of gas per day per well and production rates of 0.6 million cubic metres (20 million cubic feet) per day are being achieved.

The upper Hanson River beds are equivalent to the Horn Valley Siltstone, the unit considered the source for the Mereenie and Palm Valley hydrocarbons.

The Cambrian Lothari Hill Sandstone provides additional reservoir potential, being described in outcrop as fine grained, subrounded to subangular, quartzose sands. The Lake Surprise Sandstone, although exposed across most of the basin, is expected to include intraformational silts and shales in the Lander Trough which could provide adequate seal, thereby allowing the formation to be an effective reservoir objective.

## 7.5. MIGRATION AND TRAPPING

Maturation modelling indicates that the main phase of hydrocarbon generation and migration in the basin would not have been reached until after the final period of basin deformation, the Alice Springs Orogeny. In the deeper parts of the Lander Trough, the main phase of hydrocarbon migration may have been reached during the orogenic period.

There are no readily recognisable traps in the basin but seismic acquisition has been limited and restricted to a small part of the southeastern Lander Trough. The effect of the Alice Springs Orogeny on Wiso Basin sediments was minimal in comparison to that seen in the Amadeus and Ngalia basins to the south.

From seismic evidence, it can be seen that there was rejuvenation of the southern Lander Trough fault scarp and a pronounced downwarping of the trough in association with uplift and erosion of the northern basin during the Alice Springs Orogeny. Although extensional rather than compressional tectonics were being applied to the basin during this time, fault bounded structures would be expected along the southern trough margin.

The Wiso Basin sequence was deposited on a highly deformed Proterozoic surface and drape of lower Palaeozoic sediments would therefore be expected particularly in the Lander Trough where Palaeozoic deformation would have been the greatest.

Within the Lander Trough valid and effective stratigraphic traps could be expected. These would be in the form of both formation wedgeouts and facies changes. Until a deep stratigraphic test is drilled in the Lander Trough further appraisal cannot be made. A seismic acquisition programme in the western Lander Trough and over the postulated cross axial high should lead to the identification of structural and perhaps stratigraphic traps in that part of the basin.

# 8.0 PLAY POTENTIAL

Very little is known about the hydrocarbon potential of the Wiso Basin and much must therefore be surmised. Existing seismic data has not identified large structural closures ready for drilling but only 200km of seismic has been acquired in the basin. The seismic which is available does show that the basin has been tectonically active, particularly during the Alice Springs orogeny, and several 'plays' may be postulated (Figure 12).

All available evidence indicates that the northern and central portions of the basin are not prospective for hydrocarbon generation and entrapment. Less than 300m of sediment is present in this area which occupies some 80% of the Wiso Basin and long distance migration through tight shelfal carbonates would be required to charge existing structures.

The Lander Trough, in the south of the basin, has been identified by magnetic, gravity and seismic data. The precise depth of the trough remains unknown with the three data sources providing somewhat different impressions. It is believed that the trough comprises a southeastern depression containing some 2000m of sediment and a northwestern depression containing some 3000m of sediment. A pronounced but low relief cross axial high is interpreted to separate the two depressions which appear to be en echelon to each other.

The lithofacies of much of the sedimentary sequence in the Lander Trough is unknown. There are several extensive hiatuses in the northern and central parts of the basin but these hiatuses may not be present in the trough. It is believed that erosion has removed a considerable part of the sedimentary sequence originally laid down in the northern basin and there could, therefore, be several unnamed formations in the depocentres of the Lander Trough which have been preserved from erosion. A basal Wiso Basin 'course clastics' sequence would be expected for example and underlying the primary source rock unit in the basin could provide an excellent reservoir objective. In addition, sediments of the Victoria River Basin which underlies the Wiso Basin sequence could prove to be very prospective, as are the equivalents in the Amadeus, Ngalia and Officer basins.

The Montejinni Limestone appears to be a particularly good source rock and the basin therefore has the primary element of an important hydrocarbon province. Maturation modelling and the available qualitative geochemical data suggests this source rock sequence would have reached peak oil generation and migration conditions soon after the major period of basin structuring. Numerous reservoirs have been identified in outcrop and in shallow stratigraphic drilling and additional reservoirs (and source rocks) will possibly be encountered in the Lander Trough when the full sequence is first penetrated by a deep well bore.

The Wiso basin has been less intensely deformed than the Amadeus, Officer and Ngalia basins, to the south, but valid structural closures should be found with a minimal seismic programme. The cross axial high which separates the northwestern and southeastern depressions should be evaluated with seismic. Horst blocks along the southern basin margin offer perhaps the best exploration potential with supratenuous folding of early Palaeozoic sediments and rejuvinated uplift resulting in further structuring during successive periods of basin deformation.

Permeability fairways may be developed in shelfal carbonates and carbonate build-ups along the hingeline that separates the Lander Trough from the Arunta Complex to the south. During each phase of Wiso basin deposition, an inland seaway would have occupied most of central Australia including relatively high standing blocks such as the Arunta Complex. Subsequent erosion has removed most of the sediments which were deposited on the structurally positive areas but hingeline deposits would have been preserved through graben development along the basin/basement boundary.

Without additional seismic and deep bore hole information, the hydrocarbon potential of the Wiso basin must remain highly conjectural. Evidence suggests that oil and gas were generated in the basin and the biggest risk appears to be structuring. Given the tectonic history of the basin it is hard to believe that Lander Trough sediments have remained undeformed.

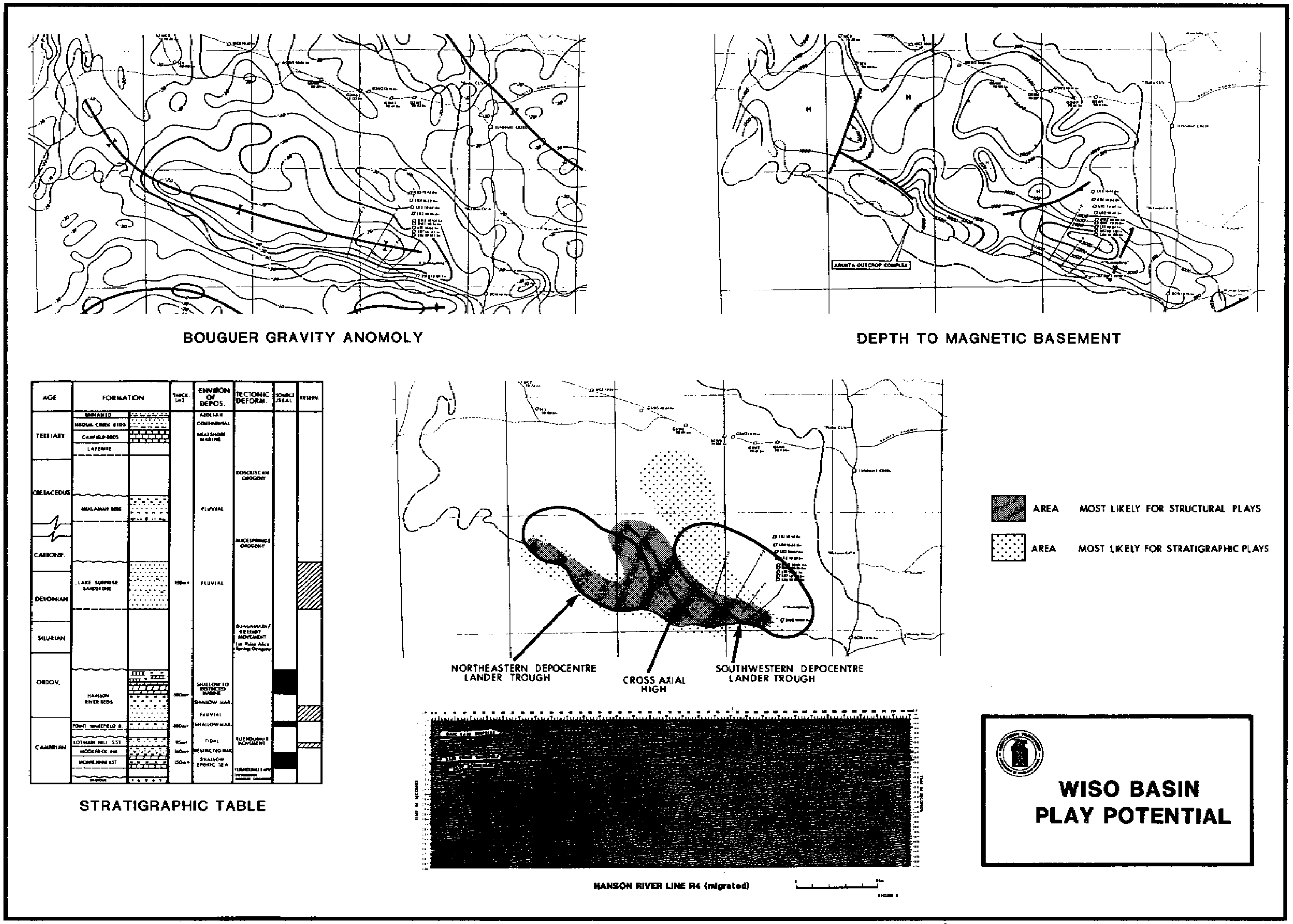

BOUGUER GRAVITY ANOMOLY
DEPTH TO MAGNETIC BASEMENT
ARUNTA OUTCROP COMPLEX
AGE
FORMATION
TERTIARY
CRETACEOUS
CARBONIF.
DEVONIAN
SILURIAN
ORDOV.
CAMBRIAN
STRATIGRAPHIC TABLE
AREA MOST LIKELY FOR STRUCTURAL PLAYS
AREA MOST LIKELY FOR STRATIGRAPHIC PLAYS
NORTHEASTERN DEPOCENTRE LANDER TROUGH
CROSS AXIAL HIGH
SOUTHWESTERN DEPOCENTRE LANDER TROUGH
HANSON RIVER LINE R4 (migrated)
WISO BASIN
PLAY POTENTIAL

FIGURE 12

# 9.0 CURRENT EXPLORATION ACTIVITY

There is no petroleum orientated exploration currently being conducted in the Wiso Basin. The only attempt at exploring the basin was by American Overseas Petroleum and Exoil Oil in the period 1964 to 1967. No petroleum wells have been drilled in the basin and there has been no deep stratigraphic drilling.

# 10.0 CONCLUSIONS

The Wiso Basin in its entirety, is a large (160,000 $km^2$) structural downwarp situated in the north central Northern Territory. Approximately eighty percent of the basin contains generally less than 300m of sediment and is therefore considered non prospective for hydrocarbons. The Lander Trough in the extreme southern position of the basin, occupies some 30,000 $km^2$ and is considered prospective for oil and gas. This trough remains virtually unexplored.

There has been no petroleum exploration in the Wiso Basin since 1967 and to date no petroleum exploration wells have been drilled. BMR investigations were carried out from 1962 to 1975 during which period twenty two shallow stratigraphic bores with an average penetration of 100m were drilled. Existing geophysical data over the Lander Trough consists of one seismic survey (5 fold, 1967), two aeromagnetic surveys processed as one (1967) and one regional gravity survey (1965). Assessment of the hydrocarbon prospectivity of the basin therefore remains speculative.

The Lander Trough contains approximately 2000–3000m of Cambrian to Ordovician sediments. Much of this sequence is not present along the exposed margins of the basin and lithofacies must therefore be postulated. Deposition of carbonates and clastics took place in shallow marine to fluviatile environments. The lower and upper limits of the sequence are defined by unconformity surfaces, the former reflecting the Petermann Ranges Orogeny and the later the Alice Springs Orogeny. Two additional unconformities are recognised within the basin sequence.

Postulated hydrocarbon potential is considered moderate. Maturation modelling and qualitative geochemistry suggest, however, that the Middle Cambrian Montejinni Limestone and the Ordovician Hanson River beds (Unit 3) will be moderately to optimumly mature and of fair source rock quality within the Lander Trough. The Hanson River beds (Unit 2) and the Montejinni Limestone provide the most important reservoir potential and a postulated basal coarse clastics unit would provide additional reservoir potential if present.

The Wiso Basin evolved with a similar tectonic and depositional history to the Amadeus and Ngalia basins and future drilling in the Lander Trough is therefore expected to identify additional reservoir objectives and source rock units.

No closed structures have been found in the Lander Trough but only 200 km of regional seismic has been acquired. Closed structures are certain to be present but additional seismic is required to locate them. The Hanson River Seismic indicates a reactivated bounding fault system with slight dip reversal of overlying sediments indicating that the trough has been deformed.

Stratigraphic trapping of hydrocarbons within carbonates of the Montejinni Limestone and within the 'basal coarse clastics' provide additional exploration potential. The only reported hydrocarbon show in the basin is a 'tarry residue' reported within the basal dolomite of the Montejinni Limestone at a depth of 72m in BMR Green Swamp Well 1 but the BMR stratigraphic wells were not drilled on closed features.

The Wiso Basin should have all of the prerequisites of an important hydrocarbon province but given an almost complete lack of geological and geophysical data, a full assessment of the true hydrocarbon potential of the basin cannot be presented. A minimum exploration programme would answer many questions regarding the prospectivity of the basin. Modern multifold seismic data should be acquired over the northwestern Lander Trough, tying older vintage data and crossing a cross axial high which has been defined on the basis of gravity and magnetics data. In addition, a deep stratigraphic (?exploration) well should be drilled to basement in the Lander Trough to determine the stratigraphy within the trough and to address reservoir and source rock potential.

Both oil and gas are expected to be present in Lander Trough sediments. Gas is particularly important as there is a waiting market for gas in Darwin and in Gove, a market which cannot be fully supplied from the existing Palm Valley and Mereenie fields. The Palm Valley to Darwin gas pipeline crosses the Wiso Basin passing through the Lander Trough and even small discoveries could therefore prove commercially viable. Additionally, the Cooper Basin Joint Venture Consortium in South Australia is looking for a large volume of interstate gas to supplement their existing production.

The Wiso basin is a moderate to high risk, moderate to low potential exploration opportunity. In order to better evaluate the hydrocarbon potential of this basin it is essential that additional seismic be acquired and a deep stratigraphic well be drilled. An exploration permit over the most prospective part of the basin would be awarded by the Northern Territory Government for a minimum work programme in order to satisfy these needs.

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# APPENDIX 1

## INFORMATION ON ONSHORE PETROLEUM TENEMENTS

Exploration for and production of petroleum in the onshore area of the Northern Territory is controlled by the Petroleum Act which came into force on 15 October 1984.

Prior to that the relevant legislation was the Petroleum (Prospecting and Mining) Act which by virtue of the savings provisions of the Petroleum Act continues to apply to permits and leases that had been issued or granted prior to that date.

The Petroleum Act was the first Australian petroleum legislation to introduce the concept of a retention tenement to provide a permittee with security of tenure over a currently non-commercial discovery. This initiative was later adopted by the Commonwealth in amendments to the Petroleum (Submerged Lands) Act 1967.

Under the terms of the Petroleum Act, an application for a permit may be made over any land not currently the subject of a petroleum tenement. The maximum area that can be applied for is 200 blocks. Each block comprises an area of five minutes of longitude by five minutes of latitude and a permit of 200 blocks covers an area of about 16,000 $km^2$.

The initial term of a permit is five years and it may be renewed for two further periods of five years with 50% relinquishment of the area held at the end of each term.

Permits are granted subject to specific work commitments which must be met year by year (or earlier).

Where a commercial discovery is made the successful explorer may apply for a production licence. The maximum area of a production licence is 12 blocks, however, a permittee may apply for more than one licence. The initial term of a production licence is 21 years and it may be renewed for further periods not exceeding 21 years as determined by the Minister for Mines and Energy.

If the original discovery proves to be currently non-commercial but is potentially of a commercial quality and quantity, the permittee may apply for a retention licence or licences of not more than 12 blocks for each licence. The initial term of a licence is five years and it may be renewed for further periods of five years.

### Onshore Permit Application Procedures

An application for a permit may be made over any land that is not already the subject of a petroleum tenement.

An applicant should provide the following information:

- the name and address of the applicant and an address for service within the Territory.
- the designated number of each block the subject of the application.
- a map clearly delineating the application area and the boundaries of existing permit or licence areas in the immediate vicinity of the application area;
- a proposed technical works programme for exploration of the blocks during each year of the term of the proposed permit;
- evidence of the technical and financial capacity of the applicant to carry out the proposed technical works programme and to comply with the Act;
- where the application is made by two or more persons, the proposed sharing arrangement between the applicants;
- the name of the designated operator and evidence of his technical capacity to carry out the proposed technical works programme;
- a statutory declaration stating the applicant's interest, if any, in or in relation to a permit or licence applied for a granted under, or in force by virtue of, the Act or the repealed Act;
- the application fee of $3,000; and
- such other information in support of the application as the applicant thinks fit.

## Summary Of Onshore Petroleum Legislation

*Exploration Permits*

| | |
|---|---|
| Application fee | $3,000 |
| Refund if application refused | Nil |
| Maximum blocks | 200 |
| Annual fee per block | $15 |
| Initial term of permit | 5 years |
| Relinquishment at end of term | 50 per cent |
| Security to be lodged | Determined by Minister<br>Normally $10,000 |

*Retention Leases/Licences*

| | |
|---|---|
| Application fee | $3,000 |
| Annual fee per block | $2,000 |
| Term | 5 years |
| Renewal | Subsequent periods of 5 years depending upon the discovery remaining sub-commercial |
| Security | Determined by Minister |

*Production Licences*

| | |
|---|---|
| Application fee | $600 |
| Annual fee per block | $9,000 |
| Security | Determined by Minister |

*Pipeline Licences*

| | |
|---|---|
| Application fee | $1,000 |
| Annual fee | Calculated in accordance with the formula:<br>A = B x C x D where A is the fee payable, B is the unit amount prescribed by the Regulation (currently 60 cents), C is the diameter of the pipeline expressed in metres, D is the length of the pipeline expressed in metres. |
| Term | Up to 21 years |
| Renewal fee | $100 |
| Variation fee | $100 |
| Security | Determined by Minister |

# APPENDIX 2

## GEOPHYSICAL SURVEYS

### SEISMIC SURVEYS

| Name | Year | Company | Contractor | Length | Fold | Group Interval | Reference |
|---|---|---|---|---|---|---|---|
| Hanson River | 1967 | American Overseas | Ray Geophysics | 217.21km | Five | 183m | PR67/001A |

### MAGNETIC SURVEYS

| Name | Year | Company | Contractor | Length | Flight Height | Direction | Line Spacing | Reference |
|---|---|---|---|---|---|---|---|---|
| Larrimah | 1964 | Barkley | Aero Service | ? | ? | ? | ? | BMR Bulletin 205 |
| Tanami | 1964 | Exoil | Aero Service | ? | ? | NE-SW | 12.5km–20km | BMR Bulletin 205 |
| Daly Waters | 1965 | Mercure Inter. | C.G.G. | ? | ? | ? | ? | BMR Bulletin 205 |
| Tanami/Barrow Creek | 1967 | American Overseas | Aero Service | 24 000km | 686m | NE-SW | 3.2km | PR67/17A |



### GRAVITY SURVEYS

| Name | Year | Company | Contractor | Length | Data Spacing | Reference |
|---|---|---|---|---|---|---|
| Wiso | 1965 | B.M.R. | Wongela Geophysical | grid of basin | 7km | BMR Rec 1965/212 |

# APPENDIX 3

## BORE HOLE AND WELL INFORMATION (Reference BMR Bulletin 205)

| Well | Location (1:250 000 Sheet) (or) (latitude/longitude) | Elevation | TD (m) | Formation Tops | (m) | Bottom Hole Formation |
|---|---|---|---|---|---|---|
| DWH Willeroo Beef Road 1 | Delamere | GL | 136.6 | Tertiary<br>Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>2.7<br>32.0 | Volcanics |
| DWH Willeroo Beef Road 2 | Delamere | GL | 183.5 | Tertiar<br>Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>3.0<br>31.1 | Volcanics |
| DWH Willeroo Beef Road 3 | Delamere | GL | 178.3 | Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>36.6 | Volcanics |
| DWH Willeroo Beef Road 4 | Delamere | GL | 125.3 | Tertiary<br>Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>4.2<br>22.0 | Volcanics |
| DWH Willeroo Beef Road 5 | Delamere | GL | 99.7 | Tertiary<br>Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>3.0<br>27.4 | Volcanics |
| BMR Larrimah 2 | Larrimah | GL | 53.6 | Mullaman Beds<br>?Jinduckin Formation<br>Montejinni Limestone<br>Antrim Plateau Volcanics | 0.0<br>7.6<br>11.0<br>49.7 | Volcanics |
| Dry River Stock Route 2 | Larrimah | GL | 158.8 | Mullaman Beds<br>Uncertain<br>Antrim Plateau Volcanics | 0.0<br>18.6<br>31.7 | Volcanics |
| McCraes Bore | Victoria River Downs | GL | 42.7 | Mullaman Beds<br>Montejinni Limestone<br>Antrim Plateau Volcanics | 0.0<br>12.2<br>29.0 | Volcanics |
| Pikers Retreat | Victoria River Downs | GL | 37.8 | Tertiary<br>Montejinni Limestone<br>Antrim Plateau Volcanics | 0.0<br>1.2<br>21.6 | Volcanics |
| Hidden Valley | Daly Waters | GL | 112.8 | Mullaman Beds<br>Montejinni Limestone<br>Antrim Plateau Volcanics | 0.0<br>47.2<br>105.2 | Volcanics |
| Murranji Stock Route 11 | Daly Waters | GL | 185.3 | Mullaman Beds<br>Montejinni Limestone | 0.0<br>92.7 | Montejinni |
| Murranji Stock Route 12 | Daly Waters | GL | 185.3 | Mullaman Beds<br>Montejinni Limestone | 0.0<br>114.3 | Montejinni |
| Dry River Stock Route 8 | Daly Waters | GL | 276.8 | Tertiary<br>Mullaman Beds<br>Antrim Plateau Volcanics | 0.0<br>0.9<br>15.2 | Volcanics |
| Widgee Bore | Daly Waters | GL | 50.4 | Tertiary<br>Mullaman Beds<br>Montejinni Limestone | 0.0<br>3.0<br>9.1 | Montejinni |
| BMR Daly Waters 1 and 1B | Daly Waters | GL | 85.6 | Mullaman Beds | 0.0 | Mullaman |
| Wave Hill 37 | Wave Hill | GL | 66.2 | Tertiary<br>Montejinni Limestone | 0.0<br>0.6 | Montejinni |
| Bradman Bore | Newcastle Waters | GL | 52.4 | Mullaman Beds<br>Montejinni Limestone | 0.0<br>35.1 | Montejinni |

# APPENDIX 3 (cont.)

## BORE HOLE AND WELL INFORMATION (Reference BMR Bulletin 205)

| Well | Location (1:250 000 Sheet) (or) (latitude/longitude) | Elevation | TD (m) | Formation Tops | (m) | Bottom Hole Formation |
|---|---|---|---|---|---|---|
| Benaud Bore | Newcastle Waters | GL | 53.3 | Tertiary<br>Mullaman Beds<br>Montejinni Limestone | 0.0<br>0.6<br>32.3 | Montejinni |
| Burge Bore | Newcastle Waters | GL | 71.3 | Tertiary<br>Mullaman Beds<br>Montejinni Limestone | 0.0<br>1.8<br>47.5 | Montejinni |
| BMR Winnecke Creek 1 | Winnecke Creek | GL | 52.9 | Tertiary<br>Hooker Creek Formation<br>Montejinni Limestone | 0.0<br>3.0<br>46.9 | Montejinni |
| BMR Winnecke Creek 2 | Winnecke Creek | GL | 72.4 | Tertiary<br>Hooker Creek Formation<br>Montejinni Limestone | 0.0<br>12.2<br>64.0 | Montejinni |
| BMR Winnecke Creek 3 | Winnecke Creek | GL | 49.4 | Tertiary | 0.0 | Tertiary |
| BMR Winnecke Creek 4 | Winnecke Creek | GL | 53.7 | Tertiary<br>Buchanan Hills Beds<br>Hooker Creek Formation | 0.0<br>3.0<br>27.4 | Hooker Creek |
| BMR Tanami East 1 | Tanami East | GL | 125.6 | Tertiary<br>Lothari Hill Sandstone<br>Hooker Creek Formation | 0.0<br>3.0<br>30.0 | Hooker Creek |
| BMR Green Swamp Well 1 | 19 25S 133 30E | GL | 93.0 | Point Wakefield Beds<br>Montejinni Limestone<br>Tomkinson Creek Beds | 0.0<br>25.9<br>82.3 | Tomkinson Creek |
| BMR Green Swamp Well 2 | 19 24S 133 16E | GL | 69.3 | Point Wakefield Beds<br>Hooker Creek Formation<br>Montejinni Limestone | 0.0<br>18.3<br>61.9 | Montejinni |
| BMR Green Swamp Well 3 | 19 20S 133 03E | GL | 91.4 | Tertiary<br>Point Wakefield Beds<br>Lothari Hill Sandstone<br>Hooker Creek Formation | 0.0<br>3.0<br>29.6<br>88.4 | Hooker Creek |
| BMR Green Swamp Well 4 | 19 16S 132 39E | GL | 179.6 | Lothari Hill Sandstone<br>Hooker Creek Formation<br>Montejinni Limestone | 0.0<br>93.9<br>178.3 | Montejinni |
| BMR Green Swamp Well 5 | Green Swamp Well | GL | 89.9 | Tertiary<br>Lothari Hill Sandstone<br>Hooker Creek Formation | 0.0<br>3.0<br>87.5 | Hooker Creek |
| BMR Green Swamp Well 6 | 19 20S 132 59E | GL | 337.1 | Tertiary<br>Lothari Hill Sandstone<br>Hooker Creek Formation<br>Montejinni Limestone | 0.0<br>3.1<br>24.4<br>185.9 | Montejinni |
| BMR Lander River 1 | 20 31S 133 30E | GL | 84.1 | Tertiary<br>Lake Surprise Sandstone<br>Hanson River Beds | 0.0<br>3.0<br>62.0 | Hanson River Beds |
| BMR Lander River 2 | Lander River | GL | 68.2 | Tertiary<br>Hanson River Beds | 0.0<br>25.2 | Hanson River Beds |
| BMR Lander River 3 | Lander River | GL | 67.4 | Tertiary<br>Hanson River Beds | 0.0<br>9.0 | Hanson River Beds |

## APPENDIX 3 (cont.)

### BORE HOLE AND WELL INFORMATION (Reference BMR Bulletin 205)

| Well | Location (1:250 000 Sheet) (or) (latitude/longitude) | Elevation | TD (m) | Formation Tops | (m) | Bottom Hole Formation |
|---|---|---|---|---|---|---|
| BMR Lander River 4 | Lander River | GL | 52.0 | Tertiary<br>Hanson River Beds<br>Point Wakefield Beds | 0.0<br>4.0<br>45.0 | Point Wakefield |
| BMR Lander River 5 | Lander River | GL | 93.0 | Tertiary<br>Hanson River Beds<br>Point Wakefield Beds | 0.0<br>3.0<br>39.0 | Point Wakefield |
| BMR Lander River 6 | Lander River | GL | 103.3 | Tertiary<br>Lake Surprise Sandstone | 0.0<br>3.0 | Lake Surprise |
| BMR Lander River 7 | Lander River | GL | 113.1 | Tertiary<br>Lake Surprise Sandstone | 0.0<br>12.0 | Lake Surprise |
| Parklands Bore | Lander River | GL | 43.6 | Hanson River Beds | 0.0 | Hanson River Beds |
| Numagalong Bore | Bonney Well | GL | 30.5 | Hanson River Beds | 0.0 | Hanson River Beds |
| BMR Bonney Well 1 | Bonney Well | GL | 76.0 | Tertiary<br>Hanson River Beds | 0.0<br>12.0 | Hanson River Beds |
| BMR Bonney Well 2 | Bonney Well | GL | 104.5 | Tertiary<br>Hanson River Beds | 0.0<br>30.0 | Hanson River Beds |
| BMR Bonney Well 3 | Bonney Well | GL | 109.9 | Tertiary<br>Buchanan Hills Beds<br>Arunta Complex | 0.0<br>12.0<br>87.0 | Arunta |
| BMR Barrow Creek 18 | Barrow Creek | GL | 96.0 | Hanson River Beds<br>Point Wakefield Beds | 0.0<br>54.9 | Point Wakefield |

# APPENDIX 4

## HYDROCARBON SHOWS AND GEOCHEMISTRY INVENTORY (Reference PR87/045)

| Well | Location | Depth | Show Description | Geochemistry Test | Value |
|---|---|---|---|---|---|
| BMR Green Swamp Well 1 | 19 25S 133 30E | 64.0m | — | TOC | 0.55% |
| | | | | HI | 435 |
| | | | | T Max | 430C |
| | | 67.1m | — | TOC | 0.76% |
| | | | | HI | 463 |
| | | | | T Max | 436C |
| | | 70.1m | — | TOC | 0.18% |
| | | 72.0m | Tarry Residue | — | — |
| | | 73.2m | — | TOC | 0.22% |
| | | 76.2m | — | TOC | 0.04% |
| BMR Green Swamp Well 6 | 19 20S 132 59E | 225.6m | — | TOC | 0.21% |
| | | 228.6m | — | TOC | 0.14% |
| | | 231.7m | — | TOC | 0.19% |
| | | 234.7m | — | TOC | 0.16% |
| | | 237.7m | — | TOC | 0.21% |
| | | 240.8m | — | TOC | 0.21% |
| | | 243.8m | — | TOC | 0.15% |
| | | 246.9m | — | TOC | 0.12% |
| | | 249.9m | — | TOC | 0.11% |
| | | 253.0m | — | TOC | 0.10% |
| | | 256.0m | — | TOC | 0.24% |
| | | 259.1m | — | TOC | 0.34% |
| | | | | HI | 185 |
| | | | | T Max | 390C |
| | | 301.8m | — | TOC | 0.17% |
| | | 304.8m | — | TOC | 0.13% |
| | | 307.8m | — | TOC | 0.24% |
| | | 310.9m | — | TOC | 0.29% |
| | | 313.9m | — | TOC | 0.43% |
| | | | | HI | 383 |
| | | | | T Max | 432C |
| | | 317.0m | — | TOC | 0.18% |
| | | 320.0m | — | TOC | 0.27% |
| | | 323.1m | — | TOC | 0.31% |
| | | | | HI | 364 |
| | | | | T Max | 437C |
| | | 326.1m | — | TOC | 0.27% |
| | | 329.2m | — | TOC | 0.24% |
| | | 332.2m | — | TOC | 0.28% |
| | | 334.1m | — | TOC | 0.51% |
| | | | | HI | 443 |
| | | | | T Max | 430C |

# APPENDIX 5

## PETROPHYSICAL AND WELL TEST INVENTORY

No DST's or petrophysical analysis have been carried out on any core or cuttings from any of the stratigraphic wells in the basin.


- TOWNSHIP
- STATION
- BASIN OUTLINE
- MAJOR ROAD
- MINOR ROAD OR TRACK
- R-3 1967 HANSON RIVER SEISMIC SURVEY
- BMR STRATIGRAPHIC BOREHOLE

0 20 40 60 80 100

NORTHERN TERRITORY GEOLOGICAL SURVEY
PETROLEUM BASIN STUDY

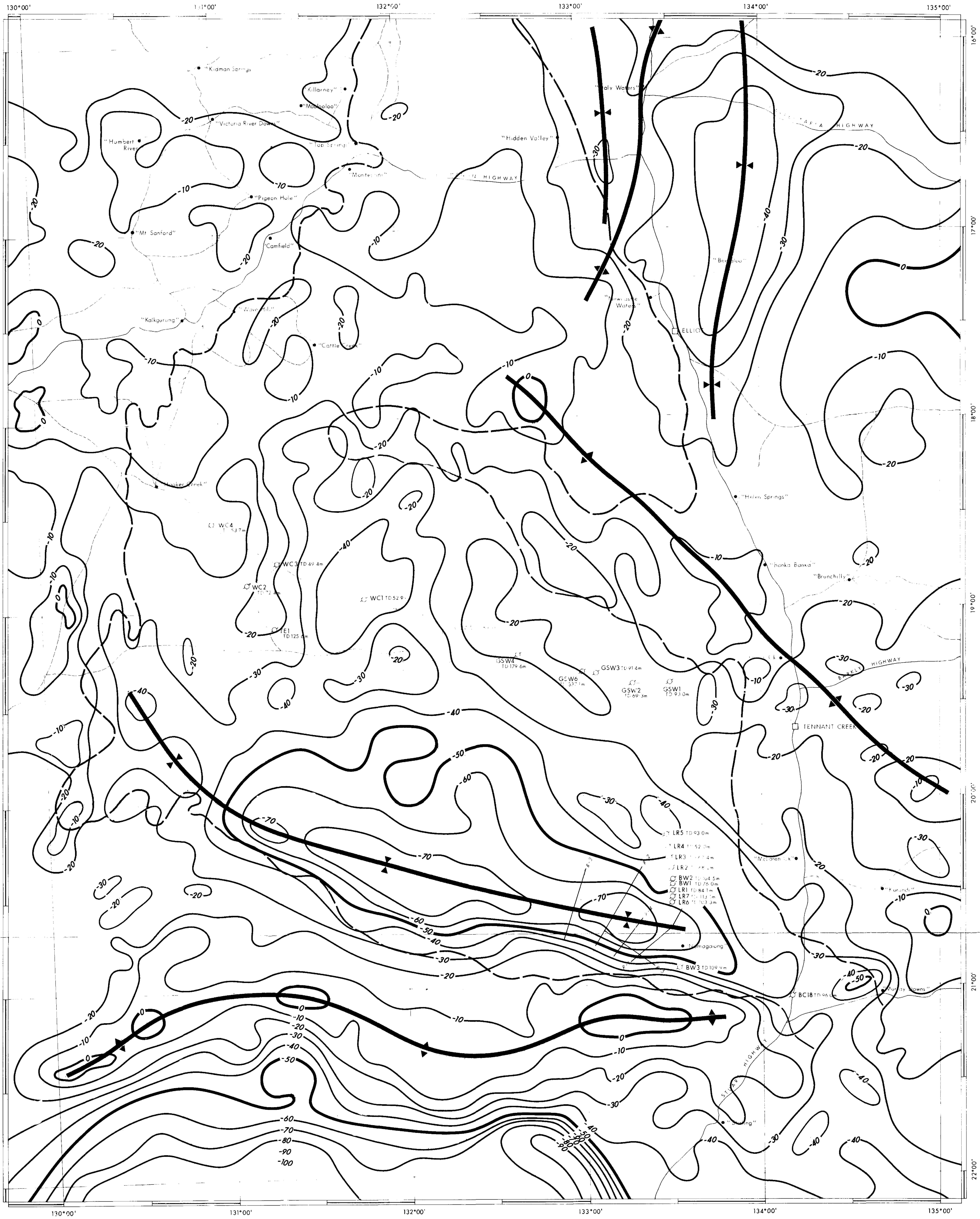
# WISO BASIN

## DEPTH TO MAGNETIC BASEMENT

Scale: 1:1,000,000
Date:
Contour Interval -500m

Enclosure No: 1

MODIFIED AFTER ADASTRA 1967




0 20 40 60 80 100

- TOWNSHIP
- STATION
- BASIN OUTLINE
- MAJOR ROAD
- MINOR ROAD OR TRACK
- R-3 1967 HANSON RIVER SEISMIC SURVEY
- BMR STRATIGRAPHIC BOREHOLE

NORTHERN TERRITORY GEOLOGICAL SURVEY
PETROLEUM BASIN STUDY

# WISO BASIN
## BOUGUER GRAVITY

Scale: 1:1,000,000
Date:
Contour Interval: 10mgal

Enclosure No: 2

AFTER BMR 1977