G E O L O G Y

SUMMARY OF PREVIOUS WORK

Geological:

Several geologists and expeditions have made reconnaissance or semi-detailed stratigraphic surveys of the central part of the Amadeus Basin. The most notable workers who have made cursory examinations of the area are Chewings, Brown, Tate (of the Horn Expedition) Ward, Mawson and Madigan.

In 1956, the Bureau of Mineral Resources commenced regional mapping of the Amadeus Basin, and Prichard and Quinlan (1962) incorporating previous nomenclature, defined a set of type stratigraphic units in the northern part of the basin. Frome-Broken Hill Pty. Ltd. undertook regional reconnaissance mapping of the whole of the basin (inter alia Leslie 1960) and since 1960, Magellan geologists have carried out locally detailed surveys in the basin, especially in the vicinity of anticlinal features (Stelk and Hopkins 1962; McNaughton 1962). Continuing their mapping programme, the Bureau of Mineral Resources covered the southern, western, and central areas of the basin and instituted local nomenclature for south-western and central facies variants in the Proterozoic and Cambrian sequence (Wells, Ranford and Cook, 1963). They made a provisional correlation between these and the northern facies of Prichard and Quinlan.

Geophysical:

The Bureau of Mineral Resources carried out a reconnaissance helicopter gravity survey of the central Amadeus area in 1961 and in general anticlinal features were shown to be coincidental with areas of gravity maxima. No other geophysical work has been carried out in the Johnnys Creek area.

Drilling:

East Johnny's Creek No. 1 was the second attempt to drill the Johnnys Creek axis; the unsuccessful Johnny's Creek No. 1, ten miles to the west, having been terminated at 877 feet due to drilling difficulties. The Mereenie gas field with four wells completed, lies ten miles due north of the East Johnny's Creek site. At a Bureau of Mineral Resources phosphate test hole, drilled to 918' at a point 6 miles south-east of the site, an oil saturated core was recovered from the Stairway Formation.

REGIONAL STRATIGRAPHY

The Amadeus Basin, in its present form, occurs as an elongate, downwarped region between the Musgrave (southern) and Arunta (northern) metamorphic-igneous complexes. However, the sediments of the basin are considered to be merely shelf deposit remnants of a former depositional basin which extended considerably further to the north and east over the Arunta Block. The section covers strata from Upper Proterozoic to Devonian and embraces an aggregate thickness of some 20,000 feet.

In the northern part of the basin the Upper Proterozoic comprises a group of four conformable formations each of which shows evidence of deposition under marine shallow water conditions. The basal Amadeus unit is the Heavitree Quartzite, a transgressive sandstone/siltstone sequence up to 1,400 feet thick which shows bold outcrop along the truncated northern rim of the basin. The conformably overlying Bitter Springs Limestone consists mainly of algal bearing dolomitic limestone some 3,000 feet in thickness but

north of the East Johnny's Creek Silt. [illegible] Bureau of Mineral Resources phosphate test hole, drilled to 918' at a point 6 miles south-east of the site, an oil saturated core was recovered from the Stairway Formation.

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varying minor amounts of shale and sandstone also occur and in places the carbonate rock has a high clastic content. The Areyonga Formation, which follows with transitional contact, mainly comprises a mixed unit of siltstones, sandstones and conglomerates of glacial aspect with limestone concentrated at the top and bottom of its sequence. Its thickness is 1400 feet in the north central part of the basin but it thins markedly to the east and west, suggesting a deltaic accumulation of outwash material. Conformably following this unit the unfossiliferous Pertatataka Formation comprises up to 2,000 feet of black to vari-coloured shales and siltstones with thin interbeds of glauconitic sandstones and oolitic limestones.

Along the south-western margin of the basin the Dean Quartzite and the Pinyinna, the Inindia and the Winnall Beds have been respectively equated with the above four formations. A total thickness of some 14,000 feet has been estimated for these beds and each unit shows an appreciable thickening in comparison with its northern counterpart. In further contrast, local unconformity is suggested between the Inindia and the Winnall Beds in the former's type area and the latter is a distinctly sandy facies variant of the Pertatataka.

The Cambrian deposits of the Amadeus Basin are included under the composite name Pertaoorrta Group, a 5-6,000 feet marine sequence which shows an interesting clastic to carbonate facies change. The better known central facies comprises the predominantly sandy Arumbera Formation, the abundantly fossiliferous Hugh River Shale and the sandy Goyder Formation. Eastward, the uppermost two units become more carbonate rich, through an increasing abundance of limestone tongues until, east of Alice Springs, this facies, the Jay Creek Limestone, occupies the entire lithological interval of the two formations.

To the west the Hugh River Shale becomes sandier, particularly in its second and uppermost quarters, whereby it is divisible into the Tempe Member, the Illara Sandstone, the Deception Member and the Petermann Sandstone. The Tempe overlies the Eninta Sandstone which is equivalent to the upper part, at least, of the Arumbera Formation. Further west the Deception Member also changes to sand and the sequence is mapped as the 3000 feet thick Cleland Sandstone which overlies the Winnall Beds with unconformity. (The Tempe and Illara have been described under the names Mission and Gardner formations by McNaughton).

To the south of the James Ranges the Chandler Limestone, occurring between the Eninta and the Tempe, comprises up to 300 feet of contorted cherty limestone, dolomite and minor clastics. However, the detailed stratigraphic relationship of the Chandler to the Tempe and the limits of the former's geographical distribution have not as yet been established.

Conformably following the Pertaoorrta is the Larapinta Group of fossiliferous marine strata. The basal unit is the Cambro-Ordovician Pacoota Sandstone up to 2,500 feet thick composed predominantly of clean quartz sandstone. The overlying Horn Valley Siltstone is 400 feet thick in the north-west but it thins and pinches out completely eastward and southward. The phosphatic Stairway Sandstone conformably overlies the Horn Valley but is more transgressive, overlapping the lower Larapintine units to the south and east where it unconformably rests upon Pertaoorrta. The formation is almost 900 feet thick in the north and central parts of the basin but it thins eastward and southward in harmony with its contiguous formations. The top Larapinta unit is the Stokes Formation comprising up to 2,000 feet of vari-coloured siltstones with limestones in the lower part and some transitional sands at the base.

The Mereenie Sandstone overlies the Stokes Formation conformably in the central part of the Amadeus Basin but elsewhere laps unconformably onto lower Larapintine units. Where conformity exists a basal 450 feet brown sand is always present which contains fossils of Ordovician aspect. The upper part of the Mereenie consists of some 2,000 feet of white to vari-coloured unfossiliferous, possibly continental sandstone, usually assigned to the Silurian on a residual basis. As with the underlying Larapinta units, the Mereenie Sandstone shows thinning to the east and south, the latter being the more marked.

The Pertnjara Formation, at least 10,000 feet of continental clastics, overlies the Mereenie with angular unconformity. It comprises a lower siltstone section and an upper unit of red-brown to white silty and pebbly sandstone. Plant and fish remains of Devonian aspect have been found in both sections. The Pertnjara Formation is the topmost Amadeus unit and it occurs as an obscuring fill type deposit over the northern and central regions of the trough.

FORMATIONS PENETRATED

Stratigraphic Table

Age	Lithological Unit	Tops Depth	Tops Subsea	Thickness
Ordovician	Lower Stairway	Surface	+2200'	160'+
	Horn Valley	160'	+2040'	187'
	Upper Pacoota	347'	+1853'	728'
	Lower Pacoota	1075'	+1125'	198'
Cambrian	Goyder	1273'	+927'	682'
Cleland	Petermann	1955'	+245'	789'
	Deception	2744'	544'	550'
	Illara	3294'	1094'	651'
	Tempe	3945'	1745'	740'
	Eninta	4685'	2485'	69'
Upper Proterozoic	Areyonga	4754'	2554'	216'
	Bitter Springs	4970'	2770'	1374'+

Formation	Thickness
Pacoota	926'
Cleland	2799'

Detailed Stratigraphy:

Lower Stairway Sandstone 0 - 160' thickness 160'+

Age: Ordovician

Predominantly white, grey and brown, clean, fine to medium grained, well sorted, pyritic, quartzose sandstone becoming coarse grained over the basal thirty feet. Matrix is siliceous mainly with occasional traces of argillaceous flakes and inclusions. Very minor dark grey phosphatic siltstone occurs in the middle of the penetrated section and dark oolites of phosphate range throughout.

Horn Valley Siltstone 160' - 347' thickness 187'

Age: Ordovician

Unit is mainly dark grey to black, fossiliferous, calcareous, pyritic, laminated siltstone interbedded with minor shale, similar to the siltstone, and grey to white, silty, dense, finely crystalline limestone. Very minor white to grey, fine to very fine, slightly argillaceous, pyritic and phosphatic sandstone occurs at the top of the formation and may be cavings or a transitional element.

Pacoota Sandstone 347' - 1273' thickness 926'

Age: Ordovician extending to topmost Cambrian

Upper Pacoota 347' - 1075' thickness 728'

Mainly white to grey, fine to medium grained, well sorted, clean, porous, siliceous, quartzose sandstone with minor interbeds of dark grey to black pyritic, micaceous, silty shale. Below 885', the shale becomes brown and green and is equal in quantity to the sandstone which also has brown beds. The unit is slightly phosphatic to 510' showes traces

of brown residual hydrocarbon on grains to 900' and has glauconite zones 365' - 390' and 775' - 835'.

Lower Pacoota 1075' - 1273' thickness 198'

Almost entirely white, minor brown, fine grained, well sorted, clean quartzose sandstone. Cement is dominantly siliceous but traces of argillaceous material and red calcareous stains are apparent. Brown residual hydrocarbon occurs on grains below 1210'. The unit stands out on the Gamma log as a uniform sand, the curves variation not exceeding 20 A.P.I. units.

Goyder Formation 1273' - 1955' thickness 682'

Age: Cambrian

Predominantly white to grey, fine to coarse grained, medium sorted, slightly argillaceous, calcareous sandstone, faintly glauconitic and pyritic in places. Minor interbeds of dark grey very micaceous, slightly pyritic, calcareous siltstone and shale occur throughout the formation and below 1430', beds of white, grey and brown, dense, finely crystalline, silty dolomite are prevalent.

Cleland Sandstone 1955' - 4754' thickness 2799'

Age: Cambrian

Five units are recognised in this interval which is an intermediary stage in the change from the central Amadeus Hugh River Shale facies to the western Cleland Sandstone variant.

Petermann Sandstone 1955' - 2744' thickness 789'

This unit comprises brown, lesser white, slightly dolomitic, micaceous and glauconitic sandstone in considerable excess of brown to minor green, micaceous siltstone. Sandstone is medium to coarse grained, poor to medium sorted to 2080' but below this is very fine to medium grained and medium to well sorted. The siltstone is platy and grades to shale. The unit is distinguished from the Goyder by the absence of carbonate beds, the appearance of brown and green siltstone, a slight decrease in resistivity and velocity and better spacing on FoRxo log.

Deception Member 2744' - 3294' thickness 550'

Lithologically similar to Petermann above, but sandstone in smaller excess of shale/siltstone and tending to grade to siltstone. Sandstone is more argillaceous than above and quartz grains are characteristically frosted and are often brown or coated with brown material, probably limonite. The unit is only poorly demarcated from the Petermann by the change in sand/shale ratio, as mentioned, and by a slight negative shift in the S.P. curve and an overall decrease in FoRxo log spacing.

Illara Sandstone 3294' - 3945' thickness 651'

Similar lithologically to the Deception unit above but showing a sand: shale ratio and log characteristics as for the Petermann. Sandstone is generally cleaner and more porous than in the Petermann. Slight scattered fluorescence was noted in the interval 3294' - 3650' and black residual hydrocarbon occurred at 3570' - 3580' and 3670' - 3690'. The top of the Illara sand is defined on the logs by a sharp 20 millivolt increase in the S.P. curve and by a sudden increase in mudcake buildup on the Caliper scale.

Tempe Member 3945' - 4685' thickness 740'

Essentially a shale-siltstone unit divisible on the logs and in the samples into two sections. The upper section 3945' - 4350' is characterised by grey to green dolomitic micaceous siltstone and shale with well developed beds of brown grey and white, glauconitic sandstone as above. Below 4350' sandstone is absent and red brown, minor green, very micaceous, dolomitic siltstone and shale occur with prominant bands of white (mainly) grey, brown and black, dense, fine dolomite below 4480'. While the upper Tempe shows log patterns in line with the monotonous featureless oscillations of the Petermann, Deception and Illara, the lower Tempe is readily marked by "dead" zones on the Gamma-Acoustic, S.P. and FoRxo curves.

Eninta Sandstone 4685' - 4754' thickness 69'

Red brown, micaceous siltstone in excess of white, grey and

pink, very fine to medium grained, poorly sorted, dolomitic sandstone. Sandstone is characterised by black, residual hydrocarbon on quartz grains at the top of the unit. Formation shows good separation on FoRxo log but there is no indication of mud cake buildup. There is an appreciable contrast with the lower Tempe due to reversion to sand in the cuttings and by a "dead" zone on the resistivity curve.

Areyonga Formation 4754' - 4970' thickness 216'

Age: Upper Proterozoic

Red brown, green and grey, dolomitic siltstone and shale, lesser grey, white and brown silty dolomite and light grey to black, slightly asphaltic, dolomitic, cherty sandstone, the last very prominant at the top of the formation but absent below 4840'. The top of the formation was placed at a drilling break when the bit passed into weathered, cherty sandstone apparently below an unconformity.

Bitter Springs Limestone 4970' - 6344' thickness 1374'+

Age: Upper Proterozoic

Principally white, pink, grey and brown, dense finely crystalline, sometimes silty dolomite with varying amounts of gypsum and brown, red and green chert. White to grey, very fine to rarely coarse grained, well sorted, asphaltic, sandstone occurs in minor quantity over the extreme top and bottom of the penetrated section. Red brown to purple/brown micaceous, siltstone grading to shale is prominant throughout and grey-green shale and siltstone are common at top of interval, forming an entirely clastic bed from 5078' to at least 5190'. This bed was seen to be brittle, highly fractured and broken in a core and it shed abundant cavings to subsequent cuttings as proven by a check against a core and Welex logs. The top of the formation is readily selected at the change to a persistently high percentage of dolomite in the samples and at the very marked shoulders on the Gamma-Acoustic log.

STRUCTURE

East Johnny's Creek No. 1 was drilled on a long eastern tail of the surface defined Johnny's Creek Anticline whose culmination lies ten miles to the west. On the East Johnny Creek structure, closure to the north, east and south, is demonstrated by dips of 13, 3 and 10 degrees respectively, but to the west it has been calculated(by Magellan Petroleum) that closure at a gentle saddle is of the order of 260 feet.

Johnny's Creek lies to the south of an anticlinal hinge line which extends from the Gardner Range in the west, through the James Ranges structures then eastward through the Mt. Burrell anticlinorium to the Hale River Metamorphic 'inlier'. North of this line the Amadeus Basin shows considerable downwarp of strata, a thick fill of Pertnjara Formation, gentle fold elements and fair conformity between formations. In contrast, the area to the south of this alignment is characterised by faulting, major unconformities and hiati, and appreciable post-depositional folding. Over this latter block the Gardner Range, Parana Hill and Petermann Creek anticlines show Pertaoorrta resting with marked angular unconformity on truncated Proterozoic units indicating considerable uplift and erosion prior to deposition of the Pertaoorrta. Varying amounts of Eninta Sandstone are missing due to onlap, particularly where the more resistant Bitter Springs had formed highs in the pre-Pertaoorrta erosion surface. Subsequent uplift of the Palaeozoic strata produced typical 'bald headed' anticlinal features. The East Johnny's Creek structure proved to be 'bald headed' to the extent of uppermost Eninta overlying basal Areyonga.

RELEVANCE TO OCCURRENCE OF PETROLEUM

Petroliferous odours were noted while drilling the Horn Valley Siltstone, the upper 250 feet of the Illara Sandstone and the Lower Tempe. There was no ignition of hydrocarbons at the blooey line in either case but some Illara samples produced positive indications of gas when

passed through the blender.

Brown residual hydrocarbon traces were noted as interstitial material throughout the Upper Pacoota and in the interval 1210' - 1320' which includes the basal Pacoota and uppermost Goyder. In addition traces of black residual hydrocarbon were observed in the lower Deception, throughout the Illara, in the upper Tempe, the Eninta and in sandstone at the top of the Bitter Springs. Black asphaltic material occurred abundantly in sandstone in the top of the Areyonga.

Traces of golden fluorescence were recorded in the Horn Valley, the top hundred feet of the Pacoota and the basal 120 feet of the Goyder. Very slight traces were noted in the upper 300 feet of the Petermann, the lower Deception, the upper Illara, the basal 200 feet of Tempe, the lower Areyonga and the Bitter Springs. In the last three instances yellow fluorescence was associated with blue in carbonate beds and both may have been mineralline. Only in the Pacoota and the Illara did residual hydrocarbon show fluorescence.

POROSITY AND PERMEABILITY OF SEDIMENTS PENETRATED

Several zones of observed porosity were recorded from the cuttings and a number of minor aquifers were encountered. Some increases in water output coincided with recorded porosity.

Water was first encountered in the sand at the base of the Stairway and the flow increased gradually through several sands in the Upper Pacoota and in the upper half of the Goyder. Porous sands in the Petermann, uppermost Deception and Illara, also yielded water. Clean looking sands in the interval 3520' - 3665' in the Illara had a petroliferous odour but produced 2420 feet of fresh water upon drill stem testing.

The Deception and Tempe were found to be tight generally but the upper parts of both members are more porous than their lower sections. Through the upper Tempe there was a sharp increase in the salinity of the water produced but no noticeable increase in flow indicating the presence of unflushed, low permeability aquifers.

The Eninta and Areyonga were characteristically tight throughout,but in the Bitter Springs, vuggy porosity in dolomite, some intergranular porosity in sands and beds of fractured shales were observed. Below 5350' the dolomite became more vuggy and this coincided with an increase in water yield below 5340' and sections of mudcake buildup indicated on the Caliper log between 5370' and 5750'. No porosity or water flow could be related to fracturing though the highly fractured shale in Core No. 6 (5091' - 5113') was very absorptive and showed a ready tendency to slake and cave. Porosity was recorded in the sands at the top of the Bitter Springs but these proved to be tight when drill stem tested.