4. GEOLOGY

4.1 Summary of Previous Work

Geology

The James Range 'A' anticline was mapped by the Bureau of Mineral Resources (BMR) in 1963 (Ranford & Cook, 1964). This mapping showed the James Ranges to be composed of a series of en-echelon anticlines with deeply eroded cores, surrounded by rim rocks of resistant Cambro-Ordovician and Devonian sandstones. The anticlines are aligned east-west and trend slightly south of due east (Figure 1).

Geophysics

The BMR flew an aeromagnetic survey (Traverse II) over the James Ranges in 1960 (Goodeve, 1961). This traverse was just to the east of the Finke No. 1 well site and indicated a slightly thickened section over the James Ranges compared to the areas to the southeast and immediately northeast, possibly due to thrusting from the north.

The Bureau of Mineral Resources carried out a reconnaissance helicopter gravity survey of the central Amadeus area in 1962 and anticlinal features were shown to underlie areas of gravity maxima (Lonsdale & Flavelle, 1963). The only other geophysical work done in the James Ranges area was a gravity profile along the Finke River conducted by International Resource Surveys Incorporated, and a short reflection seismic survey on the southern flank of the ranges in the vicinity of Highway No. 1 by Geophysical Associates Pty. Limited. The gravity results showed minima over the anticlinal trend, interpreted as due to a salt core, but the seismic results were inconclusive due to poor quality reflections.

Pancontinental Petroleum Limited conducted the Highway Seismic Survey over the eastern James Ranges in 1981 and reshot the old International Resource Surveys line down the Stuart Highway.

Geochemistry

Vaporsearch Pty. Ltd. conducted a helicopter geochemical survey over the eastern Amadeus Basin in 1981 using a "Remote Gas Sensor" technique. The airborne survey was followed by ground back-up geochemical surveys in areas of interest. Very significant microseepages, two to three times background, were recorded in the James Range 'A' area. Finke No. 1 was sited to test the highest concentration of gas seepage identified in the James Range 'A' anticline.

Photogeological Study

A photogeological study of the Finke No. 1 site was carried out by Australian Photogeological Consultants in April, 1983. The conclusions of the study are summarised below:-

The assymmetry of the eastern part of the James Range 'A' anticline is self-apparent under the stereoscope and the axis is close to the southern, strike-faulted limb. Reasonable symmetry prevails elsewhere and the axis is centrally situated between the outcropping limbs.

Cross-folding has influenced the development of synclinal saddles in the crest of the anticline, resulting in elliptical elongate domal folds. One saddle west of James Range A No. 1, is evident in good outcrop. Faint trends of bedding in suboutcrop allowed reasonable confidence in the existence of a further saddle some kilometres east of the Finke River.

The domal area between these two saddles may be affected by some faulting. In the resistant strike ridges to north and south, minor displacements are visible in the marker beds. Beds appear to be displaced by progressively smaller amounts upwards in the sedimentary succession on the northern limb. On the opposite limb there is evidence of a general "east-side-up" displacement on the faults. Elsewhere there is evidence that other small transverse faults die out rapidly. No major faults exist except for the east-west strike-fault on the southern limb.

Drilling

The James Range A No. 1 well was drilled by Exoil (N.T.) Pty. Ltd. and partners as a stratigraphic and structural test of the James Range 'A' anticline, southwest of Alice Springs. The James Range A No. 1 well is located 7.5 kilometres east of the proposed Finke No. 1 site. James Range A No. 1 was air and mist drilled to a total depth of 914.4 metres and was abandoned as a dry hole on May 10, 1965.

According to McTaggart & Pemberton (1965), 617.5 metres of Cambrian Pertaoorrta Group and 297 metres of Proterozoic were penetrated. The Pertaoorrta was interpreted to overlie steeply dipping Areyonga and Bitter Springs Formations, indicating considerable pre-Pertaoorrta uplift and erosion of the Proterozoic. The basal formation of the Pertaoorrta was thinner than expected due to onlap.

Traces of residual hydrocarbons were noted near the base of the Pertaoorrta Group, but no significant indications of oil or gas were encountered.

4.2 Summary of Regional Geology

The Amadeus Basin is an 800 kilometre long, east-west oriented intracratonic depression lying in the southern part of the Northern Territory and extending partly into Western Australia. Commencing with Late Proterozoic clastics, which rest on an older Precambrian basement of metamorphic and igneous rocks, the basin has had a long and diversified history of sedimentation (Figure 4). Following Late Proterozoic sedimentation, rocks of Cambrian, Ordovician, possibly Silurian, Devonian and Permian age were laid down. Depositional and climatic conditions varied greatly in space and time throughout this long history. The Late Proterozoic, Cambrian and Ordovician were largely times of marine sedimentation resulting in the accumulation of great thicknesses of sandstone, shale, limestone and dolomite, with periods of evaporite (salt) deposition in the Late Proterozic and Cambrian. Two periods of glaciation also occurred in the Late Proterozoic. Silurian?-Devonian sandstones, which were deposited during a period of aridity, are partly fluviatile and aeolian. Mountain building movements along the northern rim of the basin provided material for a thick wedge of fluviatile sediments in the Late Devonian. Minor fluviatile and lacustrine deposition in the Permian and again in the Tertiary concluded the sedimentary history of the Amadeus Basin.

Sedimentation was modified by tectonic movements which occurred intermittently from Late Proterozoic to Late Devonian. Tectonic movements in the Proterozoic established the shape of the basin, and formed the structural framework within which subsequent movement took place (Figure 4).

Two major cycles of sedimentation associated with tectonism are evident. The older cycle began in the Proterozoic with mature orthoquartzite and carbonate rocks and finished with

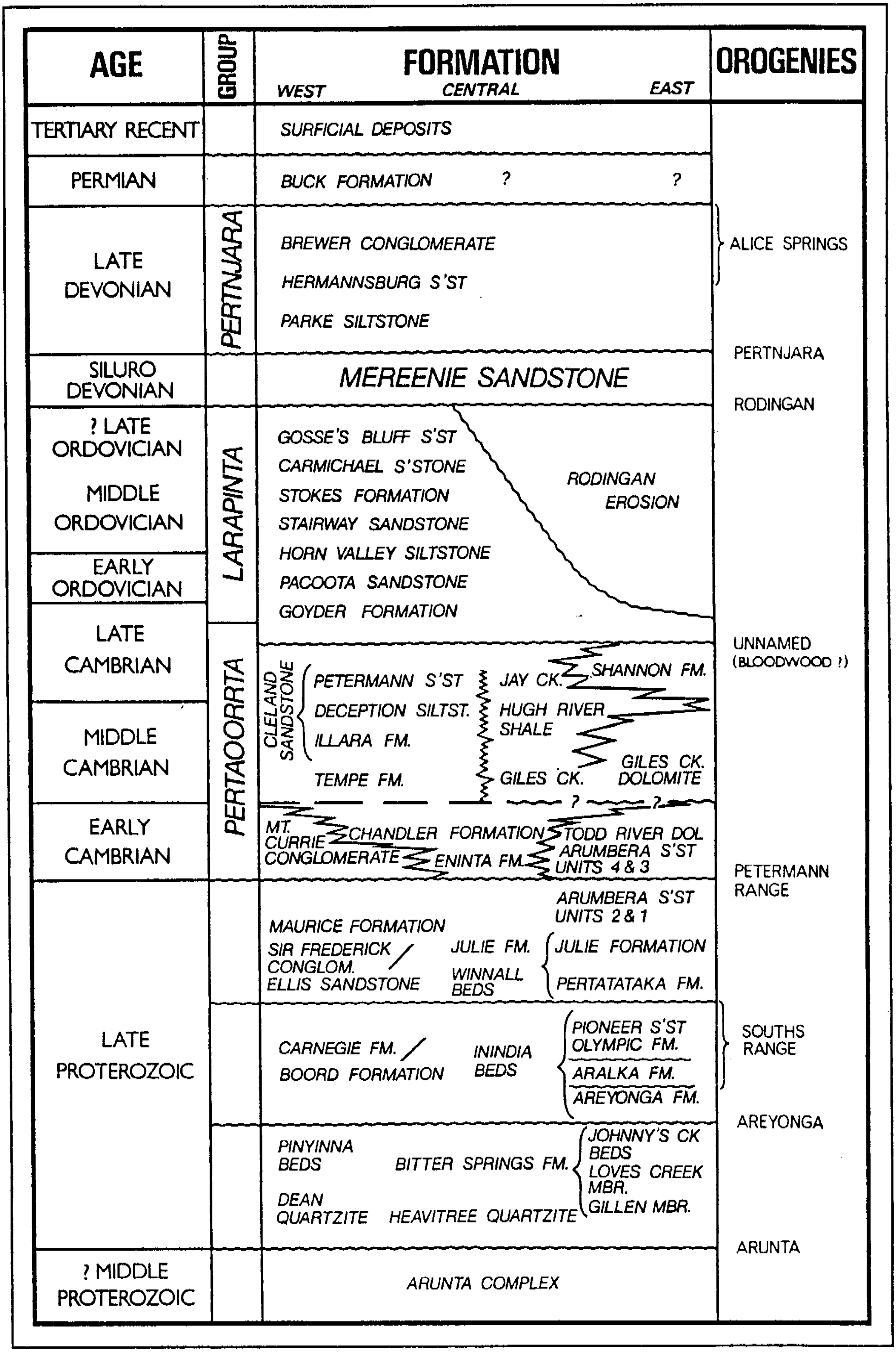
AGE
GROUP
FORMATION
WEST
CENTRAL
EAST
OROGENIES
TERTIARY RECENT
SURFICIAL DEPOSITS
PERMIAN
BUCK FORMATION
?
?
LATE DEVONIAN
PERTNJARA
BREWER CONGLOMERATE
HERMANNSBURG S'ST
PARKE SILTSTONE
ALICE SPRINGS
PERTNJARA
SILURO DEVONIAN
MEREENIE SANDSTONE
RODINGAN
? LATE ORDOVICIAN
MIDDLE ORDOVICIAN
EARLY ORDOVICIAN
LARAPINTA
GOSSE'S BLUFF S'ST
CARMICHAEL S'STONE
STOKES FORMATION
STAIRWAY SANDSTONE
HORN VALLEY SILTSTONE
PACOOTA SANDSTONE
GOYDER FORMATION
RODINGAN EROSION
LATE CAMBRIAN
MIDDLE CAMBRIAN
EARLY CAMBRIAN
PERTAOORRTA
CLELAND SANDSTONE
PETERMANN S'ST
DECEPTION SILTST.
ILLARA FM.
TEMPE FM.
JAY CK.
SHANNON FM.
HUGH RIVER SHALE
GILES CK.
GILES CK. DOLOMITE
?
?
UNNAMED (BLOODWOOD ?)
MT. CURRIE CONGLOMERATE
CHANDLER FORMATION
ENINTA FM.
TODD RIVER DOL
ARUMBERA S'ST UNITS 4 & 3
PETERMANN RANGE
LATE PROTEROZOIC
ARUMBERA S'ST UNITS 2 & 1
MAURICE FORMATION
SIR FREDERICK CONGLOM.
ELLIS SANDSTONE
JULIE FM.
WINNALL BEDS
JULIE FORMATION
PERTATATAKA FM.
CARNEGIE FM.
BOORD FORMATION
ININDIA BEDS
PIONEER S'ST
OLYMPIC FM.
ARALKA FM.
AREYONGA FM.
SOUTHS RANGE
AREYONGA
PINYINNA BEDS
DEAN QUARTZITE
BITTER SPRINGS FM.
HEAVITREE QUARTZITE
JOHNNY'S CK BEDS
LOVES CREEK MBR.
GILLEN MBR.
ARUNTA
? MIDDLE PROTEROZOIC
ARUNTA COMPLEX

FIGURE 4.

relatively immature fluviatile sandstone in the early Cambrian (Petermann Range Orogeny). The second cycle commenced later in the Cambrian with marine sedimentation predominating and ended in the Late Devonian with the Alice Springs Orogeny. Smaller local cycles are associated with the movements that have been named on Figure 4.

Folding and faulting in the southwestern area initiated in the Proterozoic, sometimes associated with salt tectonics, produced east-west striking anticlines, often faulted along the flanks and showing thinning of Late Proterozoic sediments over the crest. These structures were modified, and new ones created, by the Alice Springs Orogeny in Late Devonian time - the final major tectonism in the Amadeus Basin. An important precursor to the Alice Springs Orogeny was the Late Ordovician Rodingan Movement. The low angle unconformity that indicates this movement is best developed in the north and northeast, where the earlier deposited Ordovician sediments were progressively eroded eastwards. The total sediment thickness and the stratigraphy of sediments preserved over any structure depend on the amount of Rodingan erosion to which that has been subjected. Thus more western structures, such as at Palm Valley and Mereenie, are more likely to have a more complete sedimentary section preserved over them than eastern structures, such as the Dingo structure.

Structures may be further complicated by the occurrence of salt diapirs, emanating from the Bitter Springs Formation or Chandler Formation, flowing into the cores of structures, as for example at the Goyder Pass Structure. The salt cored structures are known to have grown intermittently from Late Proterozoic to Devonian time, as shown by local thinning of units.

At least two generations of thrust faulting are present in the Amadeus Basin, with thrusting from both north and southwest. Thrusting events probably took place during the Petermann Range Orogeny (Late Proterozoic - Early Cambrian) in the southwest and during the Alice Springs Orogeny. These thrusting movements further complicate the geology and have lead to thickened section, overthrust anticlines and possibly the development of fracture porosity.

4.3 Stratigraphy

The section penetrated by Finke No. 1 is compared to the predicted section in Enclosure 3, and with the sections drilled at Highway No. 1, James Range A No. 1, East Johnny's Creek No. 1 and Ochre Hill No. 1 in Enclosure 4. Table 1 shows the stratigraphic succession penetrated at Finke No. 1.

Table 1. Stratigraphy at Finke No. 1

FORMATION	TOP (metres KB)	THICKNESS (metres)	LITHOLOGY
Quaternary	0	6	Scree/outwash
Upper Giles Creek	6	63	Siltstone, limestone
Middle Giles Creek	69	120	Siltstone, dolomite
Lower Giles Creek	189	25	Siltstone
?Arumbera	214	24	Sandstone, chert
"Finke Beds"	238	35	Dolomite
Johnny's Creek Beds	273	126	Dolomite, siltstone
Bitter Springs	399	190.3+	Dolomite

Quarternary: 0-6 m (Thickness 6 m)

The surficial deposits encountered in Finke No. 1 consist of a mixture of coarse grained subangular scree and fluvial outwash, with quartzite boulders up to half a metre and finer infilling of clay, sand and gravel. Many of the boulders are derived from the Pacoota Sandstone, which outcrops in the inner rimrock of the breached anticline.

Upper Giles Creek Dolomite: 6-69 m (Thickness 63 m)

The base of the Upper Giles Creek Dolomite is selected at a prominent gamma ray low over a thick development of dolomite. The top of the section is truncated.

The lithology is dominantly siltstone with subordinate shale and limestone, and minor sandstone.

The siltstone is red brown to brick red and occasionally medium grey to black or green, micaceous to very micaceous, soft to hard, blocky to subfissile, brittle, sometimes sandy, in part calcareous or dolomitic and occasionally carbonaceous. Calcite veining is present in part. The siltstone grades in part to brick red and minor dark grey and black shale.

The limestone in the upper part is pale grey, white and buff, micritic, sandy or silty in part, and with carbonaceous mottling. In the lower part the limestones are reddish pink, cream and pale grey, dolomitic in part and slightly sandy and silty.

The minor sandstones are white, buff and yellow, very fine grained, very calcareous and grade to sandy limestone. No porosity is evident in these sandstones.

<u>Middle Giles Creek Dolomite</u>: 69-189 metres (Thickness 120 m)

The top of the Middle Giles Creek Dolomite is marked by low gamma ray values and the incoming of dolomite.

Between 69 and 103 metres, the gamma ray curve indicates several major carbonate beds up to 3 metres thick which grade into shale and minor siltstone above and below. The dolomite is white, grey and pale brown, micritic to in part sucrosic, occasionally slightly silty or sandy and in part carbonaceous. Between 92-95 metres the section is essentially limestone, yellowish grey, micritic, and slightly sandy. The interbedded shale is dark grey to black, blocky to subfissile, micromicaceous to micaceous and carbonaceous. The siltstone is pale to medium grey to green, micromicaceous, sandy in part and occasionally subfissile.

Below 103 metres to about 180 metres the section is dominantly siltstone and shale, with minor sandstone, limestone and dolomite. The siltstones are as above to about 110 metres, below which they become reddish brown and grey to brown, mottled in part, micromicaceous, slightly calcareous and occasionally sandy. Minor sandstone occurs between 105-110 metres and is yellowish grey, but occasionally white, very fine grained, moderately sorted, siliceous but with limonitic and occasionally calcareous or kaolinitic cement. No porosity was reported. A limestone bed (118-134 metres) is greyish tan, occasionally grey, micritic and sandy in part. Between about 149-153 metres there is a calcareous dark grey to black extremely micaceous siltstone mottled with white very fine grained calcareous sandstone. Below 153 metres the section becomes shaly with pale to medium grey micromicaceous shale and pale red to pink, brick red and grey to black siltstone predominating with traces of pale grey, buff and pale brown slightly carbonaceous, micritic, dolomitic limestone down to about 180 metres.

The section between 180-189 metres is dolomitic, pale grey to dark grey and tan carbonaceous limestone, sandy and silty, in part pyritic, micritic to occasionally sucrosic and calcite veined.

Source rock studies (Appendix F) over the interval suggest no source beds are present. The highest total organic carbon (TOC) value was 0.32 wt% from cuttings between 150-165 metres. The section appears marginally mature to mature for oil on the Rock-Eval T_{max} results. Palynological analysis of the section between 150 and 200 metres proved unsuccessful (Appendix H), although much light brown dispersed organic matter was present.

<u>Lower Giles Creek Dolomite</u>: 189-214 metres (Thickness 25 m)

The Lower Giles Creek Dolomite is clearly marked by a high gamma ray count section on the gamma ray log. While limestone is abundant in the cuttings, it is clear from the log response that much of the carbonate is caved.

The section is dominantly integrading siltstone and shale. The siltstone is pale to medium grey and green, micromicaceous, pyritic and calcareous above 205 metres, but below this depth grades to pale brown and grey brown, and becomes dolomitic. The shale is pale grey to black, micromicaceous, pyritic, calcareous and dolomitic. Calcite veining is common in the section.

The black colour of some of the shale suggested that hydrocarbon source beds may have been present but geochemical studies proved the rocks to contain only very low amounts of organic matter (Appendix F).

?Arumbera Sandstone: 214-238 metres (Thickness 24 m)

The section here equated with the Arumbera Sandstone is dominantly sandstone, but also includes cherty limestone, chert and sandy siltstone.

The sandstone between 214 and 230 metres is dirty grey to white, pale brown to grey brown in colour, occasionally clear, very fine to medium grained, occasionally coarse, sub angular to subrounded and poorly sorted, silty in part, micaceous and carbonaceous in part, very calcareous to occasionally dolomitic and grading to sandy limestone, contains yellow micaceous shale inclusions in part and has nil to occasionally fair intergranular porosity. Below 230 metres the sandstone becomes finer, grading to siltstone. Dirty grey to dark grey, black and brown grey with mottling in part, the sandstone also contains mica, frequent lithic fragments, chert, is carbonaceous in part, and has occasional coarse loose clear to frosted quartz grains. Porosity is very poor. The siltstone is minor, and medium to dark grey in colour, very micaceous and grades to sandstone.

The limestones are white to red brown, cream, pale grey to tan, occasionally carbonaceous and black, microcrystalline to sucrosic, pyritic in part, occasionally grading to very hard chert. The abundance of crystalline calcite suggests possible infilled fractures or vugs may be present.

The chert is white to cream, very pale tan, pale grey, occasionally banded, angular and very hard with semi-conchoidal fractures.

"Finke Beds": 238-273 metres (Thickness 35 m)

This interbedded dolomite and intergradational siltstone/ shale section was not encountered at James Range A No. 1, but log character suggest it may be represented between 853 metres and 888.5 metres at Ochre Hill No. 1.

The section consists dominantly of dolomite which is medium grey to occasionally dark grey, brown grey when carbonaceous, and pale pink, white and pinkish grey when non-carbonaceous. The grain size varies from micritic to finely sucrosic with the development of vuggy porosity in part. The section contains minor to abundant chert and is often silty approaching dolomitic siltstone in part. Pyrite and anhydrite are minor constituents of the dolomite. The rocks are very hard and splintery, often with subconchoidal fracture. Stylolites are common and composed of very dark grey or black shale. Petrographic description of core over the interval 252.6 to 254.3 metres are included in Appendix D.

Porosity is variably developed and ranges from poor to good in secondary porosity in partially infilled fractures and vugs. Much of the white sparry limestone reported from cuttings appears to reflect dogtooth spar infill from fractures.

Good oil shows were present in the unit after coring commenced. Between 252.6-254.2 metres the cores showed more than 40% bright yellow gold fluorescence in all secondary porosity. The cut was very fast and streaming, and left a thick bright gold yellow residual ring. Pale brown to straw coloured oil was visible in vugs and veins, occasionally appearing dark and viscous. Oil was seen to coat crystals in vugs. Below 254.2 metres the amount of fluorescence decreased with decreasing porosity but gilsonite or a similar dead oil occurs in fractures and vugs.

DST No. 1 was run over the interval 249.6-258.2 metres to test this oil show (Appendix K), but the formation proved tight with no permeability present. Subsequent core plug analyses (Appendix C) showed no permeability, but, due to technical problems, whole-core analyses were not run to assess the vuggy porosity. However, the results of DST No. 1 suggest that the vuggy porosity noted in core is non-effective.

Geochemical analyses of the oil recovered from sealed core samples shows that the oil is biodegraded and water washed (Appendix F). Source rock studies of selected core samples from 252.61 metres and 258.9 metres suggest marginal source bed development at 258.9 metres and that these source beds are presently oil mature (Appendix F).

Johnny's Creek Beds: 273-399 metres (Thickness 126 m)

The section between 273 and 399 metres is here correlated with the Johnny's Creek Beds as defined by Gorter (1982). The basal unit of the Beds is also recognised for the first time in James Range A No. 1 well (Enclosure 4).

The sequence is readily divisible into three on log characteristics and lithology.

Upper Unit: 273-330.5 metres (56.5 metres)

The upper unit consists of red brown siltstone and lesser dolomite. The siltstone is dominantly red brown or chocolate brown, but is mottled grey green or pale grey in part. Accessories include mica, calcareous and dolomitic cements, and the siltstones often grade to shales. Microveins of calcite are occasionally present.

The dolomites are calcareous, pale grey to dark grey, grey green and off white, hard, micritic to occasionally coarsely crystalline, cherty in part, and often brecciated. The irregular streaks and veins of dark grey, pyritic, argillaceous material reported are probably stylolites. Algal structures (eg. 299.8-299.9 metres, Appendix H) and ?cherty oolites are occasionally present. Porosity is generally poor but is occasionally present in partially quartz-infilled fractures and vugs, although gypsum or gilsonite sometimes infills the latter. Petrographic descriptions of samples at 299.65 to 299.78 metres and 305.09 to 305.20 metres are included in Appendix D.

Poor oil shows were noted between 297.7-299.5 metres and 304.6-308.1 metres with fluorescence and cut, and petroliferous odour on freshly broken surfaces. Geochemical analyses (Appendix F) indicate these shows to be residual oil.

Middle Unit: 330.5-355 metres (24.5 metres)

The lithology of the middle unit is predominantly massive white to light grey dolomite, generally micritic to occasionally microsucrosic, frequently stylolitic, rarely cherty, with occasional algal mat remnants (eg. 343.8-343.9 metres, Appendix H) and rare gypsum patches. Fracturing is light to moderate with occasional veining of dogtooth calcite infill and en-echelon tension fractures. There are minor argillaceous patches, frequent carbonaceous zones and the dolomite grades to grey shale in places. Porosity is overall poor, but good fracture and vugular porosity is evident with good intergranular mouldic porosity about 352.5 metres (see Frontispiece). Vugs are often partially filled with quartz or dogtooth spar crystals, but some contain gilsonite. Petrographic descriptions of three core samples from the middle unit are included in Appendix D.

Traces of residual oil, occurring as black carbonaceous or tarry material with dull gold, orange or yellow fluorescence and fast cut, or as live brownish liquid oil, are sporadic throughout the dolomite.

A fracture zone was encountered at 333-333.5 metres which took several barrels of drilling fluid.

Lower Unit: 355-399 metres (44 metres)

The lower unit is dominantly red brown and chocolate coloured shaly siltstone, similar to the upper unit. The siltstone is finely micaceous in part and slightly to moderately calcareous with frequent blebs of irregular greyish green siltstone. The section is lightly fractured with thin calcite veining and en-echelon tension fractures in part.

Close log correlation is apparent with the 744-791 metres level in James Range A No. 1. At the latter well, where the section is similarly dominantly red brown siltstone with traces of grey and blue-grey siltstone and minor chert, the majority of this section had previously correlated with the Areyonga Formation (McTaggart & Pemberton, 1965). The central part of the section at James Range A No. 1 (767-780 metres) consists of red brown siltstone and mottled tan and white dolomitic siltstone, gypsiferous sandstone and sandy dolomitic limestone. A similar log motif is present in the central part of the lower unit at Finke

No. 1 (362-373 metres) suggesting a similar lithology should be present there also, but no comparable section has been described from the cores.

The base of the Johnny's Creek Beds has been selected on the top of a sharp decrease in the gamma ray count and the first appearance of massive dolomite, marked by increases in the density log and slower sonic transit times.

<u>Bitter Springs Formation</u> (Loves Creek Member): 399-509.3 metres TD (Thickness 190.3 m plus)

The Loves Creek Member of the Bitter Springs Formation consists of predominantly dolomite and minor chert and siltstone.

The dolomites are light grey to dark grey, white, very pale brown, calcareous, micritic to sucrosic, abundantly stylolitic in part, occasionally argillaceous or carbonaceous, occasionally semitranslucent, white, with light grey chert, rare veins satin spar, very rare trace pyrite and frequently contain stromatolites. Intraformational breccias are common in part and fractured zones occur, often with calcite infilling. A petrographic description of banded dolomite from 408.35 to 408.47 metres is included in Appendix D.

Porosity is generally poor to occasionally good, and ranges from vugular and fracture porosity to intercrystalline in part. The interval 453.2-453.5 metres had good fracture and vuggy porosity, and 2 units of total gas were recorded with minor (195 ppm) methane indicated on the chromatograph (Enclosure 2).

The section contains many stromatolitic intervals with various previously described forms present. Several of the stromatolite types are referable to forms described from the Loves Creek Member of the Bitter Springs Formation elsewhere in the basin. These forms include species of Kotuikania, Inzeria and Boxonia (Appendix H).

4.4 Structure

James Range 'A' anticline lies on an anticlinal hinge line which extends from the Mereenie area in the west, through the James Ranges structures eastward. North of this line the Amadeus Basin shows considerable downwarp of strata, a thick fill of Pertnjara Group molasse sediments, gentle fold elements and reasonably good conformity between stratigraphic units. In contrast, the area to the south of this alignment is characterised by severe faulting, major unconformities and hiati, and appreciable post-depositional folding.

At the Highway No. 1 location (Figure 1) the basal Cambrian clastic section (Arumbera Sandstone) is absent. Erosion following early movements associated with the Petermann Range Orogeny (Late Proterozoic to Early Cambrian) resulted in a "bald headed" anticline, ie. erosion of pre-Arumbera Sandstone sediments occurred (Enclosure 4). At Highway No. 1, the Chandler Formation (Early Middle Cambrian) overlies probable Bitter Springs Formation (Late Proterozoic). The molasse of the Arumbera Sandstone were deposited basinward of the structural high.

In contrast James Range A No. 1 suggested that the Arumbera Sandstone would be present in the Finke No. 1 area, and unconformably overlie the Bitter Springs Formation. While at both James Range A No. 1 and Highway No. 1 wells "bald headed" structures are present (Enclosure 4), at James Range A No. 1 molasse sediments occur above the Bitter Springs

Formation, suggesting that the area was further basinward from the Petermann Range Orogeny induced structures than at Highway No. 1. A similar stratigraphy to that at James Range A No. 1 was expected at the Finke No. 1 site.

Finke No. 1 was drilled approximately 300 metres south of the axis of the western culmination of the James Range 'A' anticline. The periphery of the anticline is well defined from rimrock of the Pacoota Sandstone. The culmination on which Finke No. 1 was drilled is separated by a saddle in the Goyder Formation and Jay Creek Dolomite from the James Range A No. 1 culmination to the east.

The Finke No. 1 location proved to be similarly "bald headed" as the James Range A No. 1 area (Enclosure 4) but in the former case the Arumbera Sandstone molasse proved much thinner than at James Range A No. 1. At James Range A No. 1 only the basal Johnny's Creek Beds are preserved below the basal Arumbera Sandstone unconformity but at Finke No. 1 117 metres of younger Late Proterozoic is present. This suggests that Finke No. 1 was drilled on a palaeohill superimposed on the much broader anticlinal hinge referred to above, and that thicker Arumbera Sandstone may be present on the flanks of this high.

4.5 Relevance to the Occurrence of Hydrocarbons

Hydrocarbon shows were encountred only in the section below the ?Arumbera Sandstone and above the Loves Creek Member of the Bitter Springs Formation. A minor gas show was recorded on the hot wire recorder in the Bitter Springs Formation itself.

All shows were recorded from vuggy or fractured dolomites, which generally had no matrix permeability. Extensive geochemical analyses (Appendix F) revealed the following:

1. The top of the oil-generation window notionally is located above ground level at the Finke No. 1 well locality, implying substantial uplift and erosional loss of section. Equivocal Rock-Eval maturation data place the bottom of the oil window within the middle Giles Creek Dolomite.

2. Carbonates of the Giles Creek Dolomite (Cambrian) and the Finke Beds (?Late Proterozoic) contain low concentrations (TOC = 0.09-0.32%) of gas-prone Type III kerogen.

3. Oil shows from 252-268 metres depth in the Finke Beds are residual, migrated paraffinic-naphthenic to aromatic-naphthenic crudes of algal/bacterial origin which have undergone various degrees of water-washing and partial biodegradation. Similar alteration processes gave rise to the asphaltic reservoir bitumen found at 267.0 metres depth. The compositions of these oils and the bitumen suggest that there have been at least two episodes of hydrocarbon migration into this reservoir formation.

4. Shows of paraffinic and paraffinic-naphthenic oil at 298-306 metres depth in the Johnny's Creek Beds display no obvious sign of water-washing or bacterial alteration. GC-MS analysis of their saturates is required to establish the maturity of these oils, and to confirm their suspected genetic affinity with the more altered oils in the overlying Finke Beds.

4.6 Porosity, Permeability and Formation Fluids

A visual porosity log was maintained by the mudlogging company while drilling (Enclosure 2). Subsequently, core analyses were carried out on selected core samples (Appendix C).

Visual porosity estimates on the cuttings show at best only fair porosity, usually associated with sandy stringers in the Giles Creek Dolomite section or in the ?Arumbera Sandstone. Water entering the hole while air and mist drilling at about 75 metres and 105 metres may have come from these sands, indicating good permeability in part. The water entering the hole is fresh, as shown by the resistivity of fluid samples caught from the blooie line while air drilling.

Fair visual porosity was observed in core immediately below the casing shoe at 252.6 metres (Enclosure 2) in dolomites of the "Finke Beds". Core analyses suggest that porosity ranges from 0.7 to 5% but permeability is very low, with a maximum of 5 millidarcies, but generally values are below 0.4 millidarcy (Appendix C). This low permeability was confirmed by DST No. 1 (Appendix J). Further core analyses (Appendix C) in the "Finke Beds" below the drill stem-tested zone confirm low permeabilities and generally low porosities, although a porosity value of 7.9% was measured. Minor fair visual porosity was noted from cores, in vugs and partially healed fractures.

In the Johnny's Creek Beds the best porosities were noted in vugular and partially healed fracture zones, with some minor development of intercrystalline (mouldic) porosity. Core analyses show the dolomite porosities are generally low, but a value of 13.9% was measured at 305.6-305.73 metres. However, permeability is again very low.

Minor fair porosity, associated with fractures and vuggy zones, is present in the Bitter Springs Formation. Drill Stem Test No. 3 (Appendix J) showed the formation to be permeable and to contain slightly brackish water. Routine core analyses indicate up to 4.2% porosity but generally low (less than 1 millidarcy) permeability. It is probable that the recovered formation water in DST Nos. 3 and 4 is contained in vuggy zones and fracture systems rather than in intergranular porosity.

4.7 Contribution to Geological Concepts

The most important contributions to the understanding of the petroleum geology of the Amadeus Basin were the presence of oil in the Late Proterozoic sequence and the preservation of younger Late Proterozoic rocks along ancestral structural highs.

permeable and to contain slightly brackish water. Routine core analyses indicate up to 4.2% porosity but generally low (less than 1 millidarcy) permeability. It is probable that the recovered formation water in DST Nos. 3 and 4 is contained in vuggy zones and fracture systems rather than in intergranular porosity.

4.7 Contribution to Geological Concepts

The most important contributions to the understanding of the petroleum geology of the Amadeus Basin were the presence of oil in the Late Proterozoic sequence and the preservation of younger Late Proterozoic rocks along ancestral structural highs.

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