

SECTION 2 - GEOLOGICAL DATA

Given the engineering problems encountered in Borrowdale-1 the following discussion is concerned only with Borrowdale-2.

2.1 Geological Summary

Borrowdale-2 was designed to test the hydrocarbon potential of the upper Roper Group along a north-north westerly trending faulted anticlinal structure. In addition to surface mapping, the prospect was detailed with two seismic lines (88-200 and 88-201) from the 1988 Roper Valley Seismic Survey. Interpreted copies of these lines are included in this report as Enclosures 1 and 2. The primary reservoir target was the Bessie Creek Sandstone which was prognosed to be intersected at approximately 550-600 metres below ground level.

The well spudded in sediments of the Upper Velkerri Formation of the Proterozoic upper Roper Group and intersected the Middle Velkerri Formation and the Lower Velkerri Formation at 46.5 and 226.7 metres respectively. At this point the formations intersected were approximately 100 metres high to prognosis. Below the Velkerri Formation the well intersected a dolerite sill at 434.5 metres which was similar to that present in other parts of the Roper Group. The primary target, the Bessie Creek Sandstone, was intersected below the sill at 526.47 metres and had fair shows over the interval 526.47 - 547.00 metres. The hydrocarbon shows comprised 20-70% whitish blue fluorescence with a pale blue streaming crush cut. An increase in total gas readings from a background of 3 units to a total of 14 units was also observed. Following evaluation of the shows a conventional bottom hole drill stem test (DST#1) was conducted over the interval 519.84 - 547 metres and recovered 360 metres of water which was muddy at the top. Subsequent core analysis has confirmed that the oil observed is most likely immovable. Details regarding DST#1 can be found in section 1.10 and Appendix 5. Core analysis results are given in Section 2.8.

Following the drill stem test, a suite of wireline logs was run and the hole drilled on to intersect the Corcoran Formation at 587.50 metres, approximately 27 metres low to prognosis. The hole reached a total depth of 614.9 metres in the Corcoran Formation with no further shows being recorded. A second suite of wireline logs was run and the hole abandoned with the setting of cement plugs over the intervals 530 - 495 metres, 87 - 57 metres and 30 metres to surface.

TABLE 3

ACTUAL Vs PROGNOSED FORMATION TOPSBORROWDALE-2

AGE	FORMATION	ACTUAL DEPTH DEPTH (M)	PROGN. DEPTH (M)	DIFF. (M)
Proterozoic	Moroak Sandstone		Surface	
	Upper Velkerri Fm	Surface	20	20 high
	Middle Velkerri Fm	46.5	170	123 high
	Lower Velkerri Fm	226.70	305	78.3 high
	Dolerite Sill	434.5	Not prog.	
	Bessie Creek Sst	526.47	515	11.47 low
	Corcoran Fm	587.50	560	27.56 low

2.2 Well Objectives and Performance

Borrowdale-2 was drilled to test the hydrocarbon potential of the Bessie Creek Sandstone at the culmination of a north - northwesterly trending faulted anticline. In addition the well was to provide valuable subsurface stratigraphic control for the upper part of the Proterozoic Roper Group.

The well intersected the siltstones and claystones of the Velkerri Formation approximately 100 metres high to prognosis. Below the Velkerri Formation, Borrowdale-2 encountered a dolerite sill, similar to those encountered elsewhere in the McArthur Basin. Below the sill, the Bessie Creek Sandstone was intersected only 11.5 metres low to prognosis and was found to contain hydrocarbons over the upper 21 metres. Subsequent drillstem tests only recovered formation water; later core analysis indicates the oil to be immovable.

While the shows in the Bessie Creek Sandstone are encouraging, the nature of the hydrocarbons intersected may indicate that the structure has been breached. Recently interpreted seismic over the structure indicates a large amount of crestal faulting which may invalidate the structural integrity of the prospect. Nevertheless the well did contribute greatly to our understanding of the hydrocarbon potential of the upper Roper Group of the McArthur Basin.

2.3 Stratigraphy

The stratigraphic nomenclature used in the following discussion is that used by Pacific Oil & Gas Pty. Limited.

PROTEROZOIC

Upper Velkerri Formation

Surface to 46.5 metres (46.5 metres thick).

Light greenish grey siltstone and claystone, interbedded with occasional dark grey carbonaceous claystone laminae. Beds dip at between 20 to 30°. Unit becomes heavily faulted between 18.3m and 46m with abundant normal and reverse faults which dip at between 30 and 40°. Rocks become highly brecciated in several areas. No visible porosity.

Middle Velkerri Formation

46.5 metres to 226.7 metres (180.2 metres thick).

Brown to black claystone and siltstone with minor disseminated pyrite throughout. Occasional grey laminae in top 10 metres of unit. Constant dip of 25°. Unit is highly organic rich, with a strong hydrocarbon odour and associated high gas readings while drilling. Fracturing seen in the overlying unit becomes progressively less pronounced with depth.

Between 113.4m and 114.2 metres, there is a recrystallized dense dolostone, strongly fractured with fractures healed with calcite. Minor oil shows were noted in small vughs and along some small fractures. No visible porosity in remainder of unit.

Lower Velkerri Formation

226.7 metres to 434.5 metres (237.8 metres thick).

Unit grades from a light bluish grey to medium grey claystone at the top, through a light grey to dark grey siltstone and into a light grey to medium grey, fine to very fine grained silty sandstone at the base. Bedding is dominantly massive in the claystones and grades to thinly bedded to laminated in the sandstone. Minor oil shows were observed in the basal sandstones. However, porosity is generally absent. The lowermost metre of sandstone has been converted into a dark grey hornfels.

STRATIGRAPHY – ROPER GROUP


CHAMBERS RIVER FORMATION		COBANBIRINI FORMATION
McMINN FORMATION	KYALLA MEMBER  MOROAK SANDSTONE MEMBER	
VELKERRI FORMATION		
BESSIE CREEK SANDSTONE		LANSEN CREEK SHALE
CORCORAN FORMATION		
ABNER SANDSTONE	HODGSON/MUNYI SANDSTONE MBR.	
	JALBOI MEMBER	
	ARNOLD SANDSTONE MEMBER	
CRAWFORD FORMATION		
MAINORU FORMATION		
LIMMEN SANDSTONE		

Figure 3



Dolerite

434.5 metres to 526.47 metres (91.97 metres thick).

The dolerite is medium dark grey, fine grained and moderately fractured. Most of the fractures are closed but several contain live oil bleeds.

Bessie Creek Sandstone

526.47 metres to 587.56 metres (61.09 metres thick).

The Bessie Creek Sandstone is a light grey to medium light grey, fine to medium grained, well sorted to moderately well sorted, strongly cemented quartz sandstone. Numerous poor to fair oil shows were recorded in the upper parts of this sandstone (526.47m - 547m). Subsequent core analysis has revealed these shows to be immovable oil. Minor porosity is present within the oil zone with the remaining sandstone showing no visible porosity.

Corcoran Formation

587.56 metres to 614.9 metres total depth (in excess of 27.34 metres).

Siltstone medium grey to greyish black, thinly bedded to weakly laminated, minor graded bedding. No visible porosity.

2.4 Mud Logging

Mud logging services were provided by Gearhart Geodata Pty. Ltd. Rate of penetration, total gas detection, fluorescence and H₂S detection services were provided, as well as lag monitoring and the preparation of a continuous mud log at a scale of 1:100. A copy of the mud log is enclosed in this report as Enclosure 2. Mud logging personnel assisted Pacific Oil & Gas staff in the handling, marking and description of core.

2.5 Electric Logging and Other Services

The following down hole electric logs were run by BPB Instruments (Australia) Pty. Ltd.

TABLE 4

ELECTRIC LOGSBORROWDALE-2

LOG	Run	Interval (m)	DATE
<u>Suite 1</u>			
Spontaneous Potential	1	547-72.65	25/7/88
Dual focussed Resistivity	2	547-72.65	"
Gamma Ray, Density	3	547-72.65 Gr to surf	"
Caliper, Neutron Porosity	4	547-72.65	"
Dual Spaced Sonic	5	547-72.65	"
<u>Suite 2</u>			
Spontaneous Potential	1	614-540	27/7/88
Dual Focussed Resistivity	2	614-540	"
Gamma Ray, Density	3	614-540	28/7/88
Caliper, Neutron Porosity	4	614-540	"
Dual Spaced Sonic	5	614-540	"

Copies of all well logs are included with this report as Enclosure Nos. 3 - 5.

A 7 level Velocity Survey was conducted by Velocity Data Pty Ltd. An interpretation report by Velseis Pty Ltd is included as Enclosure 8.

2.6 Formation Sampling

2.6.1 Ditch Cuttings

Rotary drill cuttings were collected at 2 metre intervals from the surface to 10 metres. A washed sample was described and a portion submitted to the Northern Territory Department of Mines and Energy.

2.6.2 Conventional Core

Borrowdale-2 was fully cored from 10 metres to total depth, except for the interval 73.5 - 76.5 metres, which was drilled with a rotary bit to enable the running of a Formation Integrity Test. The core was logged and chip samples taken at 2 metre intervals for microscopic evaluation. A detailed description of the core is given in Appendix 4.

The core from Borrowdale-2 is stored at the CRA Exploration Pty. Limited yard in Darwin.

2.7 Hydrocarbon Shows

Fair hydrocarbon shows were recorded in the top of the Bessie Creek Sandstone over the interval 526.47 - 547.00 metres. The shows comprised 20-70% whitish blue fluorescence with a pale blue streaming crush cut. In addition, an increase in total gas to 14 units from a background of 3 units was also observed. Full details of the show are recorded in the Show Evaluation Report enclosed as Appendix 6.

2.8 Geochemistry

A total of five samples from Borrowdale 2 were sent to Gearhart core data Pty Ltd in South Australia for Geochemical analyses. The bulk composition and Alkane ratios of the oils were analysed. Samples were selected from the section 519.84 to 547.00m and the results of these analyses are given in Appendix 7.

2.9 Core Analysis

Eight core plugs were analysed from the Bessie Creek Sandstone in Borrowdale-2. Analyses were conducted for permeability, helium injected porosity, residual oil and water saturations and grain densities. The results of these analyses are given in Table 5.

TABLE 5

CORE ANALYSIS

BESSIE CREEK SANDSTONE

BORROWDALE-2

SAMPLE NO.	DEPTH METRES	PERMEABILITY MILLIDARCYS K.A.	POROSITY % HE INJ.	RESID. SAT. % PORE		GRAIN DENS.	SAMPLE DESCRIPTION AND REMARKS
				OIL	WATER		
1	527.40	0.036	3.8	6.3	45.3	2.64	Hor & vert fract. Micro fractures Hor & vert fract.
2	534.10	0.007	1.6	2.1	21.1	2.64	
9	536.72	0.001	1.2	26.7	13.3	2.62	
3	539.42	27	1.9	2.4	24.0	2.64	
4	542.09	0.006	2.2	5.3	53.6	2.65	
5	543.52	0.010	2.4	2.9	29.1	2.63	
6	544.72	0.006	2.5	1.3	52.7	2.65	
7	584.26	0.010	1.0	8.6	21.6	2.61	
8	585.35	0.021	2.9	6.7	33.7	2.65	

2.10 Magnetic Susceptibility

Magnetic Susceptibility measurements were made at 1 metre intervals along the entire length of core from Borrowdale-2. A magnetic susceptibility log is included as Enclosure 6.

2.11 Contributions to Geological Knowledge

While not being a commercial discovery Borrowdale-2 has contributed greatly to our understanding of the hydrocarbon potential of the upper Roper Group of the McArthur Basin. In particular it would appear that the Velkerri Formation is a mature source rock for oil generation and has in fact sourced the oil in the Bessie Creek Sandstone. It also appears likely that the presence of oil in the sandstones has gone some way in preserving the porosity and permeability of the sands from diagenesis.

It is thought that the main reason behind the failure of the well was that the anticlinal structure has been breached by later faulting. This appears particularly evident on the seismic that has been acquired over the well site (Enclosure 1.). In summary it appears likely that Borrowdale was not a valid test of four way dip closure.

Keywords

Proterozoic; Drill Stratigraphic; Geophys Borehole; Hydrocarbon Potential.

Location

Mais 1:100,000 Sheet 5667, EP5, Borrowdale 1, Borrowdale 2, McArthur Basin, Northern Territory.

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