MINERAL PROSPECTS, GLEN HELEN PASTORAL HOLDING

Hermannsburg - 1:250,000 Sheet Area SF/53-13

by

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Courtesy of B.M.R. & N.A.S.A.

Frontispiece. Satellite Photograph Western Alice Springs District.
1. SUMMARY

This report briefly assesses the mineral potential of the Glen Helen Pastoral Holding, southern Northern Territory, by reviewing the results of direct exploration activity and regional studies conducted in the area.

Amadeus Basin sedimentary rocks comprise the southern and western sections of the lease area. These rocks are hosts to hydrocarbon accumulations in the stratigraphically related Palm Valley and Mereenie Gas Fields. There appear to be reasonable prospects that further exploratory work could define hydrocarbon traps in the Glen Helen district.

Although the Amadeus Basin succession is known to contain occurrences of nitrogenous and phosphatic minerals in the Glen Helen area, it is not thought likely that these rocks will be considered of particular interest to mineral explorers in the foreseeable future. There is limited evidence to suggest that the Undandita Member of the Brewer Conglomerate, the basal section of the Brewer Conglomerate, and the Carmichael Sandstone/Stokes Siltstone may be worthy of more detailed exploration for uranium mineralization.

Arunta Block metamorphic and igneous rocks make up the northern and eastern sections of the lease area, and are thought to have minor potential for the discovery of economic uranium mineralization. They are not known to be of any particular interest for base-metal mineralization, although several minor occurrences are known in the region. They are not known to contain any occurrences of non-metallic mineralization.
2. **INTRODUCTION**

The Glen Helen Pastoral Holding covers an area of 2,168 square kilometres, approximately 150 kilometres west of Alice Springs, in the southern part of the Northern Territory. A well-maintained gravel road linking Haasts Bluff and Alice Springs provides good access to much of the lease area, which has had the Finke Gorge, Redbank and Ormiston Gorge Reserves excised from it. Most of the area is topographically rugged, and includes the slopes of Mounts Zeil, Sonder and Razorback.

It has been proposed that the area should be resumed by the Northern Territory Government as a National Park. This report provides a brief assessment of the mineral potential of the area.

![Location diagram showing pastoral lease boundaries, western Alice Springs district.](image)

3. **REGIONAL GEOLOGY**

3.1 **General**

The Glen Helen area straddles part of the north-central margin of the Adelaidean-Palaeozoic Amadeus Basin, and is broadly comprised of Arunta Block metamorphic and igneous rocks to the north and sedimentary rocks of the Amadeus Basin succession to the south.
The Bureau of Mineral Resources, Geology and Geophysics (B.M.R.) published a geological map of the Hermannsburg 1:250,000 Sheet area in 1968. Although Amadeus Basin sequence rocks were mapped in some detail, Arunta Block rocks were largely undifferentiated. A preliminary edition of the Hermannsburg 1:100,000 Sheet area was published by the B.M.R. in 1975, and has been used here to describe the geology of the eastern section of the Glen Helen region. The geological map of the western section has been compiled largely from data recorded in company reports by Esso Australia Ltd. and Uranerz Australia Pty. Ltd. It is poorly controlled and should be regarded as a guide only.

3.2 Arunta Block Rocks

The deposition of Arunta Block sediments is the earliest identifiable event in the area, and occurred more than 1620 m.yrs. ago. The basement upon which deposition took place has not been identified, but is thought to have been granitic, and may now be represented by felsic gneisses. Later metamorphic events appear to have least affected those Arunta Block sediments in the extreme south-east of the Glen Helen lease area, where original arkose, mudstone, clean sandstone and basalt can be identified. Elsewhere, the original nature of the rocks is obscured by later metamorphic and deformational events.

Granulite-facies rocks in the extreme north of the area are separated from granites, migmatites and amphibolite-grade metasediments to the south by a linear belt of highly deformed rocks, the Redbank Zone (Plate 1). The more northerly rocks are thought to have lain at greater depth than those to the south during metamorphism dated at around 1620 m.yrs., and hence reached a higher metamorphic grade (Chewings Range Phase of metamorphism). Uplift along the major thrusts of the Redbank Zone subsequently brought the granulite-facies rocks into their present juxtaposition with rocks to the south (Marjoribanks, 1973, Marjoribanks & Black, 1974).

Rocks south of the Redbank Zone were extensively migmatized during the Orniston Phase of metamorphism, at around 1080 m.yrs. before present (Plate 2). The migmatization and action of metasomatizing fluids tended to be localised about large (possibly intrusive) granitic bodies, and regional migmatization is thought to be related to much more extensive granite development at depth (Marjoribanks, op.cit.).
Numerous pegmatite sills and dykes - probably emplaced during the Ormiston Phase of metamorphism - occur throughout the district, and are themselves cut by a suite of dolerite dykes. The dolerite bodies are up to 8m wide, possess an igneous texture, and have sharp chilled margins against the country rock. They are considered to be the youngest of the Arunta Block rocks in the region, and were truncated by the unconformity at the base of the Amadeus Basin succession, following a prolonged period of Arunta Block peneplanation.

From outcrop geology and gravity characteristics, the Redbank Zone is known as an important deep-seated crustal suture, and it is possible that rocks of upper mantle or lower crustal origin have intruded along it. The Strangways Range Carbonatite and the Mordor alkaline-ultramafic Complex are found in analogous structural situations north-east of Alice Springs. Although rocks of this genesis are not presently known to outcrop either in the Glen Helen area or elsewhere along the Redbank Zone, it is noted that the area is structurally not unfavourable for their occurrence.

3.3 Amadeus Basin Rocks

The earliest Upper Proterozoic sediments deposited in the area comprised approximately 600m of marine and fluvialite sand (Heavitree Quartzite) laid down on a stable epicontinental shelf. Following weak epeirogenic movements, evaporites formed in a shallow restricted sea, and were succeeded by penesaline sediments, marine stromatolitic carbonates and mud; the whole totalling approximately 900m (Bitter Springs Formation). Both these units were blanket deposits, and it was not until after the succeeding earth movements that deposition became localised in the Amadeus Basin.

A period of mild diastrophism (the Areyonga Movement) followed, and was succeeded by the deposition of glaciogene diamictite, conglomerate and sandstones of the Areyonga Formation and the Pioneer Sandstone (not differentiated from the Areyonga Formation on Plate 2). These beds are overlain conformably by 600m of siltstone and shale of the Pertatataka Formation, followed conformably by the siltstones and sandstones of the infra-Cambrian Arumbera Sandstone - the basal unit of the Pertaoorrrta Group. The Arumbera Sandstone is overlain conformably by marine lutites, carbonates and calcareous and silty sandstones of the Hugh River Shale, Jay Creek Limestone and the Goyder Formation, respectively.
The sandstone, siltstone and few carbonate beds of the Cambro-Ordovician Larapinta Group were deposited conformably on the Pertaatorta Group rocks during several marine transgressions and regressions in a widespread epelitic sea, thought to have extended well north of the presently preserved basin margin. In the Glen Helen region, the Larapinta Group is comprised of the Pacoota Sandstone, Horn Valley Siltstone, Stairway Sandstone, Stokes Siltstone and Carmichael Sandstone.

The Larapinta Group rocks are overlain with erosional unconformity (related to local diastrophism of the Rodingan Movement) by a sequence of heavily crossbedded paralic sandstones - the Merleenie Sandstone. These rocks are thought to be of Devonian age, and probably record the latest marine connection in the Amadeus Basin.

The late Devonian Pertnjara Movement, and subsequent diastrophic events, resulted in successive uplifts of a large block of Precambrian rocks and the overlying Proterozoic and Palaeozoic sedimentary rocks along the whole northern margin of the Amadeus Basin. The uplifted rocks were deeply eroded, and a thick wedge of molasse, the Pertnjara Group, (maximum thickness 3500m at the northern basin margin) was deposited on the southern flanks of the mountain chains. On the Glen Helen lease area this sequence is made up of the Parke Siltstone, Hermannsburg Sandstone (and its uppermost Ljiltera Member), the Brewer Conglomerate and its uppermost Undandita Member (Wells et al., 1970, Jones, 1972.).

3.4 Cainozoic Sediments

Thin sequences of Tertiary fluviatile and lacustrine sands, gravels, and clays, together with Quaternary river and aeolian sands, cover approximately 30% of the lease area.
<table>
<thead>
<tr>
<th>Age</th>
<th>Rock Group</th>
<th>Formation/Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cainozoic</td>
<td></td>
<td>Unnamed unconsolidated fluviatile, aeolian and lacustrine sediments.</td>
</tr>
<tr>
<td>Devonian to Carboniferous</td>
<td>Pertnjara Group</td>
<td>Brewer Conglomerate and uppermost Undandita Member Hermannsburg Sandstone and uppermost Ljiltera Member Parke Siltstone.</td>
</tr>
<tr>
<td>Silurian to Devonian</td>
<td></td>
<td>Mereenie Sandstone.</td>
</tr>
<tr>
<td>Cambrian to Ordovician</td>
<td>Larapinta Group</td>
<td>Carmichael Sandstone Stokes Siltstone Stairway Sandstone Horn Valley Siltstone Pacoota Sandstone.</td>
</tr>
<tr>
<td>Cambrian</td>
<td>Pertacorrtta Group</td>
<td>Goyder Formation Jay Creek Limestone Hugh River Shale Arumbera Sandstone.</td>
</tr>
</tbody>
</table>
4. MINERAL POTENTIAL

4.1 Uranium Mineralization

The Glen Helen area may be considered to have potential for three major styles of uranium mineralization, although others are possible. In Arunta Block rocks, exploration by Esso Australia Ltd. has been directed towards the discovery of a 'Rossing' type uranium deposit. At Rossing itself, in Namibia, very large reserves of low grade disseminated uranium ore occur in syntectic (alaskitic) granite.

Uranerz Australia Pty. Ltd. has explored the Amadeus Basin section (principally the Undandita Member of the Brewer Conglomerate) for sandstone uranium deposits similar to those found in New Mexico and Wyoming, United States of America. Characteristically, this type of mineralization has been found in poorly sorted, coarse-grained (locally conglomeratic) arkosic sandstones, generally containing at least traces of carbonaceous matter. The host rocks are thought to have possessed reasonable porosity and permeability at some stage in their history.

Cainozoic rocks to the north of the Glen Helen area, in the Burt Plain, have been found to include calcretes with traces of carnitote mineralization. They have been explored for uranium mineral deposits similar to those found at Yeelirrie in Western Australia, but with little success so far.

Since the style of mineralization sought is distinctive for each geological setting, the mineral potential of each regime needs to be considered separately.

4.1.1 Arunta Block Rocks

4.1.1.1 Exploration

The Arunta Block rocks in the area have been radiometrically checked from the air on four occasions. Ground checks have also been undertaken, as detailed below.

(a) 1965 Bureau of Mineral Resources. East-west flight lines, 5km apart, 250m above ground level. Total count scintillograph.
Fig. 2. RADIOMETRIC CONTOURS (B.M.R. 1976 Survey)
Fig. 3. BOUGUER ANOMALIES

Gravity values relative to Alice Springs pendulum station. (B.M.R. 1960 Survey)
Fig 4. REGIONAL MAGNETIC AND RADIOMETRIC FIELD (B.M.R. 1965 Survey)
(b) 1976. Bureau of Mineral Resources. North-south flight lines, 1.5km apart, 100m above ground level. Four channel differential spectrometer, detector volume 3700cm$^3$.

(c) 1976. Esso Australia Ltd. North-south flight lines, 0.3 km apart, 60m above ground level. (Bell 206B Jetranger helicopter.) Exploranium DGRS-1002 differential spectrometer, detector volume 7407 cm$^3$.

(d) 1977. Esso Australia Ltd. As for (c). (Cessna 172 with a Robertson STOL conversion.)


4.1.1.2 Results

The Esso Australia Ltd. airborne surveys confirmed the earlier B.M.R. conclusions that Arunta Block rocks in and around the Glen Helen region have a particularly high level of regional radioactivity. A number of anomalies were selected for ground follow up; and where the ground spectrometer survey indicated traces of uranium mineralization, samples were collected for analysis. The results of analysis are recorded below in Table 2.

<table>
<thead>
<tr>
<th>Sample Site Number</th>
<th>Uranium Oxide (U$_3$O$_8$)</th>
<th>Thorium Oxide (ThO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>46</td>
<td>58</td>
</tr>
<tr>
<td>S2</td>
<td>56</td>
<td>28</td>
</tr>
<tr>
<td>S3</td>
<td>23</td>
<td>42</td>
</tr>
<tr>
<td>S4</td>
<td>14</td>
<td>45</td>
</tr>
<tr>
<td>S5</td>
<td>24</td>
<td>51</td>
</tr>
<tr>
<td>S6</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>S7</td>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>S8</td>
<td>28</td>
<td>75</td>
</tr>
<tr>
<td>S9</td>
<td>7</td>
<td>75</td>
</tr>
<tr>
<td>S10</td>
<td>32</td>
<td>220</td>
</tr>
<tr>
<td>S11</td>
<td>50</td>
<td>160</td>
</tr>
<tr>
<td>S12</td>
<td>24</td>
<td>110</td>
</tr>
<tr>
<td>S13</td>
<td>30</td>
<td>170</td>
</tr>
</tbody>
</table>

All analytical results reported in parts per million. For sample site locations refer to Plate 2.

The analytical results were considered to
show that most of the high background in
the area is due to potassium from biotite
and potash feldspar-rich rocks, and thorium
from accessory minerals.

4.1.1.3 Prospects

In view of the relatively detailed nature
of the airborne surveys undertaken by Esso
(Australia) Ltd. and the B.M.R., it is
thought unlikely that any large body of
disseminated uranium mineralization will
now be found to outcrop in Arunta Block
rocks of the Glen Helen region. However,
there are clear similarities between the
stage of anatetic metamorphism reached in
the migmatitic Ormiston Zone at Glen Helen
(see Plate 1) and that in the Rossing and
Khan Formations at Rossing. Because of
these similarities it is felt that there is
a weak, but non-negligible possibility that
"Rossing-style" uranium mineralization
occurs at depth on the Glen Helen lease area.

There is a rather stronger possibility that
small bodies of uranium mineralization occur
undetected at or near-surface associated
with faults, fractures or pegmatite pods.
The available evidence seems to suggest
that further exploration for this type of
mineralized body might be warranted in the
following localities.

1. Horizon A.

Sample sites S5 and S6 (Esso Australia Ltd.
selected their sample sites from airborne radio-
metric data) and Anomaly A14 are aligned
approximately parallel with the mapped strike
of foliation, over a distance of approximately
2.5 km (see Plate 2). Localities A14 and S5
appear to be closely associated with the inter-
sections of major faults.

2. Horizons B and C.

Localities designated on Plate 2 as S10 and A15,
and separately A16 and S11, form two short
(approximately 0.5 km) alignments over mapped
pegmatite veins.
3. Horizon D.
Anomaly A17 occurs as a single-point record on the airborne radiometric data, associated with a major shear zone.

4. Horizon E.
Anomaly A18 occurs on a major shear which has been found to contain traces of uranium mineralization approximately 5 km further to the northeast, outside the Glen Helen area.

However, fault, fracture or reef-bound uranium mineralization is characteristically of limited tonnage, and may not be considered an attractive exploration target, particularly in an area where exploration costs are relatively high.

4.1.2 Amadeus Basin Rocks
4.1.2.1 Exploration
Many of the Amadeus Basin rock sequences which outcrop in the Glen Helen region have been radiometrically surveyed on several occasions. They were covered in the B.M.R. 1965 airborne survey referred to in section (3.1.1), and also as detailed below.

(a) 1973. Uranerz Australia Pty. Ltd.
Flight lines north-south, spaced approximately 2 km apart, approximately 20-60 m above ground level. Scintrex Gam-2 4-channel differential spectrometer, with 101.6x127 cm Sodium Iodide sensor. (Cessna 206 aircraft.)

(b) 1974. Uranerz Australia Pty. Ltd.
Flight lines north-south, spaced approximately 0.5 km apart, at approximately 20-50 m above ground level. Detector as above. (Bell 473-2A helicopter.)

(c) Ground checks of selected anomalies were made with scintillometers, and a small number of stream sediment samples were also collected for analysis. (Thomas, 1975.)

4.1.2.2 Results
A number of airborne radiometric anomalies were recorded on the Glen Helen area during
the Uranerz Australia Pty. Ltd. surveys and are listed below in Table 3. Notes on the radiometric results of re-flying a number of these localities are listed under "Remarks".

<table>
<thead>
<tr>
<th>Anomaly Number (Refer Plate 2)</th>
<th>AIRCRAFT</th>
<th>FORMATION OR ROCK TYPE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Fixed-wing</td>
<td>Brewer Conglomerate</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A2</td>
<td>&quot;</td>
<td>Brewer Conglomerate</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A3</td>
<td>&quot;</td>
<td>Quaternary Alluvium</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A4</td>
<td>&quot;</td>
<td>Brewer Conglomerate</td>
<td>Tentatively Repeated</td>
</tr>
<tr>
<td>A5</td>
<td>&quot;</td>
<td>Quaternary Alluvium</td>
<td>Not Followed Up</td>
</tr>
<tr>
<td>A6</td>
<td>&quot;</td>
<td>Brewer Conglomerate</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A7</td>
<td>&quot;</td>
<td>Stokes Siltstone</td>
<td>Repeated</td>
</tr>
<tr>
<td>A8</td>
<td>&quot;</td>
<td>Hermannsburg Sandstone</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A9</td>
<td>&quot;</td>
<td>Brewer Conglomerate</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A10</td>
<td>Helicopter</td>
<td>Brewer Conglomerate</td>
<td>Repeated</td>
</tr>
<tr>
<td>A11</td>
<td>&quot;</td>
<td>Stokes Siltstone</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A12</td>
<td>&quot;</td>
<td>Stokes Siltstone</td>
<td>Not Repeated</td>
</tr>
<tr>
<td>A13</td>
<td>&quot;</td>
<td>Brewer Conglomerate</td>
<td>Tentatively Repeated</td>
</tr>
</tbody>
</table>

Only two of the anomalies (designated A7 and A10 on Plate 2) were found to "repeat" on resurvey. A further two, designated A4 and A13 were reported to "tentatively repeat", while a fifth, designated A5, was not rechecked.

Three of the four "repeated" or "tentatively repeated" anomalies were recorded over the Brewer Conglomerate, the fourth over the Stokes Siltstone, and the unchecked anomaly was recorded over Quaternary alluvium overlying Stokes Siltstone. It should be noted that the Uranerz Australia Pty. Ltd. surveys were primarily designed to overfly the post-Silurian Amadeus Basin sequence, and coverage of older rocks in the section is incomplete. However, B.M.R. 1965 and 1976 radiometric surveys did not record any marked radioactivity associated with the older Amadeus Basin sequence rocks in the Glen Helen area.
Magellan Petroleum (N.T.) Pty. Ltd. Tyler No. 1, sited approximately 5 km south of the Glen Helen lease area, intersected a generally non-radioactive sequence from the Undandita Member of the Brewer Conglomerate to midway through the Stairway Sandstone. However, increased radioactivity was recorded in the following units:

(a) Locally within the Brewer Conglomerate (probably Undandita Member),
(b) Parke Siltstone,
(c) Within a silty section near the Carmichael Sandstone-Mereenie Sandstone boundary, and
(d) Within a silty, shaley section in the Mid-Mereenie Sandstone.

4.1.2.3 Prospects

Potentially economic uranium mineralization has been reported east of the Glen Helen lease area, south of Alice Springs in the Undandita Member of the Brewer Conglomerate. A relatively small section of this unit outcrops in the extreme south of the Glen Helen area, and two airborne radiometric anomalies were reported to be associated with it. However, Uranerz Australia Pty. Ltd. found that neither anomaly could be repeated on resurvey. It is noted that these two anomalies align with a third anomaly, located outside the leased area, which was found to "repeat tentatively". This alignment lies at a low angle to the photo-interpreted strike of bedding, approximately at the base of the Undandita Member outcrop. It is possible that these radiometric highs are a weak reflection of a mineralized horizon (marked on Plate 2 as Horizon \(^{F^*}\)).

Radiometric anomalies have been recorded on four or more flight-lines over two other stratigraphic units, as detailed below.

(a) Horizon \(^{G^*}\)

Radiometric anomalies A4, A6, A10 and A13 were recorded on well-separated flightlines near the base of the Brewer Conglomerate outcrop, and may reflect the presence of sporadic radioactive mineralization.
(b) Horizon "H"

Radiometric anomalies A3, A5, A7, A11 and A12 were recorded over outcropping or subcropping Stokes Siltstone/Carmichael Sandstone, and may be related to traces of radioactive mineralization in those beds. This horizon may correspond to the radiometrically distinctive unit found near the Carmichael Sandstone-Mereenie Sandstone boundary in Tyler No. 1 (Plate 7 and Huckaba & Magee, 1969).

It is difficult to assess the relative importance of these radiometric features without access to the original flight-line data, particularly since Uranerz Australia Pty. Ltd. did not comment on the results of their exploration in the Glen Helen area itself. The writers feel that the horizons identified above are probably worthy of further exploration for uranium mineralization.

4.1.3 Cainozoic Cover Rocks

Although basement rocks in the area should provide a relatively ready source of uranium ions, the opportunities for concentration to ore-grade in the youngest rocks appear slim. Calcretes are not known to occur in the local Cainozoic succession, which is thought to be comprised of thin sequences of fluvialite sandstone and conglomerates. Although Uranerz Australia Pty. Ltd. anomalies A3 and A5 were recorded over Cainozoic cover, they are thought to be related to radioactive mineralization dispersed from Amadeus Basin sequence rocks at shallow depth. Stream sediment sampling analysis by Uranerz Australia Pty. Ltd., near the southern boundary of the Glen Helen area returned low values of from 1 to 3 ppm uranium from Quaternary river alluvium.

Although traces of uranium mineralization are found in Cainozoic calcrete to the north on the Burt Plain, and although there is no lack of suitable basement "source" rocks in the area, there is at present no direct evidence that concentrations of uranium minerals are likely to occur in Cainozoic rocks in the Glen Helen lease area.

4.2 Base Metal Mineralization
WELL LOG - TYLER NO. 1

SCALE 1:20,000

DEPTH (METERS) GRAPHIC LITHOLOGY FORMATION

000 M

CONGLOMERATE
SANDSTONE
SILTSTONE

LIMESTONE
DOLomite
SILHAE

1000 M

BREWER CONGLOMERATE 1325 M

2000 M

HERMANNBURG SANDSTONE 849 M

3000 M

PARKE SILTSTONE 91 M

MEREHIE SANDSTONE 707 M

CARMICHAEL SANDSTONE 135 M

STICKS SILTSTONE 473 M

STAIRWAY SANDSTONE 300 M

FIG. 6

4.2.1 Occurrences

Surficial high grade lead, zinc and copper oxidized mineralization is associated with Arunta Block granite/calc-silicate contacts at the Stokes Yard Base Metal Prospect (located on Plate 2). However, a programme of five diamond drill holes encountered no significant mineralization at depth (Fruzzetti, 1972).

Faulks (1967) briefly inspected occurrences of copper mineralization in quartz veining on the Arunta Block section of the Glen Helen lease area. He considered the extent of mineralization to be too small to be of economic interest.

In the course of their uranium exploration programme, Esso Australia Ltd. geologists noted the occurrence of traces of oxidized copper mineralization in "coarse-grained migmatized garnetiferous granulite-facies rock", as float in a creek 1 km south of Mt. Heughlin (Fraser, op. cit.). No follow-up work was undertaken, and there is no reason at this stage to attach any economic significance to the find.

4.2.2 Prospects

Much of the Glen Helen area has not been mapped in detail, and only the most cursory prospecting for base-metal mineralization has been undertaken so far. If rocks of deep-seated origin should be found to occur associated with the Redbank Zone, they would be worthy of investigation for base-metal mineralization. It is also possible that more mineralization of the style noted at Stokes Yard (Fruzzetti, op. cit.) occurs in the area. However, on the evidence available, the Glen Helen lease area cannot presently be considered of particular interest for the occurrence of economic base-metal mineralization.

4.3 Non-Metallic Mineralization

4.3.1 Occurrences

Nitre (potassium nitrate) has been found lining a small cave in Bitter Springs Formation rocks near the eastern margin of the Goyder Pass Diapir (Shepherd, 1929 & Plate 2). Mawson (1929) reported that a 2 m deep winze in yellow ochreous rocks of the cave floor indicated that the nitre persisted with depth, and that an average sample over 1.3 m on the south side of
the cave returned an analysis result of 19% potassium nitrate. However, Owen (1940) considered that an average grade of the rock exposed in the cave faces might be less than 1% potassium nitrate, and recommended no further work.

In 1970 the B.M.R. drilled nearby to test for evaporite sequences in the Goyder Pass Diapir (Plate 2), and in particular for potash, or sulphur-bearing minerals (Wells and Kennewell, 1972). The hole intersected 40 m of lacustrine? Tertiary sediments before entering a highly cavernous formation of clay and chert - presumably within the Bitter Springs Formation. Drilling difficulties caused the hole to be abandoned at 91 m in depth.

Phosphorites occur sporadically through the Amadeus Basin, primarily in the Ordovician Stairway Sandstone. Weak traces of phosphate mineralization have been recorded in this formation on the southern Glen Helen area.

4.3.2 Prospects

The Bitter Springs Formation is known to contain thick evaporite sequences elsewhere in the Amadeus Basin. Also, seismic evidence is consistent with the suggestion that flowage of incompetent beds has occurred into the crest of the Carmichael-Deering Creek Anticline, of which the Goyder Pass Diapir is a surface expression (Froelich & Kreig, 1969). Additionally, the Bitter Springs Formation is elsewhere known to contain significant, though non-commercial, accumulations of hydrocarbons. It is possible that sulphur deposits occur in Bitter Springs Formation rocks in the region of the Goyder Pass Diapir, formed by a redox reaction between gypsum and trapped hydrocarbons. It is also possible that potash-rich beds occur within evaporite sequences in the Bitter Springs Formation.

However, world demand for sulphur and potassium salts is weak, and for phosphate, marginal and it is considered unlikely that the Glen Helen area will be considered of particular interest for the discovery of related minerals in the foreseeable future. If rocks of deep-seated origin should be found associated with the Redbank Zone, they could possibly prove prospective for non-metallic minerals such as vermiculite, phosphate or diamonds.
5. **HYDROCARBON POTENTIAL**

5.1 **Nearby Hydrocarbon Occurrences**

Exploratory drilling in the northern Amadeus Basin has resulted in the discovery of two major gas fields, in the Mereenie and Palm Valley Anticlines. Eight wells have been drilled on the Mereenie Anticline which lies approximately 70 km southeast of the Glen Helen lease, and three on the Palm Valley Anticline, approximately 30 km south of the lease. In both fields the major producing formation is the Pacoota Sandstone of the Larapinta Group. Lesser production also comes from the Stairway Sandstone, and in the Palm Valley Anticline, from fractured siltstone in the Horn Valley Siltstone. The cap rocks are the lutites of the Stokes Siltstone, the siltstone of the middle unit of the Stairway Sandstone, and the Horn Valley Siltstone.

The Mereenie wells produce condensate at the rate of 10 barrels per million cubic feet of gas. The gross thickness of the column is approximately 330 m, and the underlying oil column has a minimum thickness of 100 m. The main problem encountered in the field is erratic porosity and permeability of the reservoir rocks.

Significant, but noncommercial, quantities of gas were encountered in the Stairway Sandstone over the interval 938–941 m in Gosses Bluff No. 1., drilled approximately 12 km south of the Glen Helen boundaries. Recent work has shown that this feature is almost certainly an astrobleme, rather than a salt-piercing structure as was originally thought.

Traces of gas were recorded from the Stairway Sandstone in Tyler No. 1, drilled to 3840 m and sited approximately 5 km south of the Glen Helen boundary. Unfortunately, variations in formation silicification had previously lead to errors in interpretation of the original seismic data. As a result, the hole was sited approximately 2 km east-north-east of the apex of the Tyler Anticline, although still within the area of closure, and was abandoned before the main prospective horizon (Pacoota Sandstone) was reached. Extensive silicification was encountered throughout the section, and the porosity and permeability of the Mereenie Sandstone and the Stairway Sandstone was found to be substantially less than expected. On this basis it has been felt (A. Magee, pers. comm.) that the whole succession may be silicified and impermeable throughout the Tyler–Glen Helen region. Although this is possible, the writers are inclined to discount the findings of a single drillhole, and feel that permeability and porosity characteristics of potential reservoir rocks of the Glen Helen region are more likely to prove erratic, as has been found in the Mereenie Anticline.
PLATE 5  Fig. 1  OBLIQUE AERIAL PHOTOGRAPH  
GOYDER PASS DIAPIR

PLATE 5  Fig. 2  TYLER ANTICLINE. SEISMIC  
CONTOURS (in feet) ON  
PACCOTA SANDSTONE
5.2 Source and Reservoir Rocks

The most promising source rocks in the Glen Helen area are the marine Cambrian and Ordovician siltstones, shales, and carbonate rocks. Of the Larapinta Group, the Horn Valley Siltstone was laid down in a euxinic environment which was favourable for the generation of hydrocarbons, while most of the Stokes Siltstone probably accumulated in a less favourable epeiric sea, with restricted circulation and high salinity. The fauna in the Stokes Siltstone is restricted to minor limestone beds and shows evidence of considerable reworking. The original organic content was probably considerably less than in the Horn Valley Siltstone.

The high organic content of the Pacoota and Stairway Sandstones indicates that they are probably potential source rocks as well as potential reservoirs. The Carmichael Sandstone, at the top of the Larapinta Group, possesses good reservoir rock properties.

Potential source rocks in the Pertacorrtta Group may occur within siltstones in the Hugh River Shale. The Arumbera Sandstone is probably the best reservoir rock.

The only Proterozoic Formation with potential as a source rock is the Bitter Springs Formation. Lenses of clean sandstone with good reservoir properties are also present.

5.3 Structure

A good deal of seismic and gravity, and some drilling work has been carried out on the northern margin of the Amadeus Basin, both south of, and within, the Glen Helen lease boundaries. Possibly the most important general information to come from this work is the evidence of thin-skin deformation of cover rocks above the Bitter Springs Formation, which includes plastic flowage, diapirism and extensive thrust faulting. There is also limited evidence for salt-solution and collapse near outcrops at the basin margin.

Detailed studies by the B.M.R. have shown that several sections of the northern margin of the Amadeus Basin are extensively overthrust - for example, in the Arltunga and Ormiston Nappe Complexes. In the Glen Helen region, Marjoribanks (1973) has shown that in the Razorback Nappe, a klippe of basement rocks with a veneer of Heavitree Quartzite, has been driven some 20 km southwards into the basin along a décollement within the Bitter Springs Formation.

As a result of these movements, the prospective Ordovician
section rocks are found in flat-lying or gently-dipping attitudes at depth beneath the steeply-dipping to overturned rocks of the overthrust MacDonnell Homoclone (see Plate 3).

Two major structural features of probable importance for the accumulation of hydrocarbons have been found by seismic work to extend onto the lease area from the south and west. They are the Carmichael-Deering Creek Anticline and Thrust Fault, which extends for some 130 km to the west, and the Northeast Gardiner-Gosses Bluff-Tyler-Glen Helen Structure.

5.3.1. **Carmichael-Deering Creek Anticline**

Seismic evidence indicates that the Goyder Pass Diapir provides a cross-sectional view of the east end of the Carmichael-Deering Creek Anticline and Thrust Fault, although other interpretations are possible (Wells et. al., 1970 & Plate 4). It is considered that this structure formed mainly during early phases of the Alice Springs Orogeny, although stratigraphic thinning over the crest of the structure is thought to indicate that it was growing slowly in Cambrian and Ordovician times. The deformation is thought to have been localised or otherwise modified by diapirism and flowage into the cores of the uplifts. Two plays occur associated with this feature, approximately 15 km from the Glen Helen lease boundaries, and will be briefly discussed as follows.

The Carmichael Prospect occurs as an anticline sealed against impermeable Pertatataka or Bitter Springs Formation rocks along the Carmichael Thrust Fault. The Northeast Carmichael Lead occurs where this fault splits into at least three subordinate faults with very irregular separations and attitudes, and which become blind thrusts (overlain by Pertajara Group rocks) with the easterly plunge of the Carmichael structure. Two Magellan Petroleum (N.T.) Pty. Ltd. seismic lines (2-7 and 2-6) show north-south turnover between the first and second thrusts at Horn Valley Siltstone level. No east-west turnover has been demonstrated, but a large fault trap is possible between the thrust sheets. The prospect is enhanced by the relatively shallow depths to the Stairway Sandstone and Pacoota Sandstone objectives:— probably around 2100 m to the Pacoota Sandstone (Plates 6 & 7).
Further east along the Carmichael-Deering Creek structure on the Glen Helen lease area, the quality of seismic reflection data is poor, and no horizon identification is possible. However, a gentle northerly dip is indicated. It is possible that plays similar to those found at Carmichael and Northeast Carmichael will be found to occur within the Glen Helen lease area, associated with the Carmichael-Deering Creek structure. Detailed seismic work would be required to adequately test this possibility, and drilling would be necessary to test any trap so defined.

5.3.2 Northeast Gardiner-Gosses Bluff-Tyler-Glen Helen Structure

A late Precambrian depositional thinning extends from Katapata Gap northeast through Gosses Bluff to the Tyler Anticline, then eastwards to the Glen Helen Lead. Good evidence of floavage of incompetent units in both the Cambrian and Precambrian sections is shown by the Gosses Bluff, Tyler and Glen Helen seismic profiles, and this ridge now separates the even, asymmetric Missionary Syncline in the east, from the deeper "Carmichael" sub-basin. It has been suggested that the ?comet impact which resulted in the formation of Gosses Bluff in the Cretaceous Period, may have triggered rapid thickening of an existing Bitter Springs Formation salt pillow at depth, thus modifying and accentuating the structure (Milton et al., 1972).

Although two wells have been drilled in plays on the Northeast Gardiner - Glen Helen ridge, neither provides a clear indication of its hydrocarbon potential, since neither reached the prospective Pacoota Sandstone. A third play, the Northeast Gardiner Prospect, has not yet been drilled.

The Glen Helen seismic lead, which lies partly within the boundaries of the Glen Helen Pastoral Holding, is based on only a small amount of shooting in the Pertnjara foothills; Magellan Petroleum (N.T.) Pty. Ltd., seismic lines 2-2.7, 2-2.7 x A, 2-3.1 and the northern end of line 2-3. If the deep east-west trough north of Tyler No. 1 continues to the east, as data from seismic line 2-2.7 appears to indicate, the syncline will be found either to become a north-over-south thrust fault, or to be folded under the MacDonnell Homocline. In either case, the north side
of the Glen Helen structure is sealed. At present there is no data available to define the eastern end of the structure. Because of the difficult terrain, seismic exploration in this area would prove expensive, and Froelich and Kreig (1969) felt that it would only be warranted if the Tyler Anticline proved productive. The writers feel that since the results of the Tyler No. 1 test are not conclusive, the Glen Helen structure should continue to be regarded as a promising lead.

5.3.3 **Idirikki Syncline**

It was suggested by Froelich and Kreig (op. cit.) that more work should be undertaken on the periphery of the Idirikki Syncline. Evidence for faulting and possible décollement surfaces should be sought in support of the possibility that large hydrocarbon traps may be present below or between thrust plates. On this basis the south-western section of the Glen Helen lease area is considered to have some prospects for the eventual discovery of hydrocarbon accumulations.

6. **CONCLUSIONS**

6.1 **Uranium Mineralization**

Uranium exploration on "Glen Helen" is thought to have been reasonably thorough at the preliminary (airborne) stage, although little attention has been paid to pre-Devonian Amadeus Basin rocks. Since no targets of outstanding importance have been defined so far, it is thought fair to conclude that there is little chance that any large radioactive body outcrops in the area. However, the results have not been without encouragement, and further work might well be considered justified at several of the localities referred to in the text.

6.2 **Base-Metal & Non-Metallic Mineralization**

Little effective base-metal and non-metallic mineral exploration has been undertaken, and there is no indication at present that the area will be considered particularly prospective for base-metal mineralization in the foreseeable future. Despite reasonable prospects for the discovery of non-metallic minerals such as sulphur or potash, low demand and relatively high transport costs may be expected to continue to discourage exploration for these commodities.
6.3 Hydrocarbon Potential

Only limited seismic work has been undertaken on the Glen Helen area, partly at least because of the expense and difficulty involved in surveying foothill terrain. However, on the basis of drilling and geophysical work in the region, it may be concluded that:

(a) A gently-dipping or flat-lying stratigraphic section suitable for the generation and possible entrapment of hydrocarbons underlies a significant section of the southwestern Glen Helen area, including the steeply-dipping and overturned rocks of the MacDonnell Homocline.

(b) A lead of some promise (the Glen Helen Lead) occurs marginal to the lease area.

(c) There is clear justification for further work on:
   (i) The northeastern extension of the Carmichael-Deering Creek Anticline and Thrust Fault.
   (ii) The periphery of the Idirriki Syncline.

Although extensive silicification was encountered throughout the section drilled in the nearby Tyler No. 1 well, the writers are inclined to discount the possibility that silicification will be found to be uniform or extensive in the Glen Helen region. They feel that porosity and permeability characteristics are likely to prove erratic, as in the Mereenie Gas Field.

6.4 General

The Glen Helen lease area appears to have some prospects for the discovery of hydrocarbon accumulations.

There is limited encouragement for further uranium exploration work in the area, but the writers find little to commend it to basemetal or non-metallic mineral explorers.

7. ACKNOWLEDGEMENTS

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8. REFERENCES


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MAP OF PRIME LITHOSTRUCTURAL UNITS, GLEN HELEN AREA

SOUTH WESTERN SECTION CHARTED

Scale 1:250,000

LEGEND

ALLUVIUM
POST BITTER SPRINGS FORMATION RICAS
BITTER SPRINGS FORMATION
HEMATITE QUARTZITE
IGNEOUS ORIGINATION ZONE (INCLUDING HIGHLY SEDIMENTED ROCKS)
REDBANK CATACLASIC ZONE
GRANULITE FACIES METAMORPHIC ROCKS
CHEWINGS RAMPS ZONE (AMPHIBOLITE FACIES)
GEOLOGICAL BOUNDARY
ULURUITE DTJE SWARA
THRUST FAULT
FAULT

PLATE 1

AFTER EMU AUSTRALIA LTD 1977

GLEN HELEN NATIONAL PARK, WESTERN AUSTRALIA
Outcrops steeply

dipping to the south

or overturned.

NOTE: Time/depth relation

found at Hermansburg in 1961

REFLECTION CROSS-SECTION BMR TRAVERSE 1

Scale 1:48000