

SECTION 2 - GEOLOGICAL DATA2.1 Geological Summary

McManus-1 was designed as an exploration well to test for the presence of hydrocarbons in a large, thrust-fault related syncline in the Proterozoic Roper Group section (Figure 3) in EP 24. The well location lies along the northern margin of the gravity-and magnetically-inferred Beetaloo Sub-Basin and is approximately 50km south west of the Mallapunyah Fault.

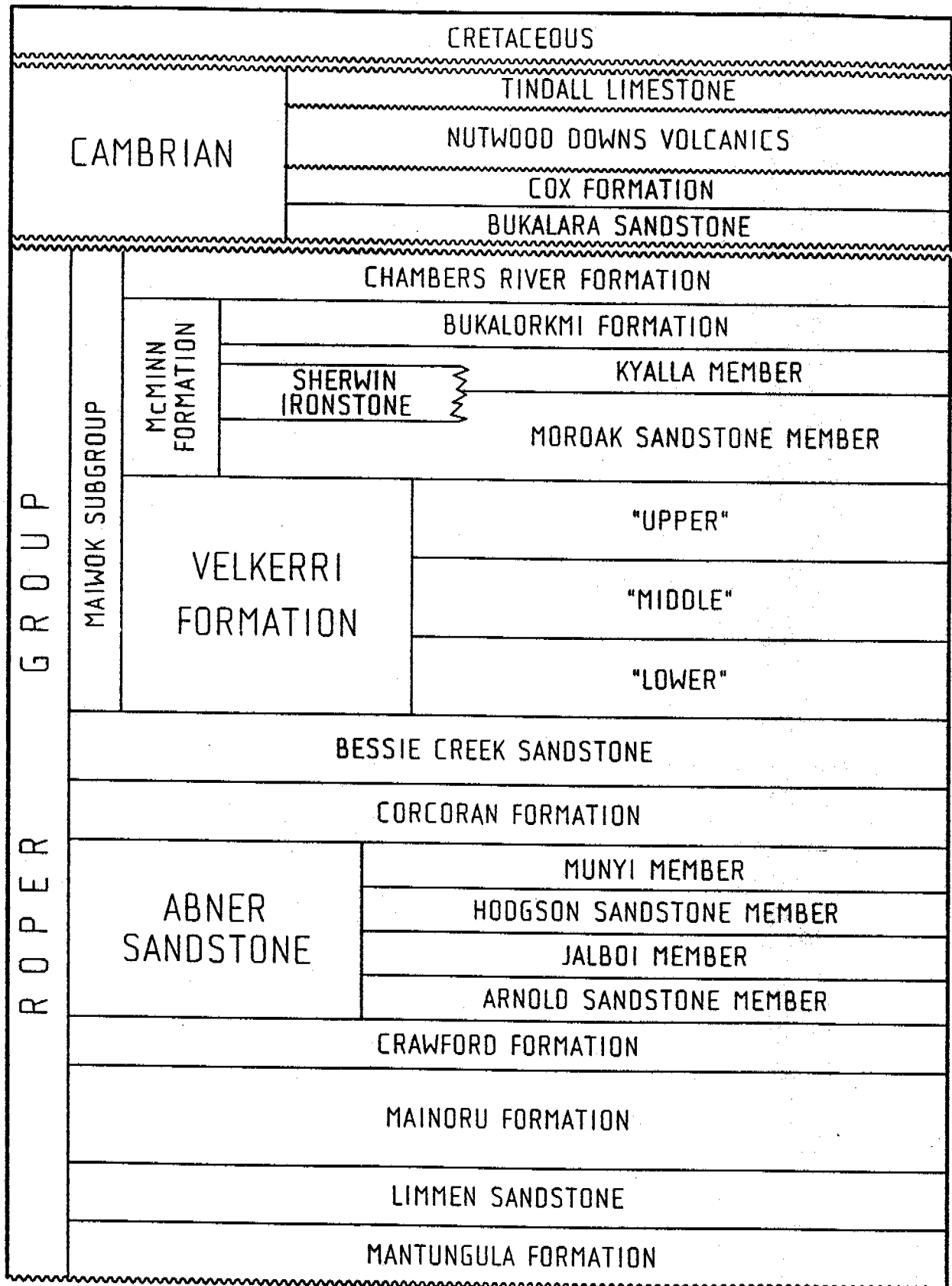
The well spudded in Cretaceous clays and silts that display a highly developed lateritic soil profile and become coarser toward the base, above an unconformity on the Cambrian Tindall Limestone at 12 metres (68 metres higher than prognosed, see Table 4). After penetrating basalt at 126 metres seven inch casing was set at 128.4 metres and drilling continued (with a six inch hammer) into the Nutwood Downs Volcanics, intersecting the Cox Formation at 264 metres. (A strong water flow was reported in the Daily Report at 227 metres, but was not recorded by the drilling crew).

Five inch casing was set at 270.8 metres and, after drilling out the casing shoe, massive and laminated siltstones, claystones and minor sandstones were drilled to 467 metres where the Cambrian Bukalara Sandstone was intersected. These sandstones pass unconformably down into siltstones and fine sandstones of the Proterozoic Kyalla Member (McMinn Formation), which was intersected at 553 metres. At about 668 metres the Moroak Sandstone Member (lowest unit of the McMinn Formation) was reached and passed gradually down into the Upper Velkerri Formation at around 738 metres. The Kyalla and Moroak Members featured several well sorted very fine-to medium-grained sandstone units with variable, but low porosities and trace hydrocarbon shows, especially around 730 metres.

Transition down into the Middle Velkerri is gradational, with the top picked at about 1200 metres. Deeper in the Middle Velkerri some thin igneous units were encountered and at 1549.7 metres the Lower Velkerri Formation was intersected, in which the hole was terminated at a total depth (T.D.) of 1617.25 metres.

Wireline logs were run from 271 metres to T.D. and a drill stem test (D.S.T.) was conducted from 1171.46 to 1319.95 metres.

# ROPER GROUP STRATIGRAPHY



PeNTcw241

Figure 3.

TABLE 4ACTUAL Vs PROGNOSED FORMATION TOPSMcMANUS-1

Age	Formation	Actual	Prognosed	Difference (m)	
Cretaceous	Undifferentiated	Surface	Surface	0	
	Cambrian				
	Tindall Limestone	12	80	68	high
	Nutwood Downs Volcanics	126	150	24	high
	Cox Formation	264	Not	-	
	Bukalara Sandstone	467	Not	-	
Proterozoic	Kyalla Member	553	Not	-	
	Moroak Sandstone Member	668	240	428	low
	Upper Velkerri Formation	738	400	338	low
	Middle Velkerri Formation	1199	650	549	low
	Lower Velkerri Formation	1550	950	600	low
	TOTAL DEPTH	1617	1400	217	low

## 2.2 Well Objectives and Performance

McManus-1 was designed as an exploration test to assess the hydrocarbon potential of sedimentary rocks along the northern margin of the Beetaloo Sub-Basin, defined as a broad gravity depression and interpreted to contain a thick section of Proterozoic Roper Group. Prior to the drilling of Atree-2, the nature of the sediments below the Cambrian unconformity at the base of the Nutwood Downs volcanics was unknown.

The results from Atree-2 indicated that the Beetaloo Sub-Basin gravity expression is a result of a thick Roper Group section below the Cambrian unconformity. In particular the intersection of the Moroak Sandstone (now believed to be the Cambrian Bukalara Sandstone), Velkerri Formation and Bessie Creek Sandstone indicated that the most prospective part of the Roper Group is within drillable depth in EP24 and contains excellent source potential and favourable reservoir potential.

The occurrence of oil shows throughout the Velkerri Formation indicated the unit was oil generative, adding to the potential of the area.

In light of the above, the results from both Atree-2 and Walton-2 were seen as very encouraging for exploration in EP24. McManus-1 has shown similarly encouraging results for source potential in the thickened Middle Velkerri Formation, with minor oil and gas bleeds over much of the interval.

Furthermore, by revealing the most complete Upper Roper Group interval in this area, McManus-1 has demonstrated the reservoir potential of the Moroak Sandstone Member, which exhibited moderate to high porosities and low to moderate permeabilities (see Table 5). Thin sands with similar properties were also present in the Kyalla Member.

As well as showing the thickest and most complete uppermost Roper Group section in the region, McManus-1 also intersected 200 metres of Cox Formation above the Bukalara Sandstone. This unit had not been encountered previously in drilling in this area and thus, was not anticipated.

## 2.3 Stratigraphy

### Undifferentiated Cretaceous:

Surface to 12 metres (12 metres thick).

Laterite/claystone, red brown to light orange brown with coarse siltstone grains. Grading downwards to light orange brown, slightly sandy siltstone. (Mullaman Beds?)

### Tindall Limestone:

12 - 126 metres (114 metres thick).

Limestone with intervals of siltstone. Limestones are light greyish white/orange to olive grey-brown in colour, cryptocrystalline to very finely sucrosic and vuggy with occasionally silty matrix.

Nutwood Downs Volcanics:

126 - 264 metres (138 metres thick).

Basalt, dark brown to black, hard to very hard with traces of quartz, feldspar, ferromagnesian minerals, chlorite and pyrite.

Cox Formation

264 - 467.3 metres (203.3 metres thick).

Claystone and siltstone, mostly olive green to greenish grey with common (but variable) reddish brown intervals and occasional interbeds of fine to very fine, light grey to light brownish red sandstone.

Bukalara Sandstone

467.3 - 552.9 metres (85.6 metres thick).

Sandstone, medium grey to white, medium to very fine grained, occasionally coarse, subangular to subrounded, moderately to well sorted, mostly poorly bedded, with light green clayey platelets and disrupted laminae occasionally defining bedding.

Traces of dead hydrocarbons (staining) from 505.85 to 513.90 metres.

Kyalla Member, McMinn Formation

552.9 - 668 metres (115.1 metres thick).

Interbedded siltstones and fine sandstones, with minor claystone. Colours range from pale grey (sandstones) through to dark grey/black (claystones). Sandstones commonly show scoured bases and fine upward to siltstones and claystones, varying between regularly interbedded couplets and flaser-like stratification. Characteristic dewatering structures more common in the lower half and sandstone becomes less common with depth.

Moroak Sandstone, McMinn Formation

668 - 738.2 metres (70.2 metres thick).

Light grey fine to very fine grained sandstone with minor intervals and interbeds of dark grey siltstone in upward coarsening packages. Sandstone is mostly massive to cross-bedded, but stratification is dominantly planar bedding/lamination when siltstone is present, with common dewatering structures. Patchy oil bleeds and fluorescence from 727.9 to 738.2 metres.

Upper Velkerri Formation

738.2 - 1199 metres (460.8 metres thick).

Laminated to thinly bedded, medium to dark grey (and occasionally light grey) siltstone, poorly to well-defined interbedding/lamination with dark grey to black claystone, which increases in abundance with depth. Dewatering and loading structures and disturbed bedding are common at the top, but decrease with depth as average grain size decreases and laminations become more regular. Organic content (black colouration) begins to increase noticeably in bands below about 1100 metres, becoming dominant at the base.

Below about 790 metres patchy fluorescence and very minor oil shows become more common with depth and towards base gas and light oil emanate from siltstone laminae.

Middle Velkerri Formation

1199 - 1549.7 metres (350.7 metres thick).

Massive to weakly defined, finely laminated mudstone/claystone, occasionally grading to siltstone and very fine sandstone. Mostly black to very dark grey, but coarser units tend to be lighter olive to brownish grey. Pyrite nodules and carbonate veinlets locally common.

Very minor oil bleeds and gas shows occur patchily throughout.

Lower Velkerri Formation

1549.7 - 1617.25 metres (67.6 metres thick).

Massive to chaotically mixed silty claystone, grading locally to siltstone. Distinctive light green/blue grey colour with randomly oriented carbonaceous flecks throughout, frequently alternating with medium dark grey intervals. Towards base get siltstone and very fine sandstone, displaying soft sediment deformation and dewatering structures, at the base of upward fining packages.

No shows recorded.

2.4 Mud Logging

Mud logging services were provided by Exlog Pty. Ltd. Rate of penetration, total gas detection, gas chromatograph, pump stroke counter, fluorescence and H<sub>2</sub>S detection services were provided, as well as lag monitoring and the preparation of a continuous mud log at a scale of 1:500. A copy of the mud log is included in this report as Enclosure 1. Mud logging personnel assisted Pacific Oil and Gas staff in the handling, marking and description of core.

2.5 Wireline Logging

A summary of downhole wireline logs run by Century Geophysical Pty Ltd. is shown in Table 5.

TABLE 5  
WIRELINE LOGS  
McMANUS-1

Log	Run	Interval (m)	Date
<u>Suite 1</u>			
Gamma, S.P	1	266.9 - 1617.4	14/11/89
Gamma, Caliper, Density	2	262.5 - 1616.3	14/11/89
Compensated Neutron	4	254.9 - 1616.4	14/11/89
Sonic	4	220.4 - 1547.2	14/11/89
Deep Guard Resistivity	5	254.9 - 1616.4	14/11/89
Magnetic Susceptibility	6	260.0 - 825.0	14/11/89
Short Guard Resistivity	7	268.5 - 1322.9	15/11/89
Dipmeter	-	tool failed	

Copies of well logs are included with this report as Enclosures, Nos. 5 - 11. A bottom hole temperature of 77°C was recorded at 1617.25 metres.

A 23 level velocity survey was conducted by Velocity Data, with the results being processed by Velseis Pty. Ltd. The velocity survey report is included in this report as Enclosure 4.

## 2.6 Formation Sampling

### 2.6.1 Ditch Cuttings:

Rotary drill cuttings from McManus-1 were collected at three metre intervals from the surface to 84.0 metres where the precollar terminated. Hammer drill-cuttings were recovered to 272 metres where five inch casing was run.

A washed sample of all cuttings was described and a portion submitted to the Northern Territory Department of Mines and Energy.

### 2.6.2 Slimhole Core:

McManus-1 was fully cored from the five inch casing shoe at 272 metres to the well's total depth, 1617.25 metres. The core was logged and chip samples taken at two metre intervals for microscopic examination. A detailed description of the core is given in Appendix 5.

The core from McManus-1 is stored at the CRA Exploration Pty Ltd yard in Darwin.

## 2.7 Hydrocarbon Shows

Details of hydrocarbon shows are listed in the core description (Appendix 5) and summarized as follows:

### Bukalara Sandstone

505-85 - 513.9 metres

Dead hydrocarbon, including brown staining. No fluorescence.

### Moroak Sandstone

727.9 - 738.2 metres

Patchy oil stains and yellow fluorescence with occasional bleeds and strong hydrocarbon odour.

### Upper Velkerri Formation

790 -831.4 metres

Patchy yellow to white fluorescence, bluish white streaming crush-cut, faint hydrocarbon odour, minor oil bleeds and exsolving of gas from core.

834.7 - 1097 metres

Minor scattered pin-point oil bleeds, patchy yellow fluorescence and minor stains.

1097 - 1172 metres

Minor oil bleeds, milky, light green light oil on core surface, immediate streaming cut, blue-white fluorescence, strong odour, some exsolving gas.

1172 - 1199 metres

Strong hydrocarbon odour, relatively abundant gas liberated from core.

### Middle Velkerri Formation

1199 - 1319 metres

Hydrocarbon odour and gas exsolving from core; both common at top, but decreasing with depth. Minor oil bleeds, especially associated with igneous units.

1374 - 1500 metres

Scattered minor gas bubbling from core throughout; very rare, minor oil bleeds as well below 1444 metres.



## 2.8 Source Rock Geochemistry

A total of 30 core samples from McManus-1 were collected from selected potential source units throughout the McMinn and Velkerri Formations and subjected to Total Organic Carbon (TOC) and Rock-Eval pyrolysis analyses. The results are included as Appendix 6.

## 2.9 Core Analysis

Twenty five core plugs were analysed from the McMinn and Velkerri Formations in McManus-1. Analysis was conducted for permeability, helium-injected porosity, residual oil and water saturation, and grain density. The results of these analyses are given in Table 6.

## 2.10 Magnetic Susceptibility

Magnetic susceptibility measurements were made at one metre intervals along the entire length of core recovered from McManus-1 using a hand held meter. The resulting magnetic susceptibility log is included as Enclosure 2 and the downhole equivalent recorded by Century Geophysical is included as Enclosure 10..

## 2.11 Contributions to Geological Knowledge

McManus-1 has added significantly to our knowledge of the Beetaloo Sub-Basin in EP 24, as well as having wider implications for extension of Roper Group sediments south beneath the Georgina Basin.

The expanded section of Upper Roper Group beneath the Proterozoic/Cambrian unconformity proved to have the potential reservoir and source units anticipated before drilling, with minor shows throughout much of the prospective section and some of the best reservoir results yet obtained.

Also, this well was of great interest above the Proterozoic/Cambrian unconformity because of the thick intersection of Cox Formation (not previously seen by Pacific in the subsurface) which may have seal potential for the very promising reservoir results obtained from the underlying Bukalara Sandstone.

The Walton-2 and McManus-1 wells were also very important in providing a better understanding of the stratigraphy of this region. Post-drill evaluation of the results resolved some problems with recognition of stratigraphic units. Foremost of these was the re-interpretation of the "Moroak Sandstone" in Atree-2 as the Cambrian Bukalara Sandstone, which is now interpreted to unconformably overlie the Upper Velkerri Formation, from which over 100 metres of section is thought to have been eroded.

TABLE 5

MCMANUS 1

Project: MCARTHUR

TENEMENT: EP24

Depth Range: 550.00 to 1300.00 metres

CORE ANALYSIS DATA

Sample Number	Mid Point	AMBIENT						OVERBURDEN						Pressure	Por Sum (%)	Oil Sum (%)	Wat Sum (%)	Report Number
		Por (%)	Horiz Perm (md)	Vert Perm (md)	Bulk Den g/cc	Gr Den g/cc	Bulk Volume (cc)	Por (%)	Horiz Perm (md)	Vert Perm (md)	Bulk Den g/cc	Gr Den g/cc	Bulk Volume (cc)					
1369220	576.60	10.4	1.10			2.79	10.2	0.700					1160 PSI				303893	
1369221	586.50	8.9	0.33			2.78											303893	
1369224	632.60	5.6	0.18			2.73											303893	
1369225	661.00	14.4	0.02			2.70	13.9	0.010					1160 PSI				303893	
1369227	670.10	12.9	55.00			2.66	12.6	44.0					1160 PSI				303893	
1367750	670.60	6.4	1.660			2.66									10.8	0.0	303990	
1369228	676.00	16.9	0.97			2.67	16.4	0.080					1160 PSI				303893	
1367749	680.40	13.4	0.190			2.65									1.0	6.5	303990	
1369229	698.00	7.7	0.25			2.71											303893	
1369230	700.00	17.1	4.80			2.66	16.7	4.100					1160 PSI				303893	
1369231	702.00	15.0	2.30			2.68											303893	
1369232	715.50	6.1	0.01			2.75	5.8	0.010					1160 PSI				303893	
1367735	722.80	6.2	0.007			2.76									13.1	0.0	303990	
1369246	724.00	11.3	0.32			2.70	10.8	0.280					1160 PSI				303893	
1367734	725.40	13.2	0.100			2.66									3.4	4.9	303990	
1367733	727.80	8.8	0.244			2.64									5.1	0.0	303990	
1367732	729.80	13.8	0.310			2.63									1.0	4.9	303990	
1367723	730.50	18.5	3.260			2.66									17.2	36.3	303990	
1369247	736.00	12.7	0.38			2.67	11.4	0.070					1160 PSI				303893	
1367730	738.00	12.3	0.100			2.70									16.5	0.0	303990	
1367725	1181.80	1.2	3.340			2.54									19.0	49.0	303992	
1367726	1220.90	1.4	0.115			2.48									6.4	33.6	303992	
1367727	1255.10	0.9	0.004			2.44									22.8	0.0	303992	
1367728	1273.00	0.8	0.008			2.46									10.7	52.1	303992	
1367729	1294.10	0.6	0.021			2.49									38.0	18.0	303992	

Number of samples reported: 25

Keywords

Petroleum, Proterozoic, Drill Stratigraphic, Hydrocarbon Potential.

Location

McManus-1, Maryfield 1:100,000 Map Sheet, EP24, McArthur Basin, Northern Territory.

List of DFO's

48228, 48240, 48241, 48246