UNDANDITA Nº1A

WELL COMPLETION REPORT

[redacted]

NORTHERN TERRITORY
GEOLOGICAL SURVEY

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UNDANDITA NOS. 1 and 1A

WELL COMPLETION REPORT

by

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PPL Report No. 94

1983

1. SUMMARY

1.1 Drilling

Undandita No. 1A, located approximately 235 kilometres west of Alice Springs in OP 178 of the Amadeus Basin, Northern Territory (Figure 1), was spudded on November 13, 1982 using Rockdril Rig 19. The well was drilled in Oil Permit 178 of the Northern Territory. Partners in the well included:-

Pancontinental Petroleum Limited (Operator)
Magellan Petroleum (N.T.) Pty. Limited (Permit Holder)
United Canso Oil & Gas Limited
International Oil Proprietary
Amadeus Oil N.L.
Apollo International Minerals N.L.
Farmout Drillers N.L.
C.D. Resources Pty. Ltd.
International Energy Development Corporation of Australia Pty. Limited.
Oilmin N.L.
Transoil N.L.
Petromin N.L.
Canada Southern Petroleum Ltd.

A 10" conductor hole was drilled to 21 metres and 8-7/8" conductor set and cemented. Drilling continued to 166 metres using at first 7-7/8" and later 7-3/8" roller bits, and 6-5/8" casing set and cemented at this depth. Diamond core drilling - 5-5/8" core bit with PQ drill rod - commenced from 166 metres. From about 182 metres, lost circulation became a problem. Despite use of LCM these problems worsened and 100% lost circulation occurred at 333 metres. At 364 metres, it was decided to attempt to cement off the lost circulation zone over the interval 331 - 346 metres, however, these attempts were unsuccessful, and coring continued to casing depth of 564 metres under 100% lost circulation conditions. A number of twist-offs occurred from 419 metres, and numerous fishing runs were required. Severe vibration problems occurred despite various repositioning of the stabilizers.

At 544 metres, 4.7" casing was run and cemented, however the casing would not hold pressure, and casing leaks were found at 296 and 301 metres. These were successfully squeezed off.

Coring 4.2" hole continued to 767 metres, where circulation was lost. LCM failed to seal the zone. Oil shows were encountered between 773 and 802 metres, but were not tested because of the lost circulation problems. Six cement jobs were run in an attempt to seal off the lost circulation zone, but while losses were reduced, the zone would not hold pressure. Coring then continued to TD of 1201 metres, with fluid losses fluctuating.

At 1201 metres, electric logs and a velocity survey were run. A cement plug was set from 799-840 metres, and two open-hole DST's attempted. DST results were inconclusive, so 4" casing was run and cemented, the casing perforated over the intervals 780-783 metres and 784-790 metres, and the well swabbed in. A total of 224 barrels was swabbed in 30-1/2 hours, producing mud, filtrate and formation water. The 4" casing was cut, 470 metres recovered, and the well then plugged and abandoned.

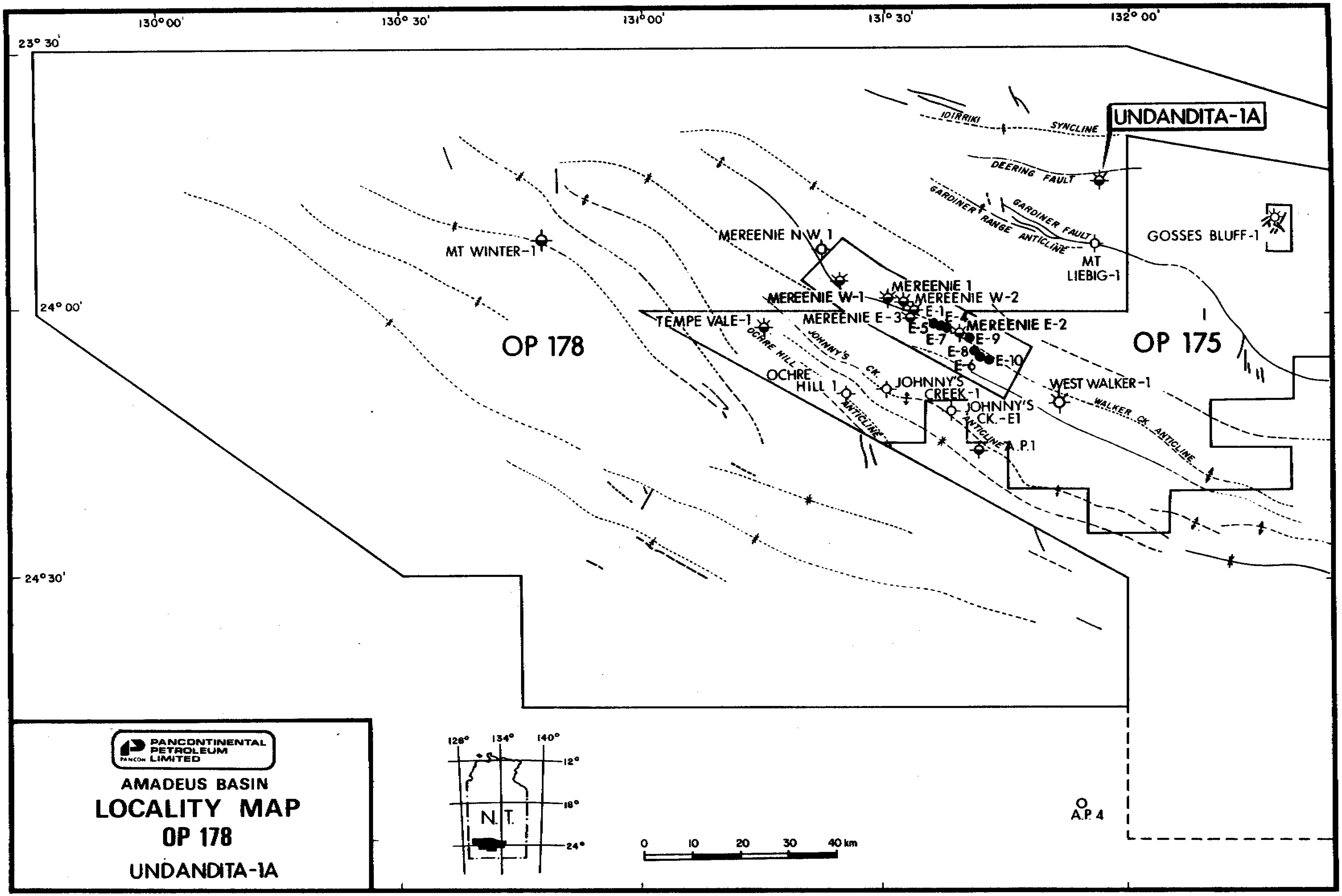
1.2 Geological

Undandita No. 1A was drilled to a total depth of 1201.25 metres KB (Driller) in late 1982 and early 1983. The well was drilled primarily to assess the hydrocarbon potential of the Pacoota Sandstone, and secondly the Stairway Sandstone, both predicted to be present in a faulted growth structure.

The stratigraphic succession in the upper part of the well was anticipated to be similar to the measured section MLW2, as mapped by the Bureau of Mineral Resources, 24 kilometres along strike from Undandita No. 1A (Wells et al., 1965). The stratigraphic succession in the lower part of the well was diffficult to predict accurately due to extensive faulting and structural thinning during Larapinta Group deposition (Bellis et al., 1982).

Undandita No. 1A penetrated 344 metres of Early to Middle Cambrian shales, siltstones, limestones and sandstones, above an evaporitic sequence of possible Early Cambrian age, which consisted of 428 metres of gypsum, anhydrite, dolomite and brecciated siltstone. Below the evaporitic sequence is 429 metres of steeply bedded calcareous sandstone, siltstone and dolomite, possibly of Late Cambrian age.

Significant hydrocarbon shows were encountered during drilling in the zone 774.75-802 metres, but these failed to produce hydrocarbons despite subsequent drill stem and production tests.



130° 00'
130° 30'
131° 00'
131° 30'
132° 00'
23° 30'
24° 00'
24° 30'
UNDANDITA-1A
IDIRRIKI SYNCLINE
DEERING FAULT
GARDINER RANGE ANTICLINE
GARDINER FAULT
GOSSES BLUFF-1
MT LIEBIG-1
MERENIE N.W. 1
MT WINTER-1
MEREENIE 1
MEREENIE W-1
MEREENIE W-2
MEREENIE E-3
E-1
E-4
E-5
MEREENIE E-2
E-7
E-9
E-8
E-10
E-6
TEMPE VALE-1
OCHRE HILL ANTICLINE
JOHNNY'S CK. ANTICLINE
OCHRE HILL 1
JOHNNY'S CREEK-1
JOHNNY'S CK.-E1
A.P.1
WEST WALKER-1
WALKER CK. ANTICLINE
OP 178
OP 175
A.P. 4
128°
134°
140°
12°
18°
24°
N.T.
0
10
20
30
40 km
PANCONTINENTAL PETROLEUM LIMITED
AMADEUS BASIN
LOCALITY MAP
OP 178
UNDANDITA-1A

FIGURE 1

2. INTRODUCTION

Undandita No. 1A was the second well drilled by Pancontinental Petroleum Limited in OP 178 of the Amadeus Basin, under a farmout agreement with the Permit Holder, Magellan Petroleum (N.T.) Pty. Limited.

The Undandita Prospect was located 235 kilometres west of Alice Springs in OP 178, Amadeus Basin, Northern Territory, Australia (Figure 1). The nearest well control is Tyler No. 1, 50 kilometres to the east and Mereenie No. 1, 45 kilometres to the southwest in the Mereenie Oil and Gas Field (Figure 1).

Undandita No. 1 was located at SP 285 on seismic line P82-U16. Near surface drilling problems caused the premature abandonment of this well at 165 metres and its relocation 60 metres south between shot points 287 and 288.

Undandita No. 1A was drilled to assess the hydrocarbon potential of the Cambro-Ordovician Pacoota Sandstone in a seismically defined faulted growth structure. A secondary objective was to assess the hydrocarbon potential of the Early Ordovician Stairway Sandstone.

3. WELL HISTORY

3.1 General Data

Well Name:	Undandita No. 1A
Operator:	Pancontinental Petroleum Limited, 11th Floor, 20 Bond Street, Sydney, N.S.W., 2000.
Tenement Holder:	Magellan Petroleum (N.T.) Pty. Limited, 8th Floor, 420 George Street, Brisbane, Qld., 4000.
Petroleum Tenement:	Oil Permit 178, Northern Territory.
District:	Mount Liebig.
Location:	131° 55' 58.3"E, 23° 42' 47.7"E
Water Supply:	Water bore drilled at site.
Elevations:	Ground Level 759 metres a.s.l. Kelly Bushing 761.5 metres a.s.l.
Total Depth:	1201.25 metres KB (Driller)
Well Spudded:	13.00 hours, November 13, 1982
T.D. Reached:	19.30 hours, January 17, 1983
Rig Released:	06.00 hours, February 1, 1983
Total Drilling Time:	66 days.
Spud to Rig Release:	81 days.
Well Status:	Plugged and Abandoned.

3.2 Drilling Plant

Drilling Contractor:	Rockdril Contractors Pty. Ltd., 1 Jijaws Street, Sumner Park, Qld., 4074.
Drilling Rig:	Rockdril Rig 19.
Make:	Longyear HD-600

Rated Depth:	1800 metres
Power:	Caterpillar 3306T Diesel engine (210 HP at 2000 RPM)
Mast:	Longyear 53'
Mast Capacity:	150,000 lbs.
Pumps:	1 5" x 6" Gardner Denver 2 Longyear 435 Bean Pumps
Rotary Power:	Retractable 14" Power Head Hydraulic 3 jaw chuck.
Drill Pipe:	800 m PQ rods (4-1/2" OD) 1800 m CHD101 rods (3.70" OD) 1800 m CHD76 rods (2.98" OD)
Well Control Equipment:	Annular preventor - Hydril Type 9K 6" rated at 3000 psi (Bore 7-1/16") BOP - Shaffer Double 6" (Bore 7-1/16") rated at 3000 psi, complete with the following ram assemblies: Blind, 2-7/8", 3-1/2", 4-1/2", 4-5/8", 3.7".

3.3 Drilling Data

3.3.1 Drilling Description

Undandita No. 1A was drilled following the premature abandonment of Undandita No. 1.

Undandita No. 1 was spudded at 1330 hours on October 10, 1982 using the Rockdril T-3 drilling rig. 9-5/8" hole was drilled to 16.5 metres and 8-5/8" casing set and cemented. 7-1/2" hole was then drilled with difficulty to 184 metres, using the following circulating fluids - air - mist, foam, aerated mud and mud. Complete loss of circulation, flowing sand and deviation problems caused the drilling string to become stuck four times for periods of three hours to eighteen hours. At a depth of 145 metres, attempts were made to straighten the hole, and in this attempt a new hole was drilled from 90 metres. Finally the well was deepened to 184 metres and 6-5/8" casing was run. This casing became stuck at 113 metres (370 ft) and freed after twenty-six hours.

Because of the difficulties experienced in keeping the well open, not being able to run the casing to bottom and problems encountered with the making up of the 6-5/8" casing threads, it was decided to abandon the hole and commence a new hole, Undandita No.1A, when the HD-600 drilling rig became available.

The HD-600 rig left Brisbane on November 6 and arrived on site on November 10. Spud-in of Undandita No. 1A was at 13.00 hours on November 13, 1982. Using spud mud, 7 inch hole was drilled to 21 metres, then opened to 10 inch hole and 8-7/8" conductor set and cemented. The cement was drilled out with a 7-7/8" roller bit, which drilled ahead to 152 metres. On pulling this bit, the other new 7-7/8" bits on location were found to be over gauge and would not run inside the 8-5/8" casing, so drilling continued to 166 metres with a 7-3/8" bit. At this depth, 6-5/8" casing was run and cemented. The Blow Out Preventers were then nippled up and pressure tested, and the cement drilled out with a 5-5/8" roller bit. Diamond core drilling with a 5-5/8" core bit and core barrel assembly commenced on November 20 at a depth of 166 metres. From about 182 metres, mud losses of about 6 barrels per hour were noted, and at 219 metres Loss Circulating Material (LCM) was circulated. While coring at 234 metres, a drive chain on the wireline winch broke, and the rig was shut down for 23 hours awaiting parts. Mud losses of 3-8 barrels an hour continued to 267 metres, where 85% lost circulation occurred and three slugs of LCM were spotted, reducing the fluid loss to just over 1 barrel per hour. At 333 metres, circulation was lost entirely. LCM plugs at first appeared to remedy the situation, but then plugged the pipe. On drilling ahead with a roller bit, circulation was again lost at 343 metres. LCM failed to control the loss. The roller bit became plugged and drilling with the 5-5/8" core bit continued under 100% lost circulation conditions. Further attempts to stop the loss with LCM failed, and the core barrel was plugged a number of times.

At 364 metres, it was decided to attempt to seal off the lost circulation zones with cement, and four separate cement plugs were set over the interval 331-346 metres. These attempts proved unsuccessful, and coring then continued under 100% lost circulation conditions. At a depth of 419 metres, the drill rod twisted off at 390 metres and 405 metres. Both fishes were recovered using a Bowen spear. At 440 metres, the inner core barrel became jammed and eventually had to be jarred free. On pulling out of the hole it was discovered that the drill rod had cracked at 375 metres, and that the centre sleeve of the core barrel had been left in the hole. Fishing runs, firstly with a spear, then with a rotary tap, recovered the outer core barrel, but left a 4" diameter steel ring in the hole. On running in with a magnet, a small section of the ring was recovered. The core barrel was then run in the hole, and the magnet run with the inner core barrel, without success. It was then decided to core ahead, and the remaining part of the fish was recovered with the core.

At 451 metres, a further pipe twist-off occurred, and was successfully fished with the Bowen spear. At this point the bottom 84 metres of drill rod was replaced with new pipe. At 480 metres, the pipe failed again (at 322 metres), but was not recovered with the Bowen spear. A bent pipe was then run with the spear and the fish was recovered. Two extra stabilizers were placed in the string before drilling ahead.

Coring continued to 544 metres, with very severe vibration problems despite various repositioning of the stabilizers. At this depth, electric logs were run and 4.7" casing run to bottom and cemented. After the BOP's were nippled up, the cement was drilled out to 545 metres and the casing tested. The casing did not hold pressure and a cement plug was then spotted on bottom. An RTTS tool was run in the hole and positioned a number of times before the casing leak was pinpointed at 295.5 metres. Two cement squeeze jobs were attempted and, after drilling out, appeared to hold pressure. On drilling through the cement at bottom to 547 metres, a leak-off test failed to hold pressure. Again using the RTTS tool, a further leak was detected at 301 metres. This was squeeze cemented, and the cement then cored out. The rig cored ahead with 4.2" hole to 614 metres, where a successful leak-off test to 500 psi was held. At about 641 metres, the mud was changed to a poly/brine system.

Coring 4.2" hole continued to 767 metres, where circulation was lost. Lost circulation material was pumped which at first appeared to seal, but on coring ahead the mud losses became worse. Oil shows were encountered in the section between 773 and 802 metres. At 803 metres, cement and LCM were pumped in an attempt to seal the loss.

From January 1 to 5, various attempts were made to seal off the lost circulation zone between 767 and 773 metres. A total of six cement jobs were attempted. In the last of these, cement was cored out from 733 to 775 metres, but again the zone would not hold pressure. It was then decided to core ahead under 100% lost circulation conditions, with losses of about 6 barrels per hour.

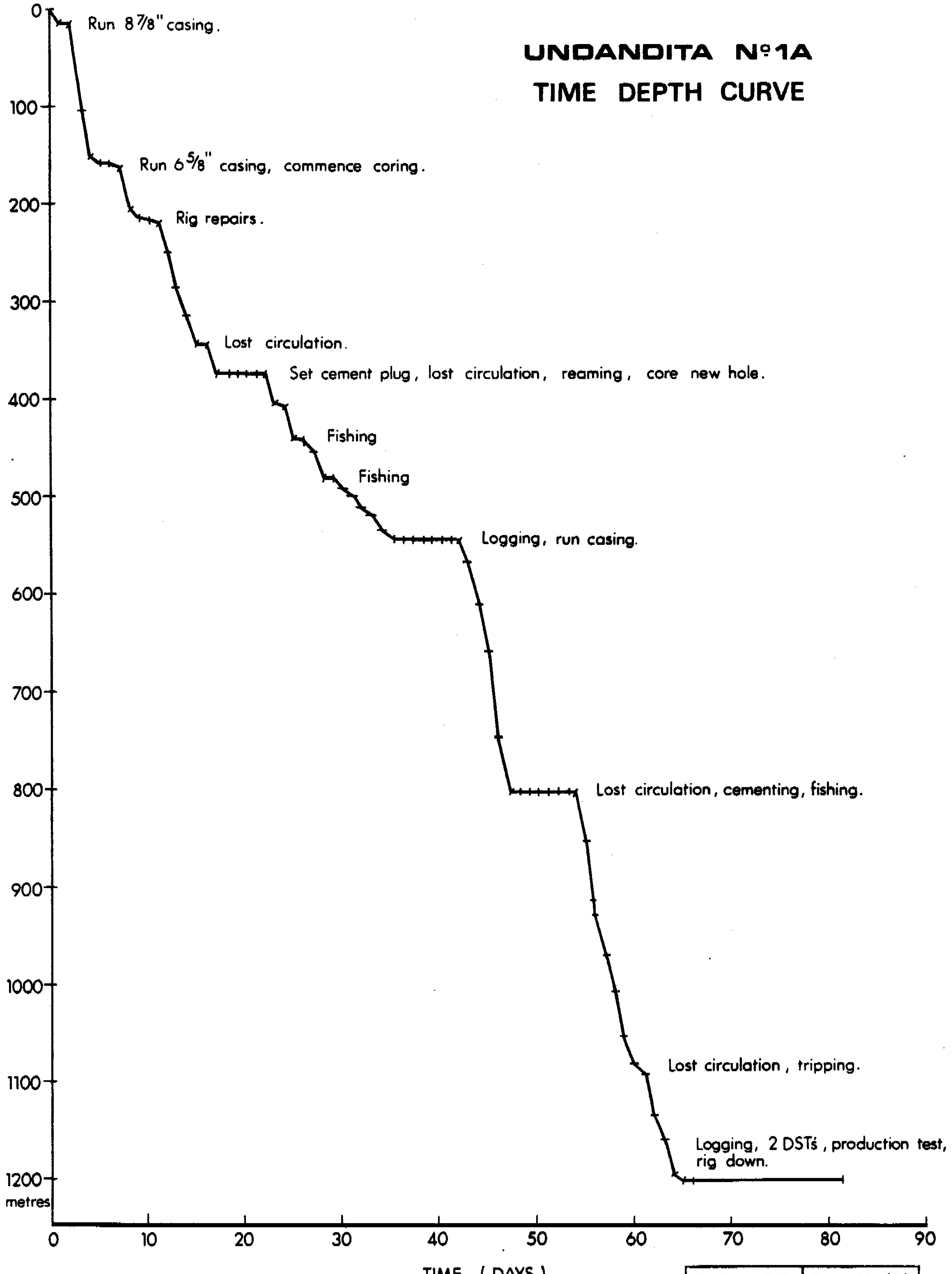
At 973 metres, the pipe became stuck following two deviation survey misruns, but was worked free. At 1056 metres mud losses increased from 6 to 18 barrels per hour, and an LCM pill was successful in temporarily reducing the losses. Further LCM pills were needed as drilling continued, and fluid loss continued to fluctuate. Harder formation with subsequent slower drilling was encountered from about 1082 metres, and a bit change was made at 1160 metres. A further bit change was required at 1194 metres, and the bit had to be reamed to bottom from 1160 metres.

At 1201 metres, electric logs were run, followed by a velocity survey. A cement plug was set (on the second attempt) from 799 metres to about 840 metres and DST No. 1 was then run over the interval 778-799 metres. This test failed because the tools became plugged, and the hydrospring was stuck open at the end of the test. Mud was pumped down the annulus and samples were taken of the initial fluid to surface.

DST No. 2 was run over the interval 779 to 799 metres and commenced with a strong blow, which decreased fairly quickly. The blow died after 39 minutes. Fluid was recovered 96 metres above the hydrospring, and the string was full of sand from 17 metres above the hydrospring. Field analyses indicated that the recoverable fluid was a mixture of mud, filtrate and make-up water. From the two DST's, it was determined that the reservoir was underpressured (1062 psig at 2616' - 797 metres). Because these tests had failed to produce reservoir fluids, it was decided to run 4" casing and to swab the well in through 2-3/8" tubing.

The cement plug was drilled out to 810 metres and the 4" casing set and cemented at 809 metres. Cement was tagged inside the casing at 808 metres. The casing was successfully pressure tested against the BOP pipe rams to 1680 psig. The 2-3/8" tubing was run to 772 metres, and completion fluid of 3 barrels diesel fuel and 30,000 ppm brine circulated into the hole. After some delays, caused both by having to transport a perforating unit from Adelaide and by problems in assembling the wireline lubricator, the 4" casing was perforated over the intervals 780-783 metres and 784-790 metres. For 30-1/2 hours the well was swabbed, producing a total of 224 barrels of fluid. From about 110 barrels, the fluid properties remained constant and this fluid was interpreted as being formation water. It was then decided to abandon the well.

The 2-3/8" tubing was pulled and explosives run in the hole to cut the casing. On the second attempt, 470 metres of 4" casing was recovered. Cement plugs were set and the well abandoned. A drilling time versus depth plot is shown in Figure 2.



Author : J. D. G.	Date : Nov '83
Drawn : D. J. P.	Figure : 2

3.3.2 Well Configuration

Hole Size	Depth	Casing & Cementing Details
10"	21m	Ran 18 metres of 8-7/8" casing. Cemented with 8 sacks Class A cement plus 1% $CaCl_2$. Recemented down annulus with 3 sacks Class A cement plus 8% $CaCl_2$.
7-7/8 -	166m	Ran 17 joints of 6-5/8" (28 lb/ft 7-3/8" Longyear "W" thread) casing to 165 metres. Cemented with 77 sacks Class A plus 1.5% $CaCl_2$. Good returns to surface.
5-5/8"	544m	Ran 74 joints of 4.7" casing (11 lb/ft, N-80, Longyear "W" thread) and 4 joints 5" casing (13 lb/ft N-80, Longyear "W" thread). Cemented as follows: 5 bbls water, 8 bbls Halliburton Flocheck, 37.8 bbls Econolite (12.8 lb/gal), 15.7 bbls Class A cement with 5% CFR-2 (14.5 ppg), displaced with 34 bbls water.
4.2"	1201m	Cement plug set at 794-840 metres (6 bbls Class A cement) then drilled out to 799m for DSTs 1 and 2. Further drilled out to 810 metres and then ran 809 metres of 4" casing (9.5 lb/ft, J-55, Atlas Bradford FL-4S thread). Cemented with 2.6 bbls of Class G cement plus 1% CFR-2 (slurry weight 14.5

ppg). Displaced with 1 bbl water and 31.2 bbls mud. After production test was completed, the 4" casing was cut and 470 metres recovered.

3.3.3 Abandonment Programme

The well was plugged and abandoned. Cement plug details are:

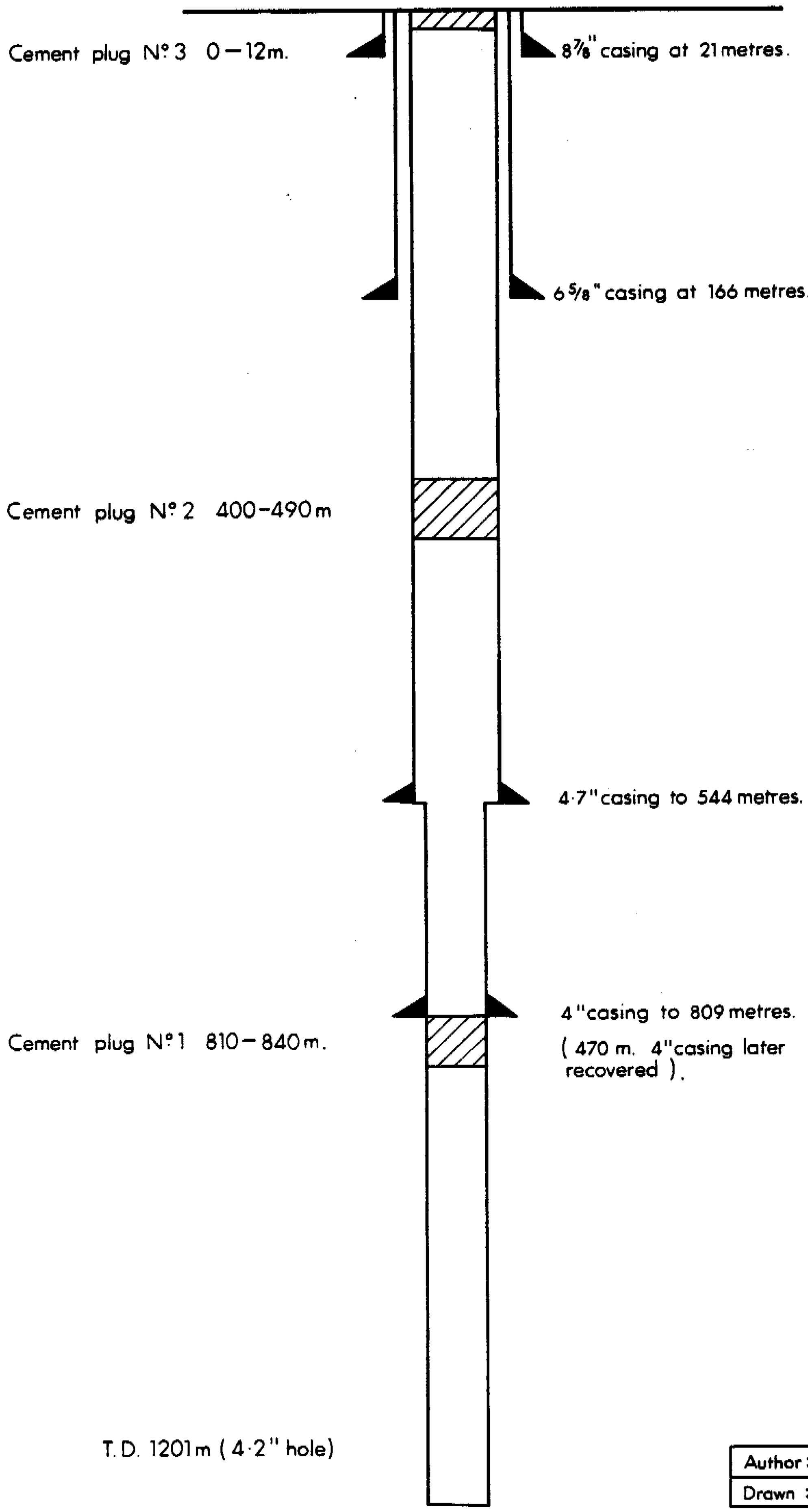
Plug No. 1	794 - 840 metres, subsequently drilled out to 810 metres as base to 4" casing cemented in place (see Section 3.3.2 above).
Plug No. 2	400 - 490 metres with 4 bbls Class A cement : slurry weight 14.7 ppg (4" casing was cut at 470 metres and pulled).
Plug No. 3	0 - 12 metres (inside 5" casing) with 4 sacks Class A cement (15.6 ppg).

3.3.4 Drilling Fluid

The spud section of the hole was drilled to 21 metres with water and gel. No problems were encountered, and 8-5/8" casing set and cemented.

The section from 21 metres to 166 metres was drilled with Aquagel and small additions of Q-Broxin ligno-sulphonate for light clay dispersion. 6-5/8" casing was set and cemented at 165m.

WELL SCHEMATIC
UNDANDITA Nº1A



Author : J.D.G.	Date : Nov '83
Drawn : D.J.P.	Figure : 3

The section of Undandita No. 1A from 166 - 543 metres was drilled with persistent mud losses to the formation which began almost as soon as the cement was drilled out at the commencement of 5-5/8" hole size. Mud losses ranged from 5 bbls/hr to complete loss of circulation, making it necessary to attempt closing off the formation with loss circulation material, namely mica and Kwikseal. Due to the small aperture between the core barrel and the drill pipe, the plumbing became blocked with LCM, so that the barrel had to be pulled and LCM circulated whilst no drilling was in operation.

At 364 metres an attempt to stem the lost circulation was made by spotting a 15.2 ppg cement plug. This was lost to the formation, so a second plug was mixed at 14.0 ppg, and a third of 14.2 ppg which lessened the problem. Drilling continued blind, circulating mud.

The pipe twisted off at 419 metres, and was retrieved in two fishing runs. The second twist off occurred at 440 metres. This fish was retrieved with a spear, however, two runs with a magnet, one with pipe, the other with wireline, were needed to retrieve the core barrel stop ring. A further twist off occurred at 461 metres which was again fished with a spear. The pipe above the core barrel was replaced and coring continued, however, a further twist off occurred at 322 metres with the bit at 481 metres. This was again successfully fished. The stabilizers were modified and operations progressed.

Drilling continued with no returns to 544 metres (4.7" casing depth).

Electric logs were run and then casing run and cemented with some difficulty.

Gypsum was drilled beneath the casing shoe. The mud system was changed from standard gel and water type to Polymer/Brine to help in the inhibition of swelling clays encountered at 630 metres. Salt was used to a concentration of 73,000 ppm to reverse the osmotic gradient and dewater the formation. Liquivis and Cellogen were used for viscosity/filter cake with CMC/LV and Dextrid for filtrate control. Drilling mud specifications were brought under stricter control with water loss now well below 10 cc/30 min.

At 767 metres, lost circulation was again a problem. At first, pumping LCM appeared to work, but on coring ahead the mud losses became worse.

At 803 metres, it was decided to attempt to seal off the lost circulation zone at 767 - 773 metres. LCM was run, and a total of 6 cement jobs attempted. The last of these appeared to work, but on drilling out, would not hold pressure. It was decided to core ahead despite the lost circulation.

The pipe became differentially stuck at 984.3 metres, and was worked loose over 5-6 hours with an Ez-Spot formulation spotted to reduce filter cake build up, increase lubricity and reduce hydrostatic head. For the remainder of the hole, losses to the formation ranged between 5 bbls/hr and 30 bbls/hr, but it was considered economic to continue drilling, bearing these expensive losses, pumping further LCM pills.

Towards the end of the hole, drilling RPM was reduced to prevent Barytes (used to replace diminishing supplies of salt) being spun out inside the pipe and barrel.

After total depth of 1201.25 metres was reached, a cement plug was spotted at 840 metres, however, it could not be found when pipe was run in hole. A second plug was successfully placed and tagged at 794 metres. DSTs 1 and 2 were then run off this plug.

4" casing was then run to 805 metres and cemented, prior to production testing.

Chemicals used at Undandita No. 1A

Materials	Quantity
Aquagel	53,045
Dextrid	5,727
Liquivis	2,620 ltr
Salt	49,550
Caustic Soda	1,360
Q-Broxin	900
Cellogen	300
Mica	1,102
Kwikseal	1,727
Bicarbonate of Soda	36
Soda Ash	164
Barytes	4,500
$CaCl_2$	1,425
Coat 415	208 ltr
Coat 413	208 ltr
XC-Polymer	659
Duovis	591
CMC-LV	4,275
Ez-Spot	208 ltr

3.3.5 Deviation Surveys

Depth (mKB)	Angle (deg)	Depth (mKB)	Angle (deg)
21	1/4	274	1/4
51.25	3/4	376	3/4
81.25	1/4	436	1/2
123	3/4	494	1/2
160	1	594	1
190	1	1002	1

3.3.6 Formation Sampling

Cuttings were collected at 5 metre intervals from the 8-7/8" conductor (21 metres) to 166 metres. Sample distribution is as follows:

1	Northern Territory Department of Mines
1	Bureau of Mineral Resources
1	Magellan Petroleum (N.T.) Pty. Limited
3	Pancontinental Petroleum Limited

Cuttings are described in Appendix A(ii).

3.3.7 Conventional Coring

Continuous cores were cut from a depth of 166 metres to total depth.

Size	Depth
5-5/8"	166 - 544 metres
4.2"	544 - 1201 metres

Cores are described in Appendices B, C, and D.

3.3.8 Gas Detector and Penetration Rate

A continuous reading hot wire detector and gas chromatograph were used from 166 metres to total depth. Samples were checked for fluorescence and the drilling rate was recorded. Sample descriptions, gas readings and drilling rates are shown in Enclosures 1 and 2.

3.3.9 Sidewall Coring

No sidewall cores were attempted in this well.

3.3.10 Wireline Logging

5-5/8" Hole:

Gamma Ray	
Multi Channel Sonic	
Neutron/Neutron	all logs run from 544
Linear Density	metres to casing at
Caliper	166 metres. Gamma Ray
SP	run to surface.
Focussed Electric	
Dipmeter	

4.2" Hole:

Gamma Ray	
Short Spaced Sonic	
Long Spaced Sonic	
Linear Density	all logs run from 544
Caliper	metres to 1201 metres.
SP	
Focussed Electric	
Dipmeter	
Velocity Survey	

3.3.11 Velocity Survey

A well Velocity Survey was carried out by Velocity Data Pty. Limited and is described in Appendix K.

3.3.12 Drill Stem Testing

Two DSTs were run on Undandita No. 1A. Both were conventional bottom hole tests using Halliburton's slim-hole (3" nominal) test string in 4.2" hole. In both tests, problems with sand plugging occurred. In DST No. 1 there was only one flow period because the hydrospring stuck open after the initial flow. The service company reports for these tests are given in Appendix E and results are summarised below:

DST No. 1: Interval - 788.3 - 799.2 metres, 20.1.83

Water Cushion: nil

Times: After 5 minutes initial flow, it was attempted to close the tool. After a further 23 minutes, it was attempted to reopen the tool. From the blow, it was not obvious whether the tool had either closed or opened, and further open/close cycles were attempted. After a further 63 minutes, the packer was pulled loose. The annulus then dropped as the hydrospring was stuck open.

Flow Description:
First Flow: very weak blow increasing to weak blow after 2 minutes. Then steady for further 3 minutes. Line was bled down to flare after tool (presumably) closed.
Second Flow: (1st attempt) extremely weak blow, which died after 20-30 seconds.

Recovery: Annulus U-tubed into test string at end of test because hydrospring was stuck open. Mud only recovered.

Comment: From pressure charts, tools were plugged almost immediately. Shut in pressure recorded on bottom chart is reservoir pressure.

Pressures: (Bottom Gauge)

IH	1174 psig (8094 kPa)
ISI (Field Reading)	1062 psig (7322 kPa)
FH	1201 psig (8343 kPa)

DST No. 2: Interval 778.6 - 799.2 metres, 21.1.83

Water Cushion: nil

Times: Flow Period - 74 minutes
Shut In - 60 minutes

Flow Description: Initial weak blow increasing to strong blow after 1 minute. Blow decreasing after 17 minutes and dead after 39 minutes.

Recovery: 2.9 bbl of water/mud, 96 metres above the hydrospring. The bottom 17 metres above the hydrospring was full of sand.

Comment: The test appeared to be mechanically OK. A probable interpretation is that the test string filled with sand fairly quickly after opening, causing the tools to plug. With the tool plugged, an effective pressure build up curve resulted, such that static reservoir pressure had been reached by the time the hydrospring was closed.

Field analyses of 4 samples of the fluid recovered indicated that only mud and filtrate had been recovered, and hence that formation fluid had not been sampled. Laboratory analyses of these samples are included in Appendix E.

Pressures: (Bottom Gauge)

IH	1195 psig (8240 kPa)
IF	360 psig (2482 kPa)
FF	1061 psig (7316 kPa)
FSI	1062 psig (7322 kPa)
FH	1145 psig (7895 kPa).

3.3.13 Production Testing

Because DSTs 1 and 2 had failed to produce formation fluid, it was decided to run 4" casing, perforate, and to swab the well in through 2-3/8" tubing.

The cement plug was drilled out from 799 to 810 metres and the 4" casing set and cemented at 809 metres. The casing was perforated by Gearhart with 1-11/16" wire form charges, at 4 shots per foot, over the intervals 780 - 783 metres and 784 - 790 metres.

Swabbing commenced at 12.30 hours on January 29, 1983 and was terminated at 19.00 hours on January 30, 1983.

Completion fluid consisted of 15 gallons diesel fuel plus 8.6 ppg brine (approximately 30,000 ppm Cl^-). After perforating, the fluid level in the hole dropped by an estimated 60 - 90 metres.

Swabbing started from a depth of about 240 metres, and was progressively increased to 340 metres. Up to 4 barrels of fluid were recovered per swab, decreasing as the swab became worn.

Fluid Samples were analysed in the field for resistivity, Cl^-, NO_3, weight, viscosity and pH. Overall trends were as follows:

a. Cl^- increased after about 10 barrels from initial 30,000 to over 50,000 ppm (equivalent to filtrate) and then declined to 10,000 ppm after 110 barrels, and remained steady thereafter. The resistivity results were consistent with that for Cl^-.

b. Nitrates decreased from 150 ppm to zero after 50 barrels. Note that the mud used while drilling Undandita No. 1A had zero nitrates.

c. Fluid weight declined steadily from 8.6 ppg initially to 8.4 ppg after about 120 barrels, and was then steady.

d. Viscosity declined quickly to that of water equivalent (25 - 26 seconds) and then remained steady.

e. pH declined from 9.5 to 7.0 after about 100 barrels.

Overall, fluid properties remained constant after about 110 barrels up until swabbing stopped with a total of 224 barrels recovered.

The fluid data sheets and plots are shown in Appendix E, along with the laboratory analyses of the swab samples taken during the test.

4. GEOLOGY

4.1 Summary of Previous Work

Geology

Regional geological mapping of the Undandita area was carried out by the Bureau of Mineral Resources (BMR) in 1961 (Wells et al., 1965). This work suggested that a major east-west fault (Deering Fault) lay approximately 8 kilometres south of the Idirriki Range. Growth along a zone, parallel to the Deering Fault, was also noted. Wells et al. (1965) suggested that there may have been piercement or growth along a line roughly parallel to Deering Creek during Larapinta Group sedimentation and indicated their belief that the structure was diapiric. They also suggested growth of the structure during Pertnjara Group deposition. This conclusion was supported by Jones (1972), who demonstrated thinning of several units within the Pertnjara Group over the structure.

McNaughton et al. (1968, Figure 2) named the structure the Carmichael Diapir, indicating their concurrence with the Wells et al. (1965) conclusion of salt involvement. The name was amended to Carmichael Structure by Wells et al. (1970), who described it as an east-west trending anticline with the beds on the southern flank steeply overturned. Froelich & Krieg (1969) called the 129 kilometre growth zone extending west of Goyder Pass the Deering Uplift, but McNaughton (1979) altered the name to Stokes Pass Uplift. So as not to add to the confusion or to add a name with genetic connotations, we have not coined a new name and will follow Wells et al. (1970) terminology herein.

Geophysics

A seismic survey conducted by Magellan in 1965 and 1966 did not resolve structure at depth over the Undandita Prospect (Magellan's Carmichael Prospect, McNaughton, 1979), but the presence of a large potential downside fault trap was suggested at Pacoota Sandstone level.

Froelich & Krieg (1969) presented a detailed assessment of the Deering uplift (their term) based on an integrated geological, seismic, gravity and magnetic study. They concluded that diapiric injection of low-density Precambrian material into the core of the uplift possibly preceded and accompanied regional décollement movements.

Pancontinental Petroleum Limited conducted the Undandita Survey in 1981. This allowed for detailed interpretation of the complex faulting, and predicted the presence of a faulted anticline with an areal closure of approximately 1,200 hectares, and up to 450 metres vertical closure at top Pacoota Sandstone level. Undandita No. 1A was spudded to test a rollover at possible top Pacoota Sandstone on the interpreted hanging wall of the structure (Bellis et al., 1982).

Detailed gravity lines in the Undandita area indicate an east-west gravity minima along the extent of the Deering Fault. This gravity feature was interpreted to be the result of an injection of low density material (ie. salt) along the faulted zone (Froelich & Krieg, 1969). Nettleton (1967) had previously interpreted the Goyder Pass-Deering trend as an extremely faulted diapiric structure with over-thrusting from the north and predicted that the source of the anomalies could be as shallow as 600 metres. Pratt (1983) has also associated the Bouguer low over the structure as due to a salt core.

An aeromagnetic survey flown by BMR in 1965 covered the Undandita area (Young & Shelley, 1977). No significant features were noted over the Goyder Pass-Deering trend, suggesting basement was not involved with the structure. However, the line spacing of this survey does not allow precise interpretation of the structure.

Drilling

No wells have been drilled in the immediate vicinity of Undandita No. 1A. The nearest wells are Tyler No. 1, 50 kilometres to the east and Mereenie No. 1, 45 kilometres to the southwest.

Tyler No. 1 was drilled by Magellan Petroleum (N.T.) Pty. Ltd. as a structural test of the Pacoota Sandstone on a seismically defined anticline. The well intersected 2,624 metres of Pertnjara Group sediments lying over 350 metres of Mereenie Sandstone. 866 metres of Larapinta Group sediments were intersected, with the well reaching a total depth of 3840 metres in the Stairway Sandstone. No hydrocarbon shows were indicated during drilling and the well was plugged and abandoned. The Pacoota Sandstone target was not reached.

Mereenie No. 1 was drilled by Magellan as a petroleum test of a large anticlinal structure mapped by the Bureau of Mineral Resources. The well spudded in, and intersected 367 metres of Mereenie Sandstone and 847 metres of Larapinta Group sediments. Total depth was reached at 1214 metres, with a gas flow of 9 million cubic feet per day from the Pacoota Sandstone.

Subsequent wells on this structure have delineated an oil leg below the gas cap, with ultimate recoverable reserves of 60 million barrels of oil and up to 0.5 trillion cubic feet of gas (Pearson & Benbow, 1976).

Minor hydrocarbon flows have also been obtained from the Stairway Sandstone in the Mereenie area.

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 Proterozoic 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 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 or Silurian 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 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 Undandita No. 1A is compared to the predicted section in Enclosure 3. Table 1 shows the stratigraphic succession penetrated at Undandita No. 1A.

The section is highly complicated by steeply dipping beds, and the intersection of a series of faults. Due to these faults, and resultant poor seismic control, the predrill stratigraphy could not be accurately predicted.

AGE	GROUP	FORMATION WEST	FORMATION CENTRAL	FORMATION 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	LARAPINTA	GOSSE'S BLUFF S'ST CARMICHAEL S'STONE STOKES FORMATION STAIRWAY SANDSTONE HORN VALLEY SILTSTONE		RODINGAN EROSION	
EARLY ORDOVICIAN	LARAPINTA	PACOOTA SANDSTONE GOYDER FORMATION			
					UNNAMED (BLOODWOOD ?)
LATE CAMBRIAN MIDDLE CAMBRIAN	PERTAOORRTA	CLELAND SANDSTONE: PETERMANN S'ST, DECEPTION SILTST., ILLARA FM. TEMPE FM.	JAY CK. HUGH RIVER SHALE GILES CK.	SHANNON FM. GILES CK. DOLOMITE	
EARLY CAMBRIAN	PERTAOORRTA	MT. CURRIE CONGLOMERATE	CHANDLER FORMATION ENINTA FM.	? ? TODD RIVER DOL ARUMBERA S'ST UNITS 4 & 3	
					PETERMANN RANGE
LATE PROTEROZOIC		MAURICE FORMATION SIR FREDERICK CONGLOM. / ELLIS SANDSTONE	JULIE FM. WINNALL BEDS	ARUMBERA S'ST UNITS 2 & 1 JULIE FORMATION PERTATATAKA FM.	
LATE PROTEROZOIC		CARNEGIE FM. / BOORD FORMATION	ININDIA BEDS	PIONEER S'ST OLYMPIC FM. ARALKA FM. AREYONGA FM.	SOUTHS RANGE
					AREYONGA
LATE PROTEROZOIC		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.

TABLE 1. STRATIGRAPHY AT UNDANDITA No. 1A

Formation	Top (Metres KB)	Measured Thickness (Metres)	Average (Degrees)	True * Thickness (Metres)
Cainozoic	0	106.0	Flat	106
Illara Sandstone	106.0	84.4	35	69
Tempe Formation	190.4	138.4	35	113
Katapata Member	328.8	14.8	25	13
?Chandler Formation	343.6	429.6	35	352
Unnamed Arkosic Marl Section - ?Fault zone	773.2	123.0	40	94
?Pacoota Sandstone (P4)	896.2	123.8	45	73
?Goyder Formation	1020.0	181.6	70-80	47

TOTAL DEPTH 1201.6 (Driller)

* True thickness was computed by averaging the core and dipmeter derived dips (θ) throughout each formation and multiplying the measured depths by cos (θ).

CAINOZOIC 0-106 metres (Thickness 106 metres)

The Cainozoic section at Undandita No. 1A consists of 45 metres of sandstone, siltstone and clay overlying 61 metres of dominantly sandstone and minor clay.

The upper sandstones are white, pale yellow, pale orange and occasionally red brown and ferruginous. The grain size is fine to medium, moderately well sorted with silty or clayey matrix. The siltstone is red brown, sandy, ferruginous and in part pebbly in the upper 21 metres. The claystone occurs as the matrix to the sandstones and is pale grey to white and pale yellow in colour.

Below 45 metres the section is dominantly white to buff coloured sandstone, which is fine to medium grained, poorly consolidated, moderately sorted with a clay matrix. Porosity is poor when clayey to good where well sorted and clean (95-106 metres) and the grain size is medium to coarse.

The section below 45 metres is correlated with moderately well sorted quartz sandstones with quartz grains set in a white clayey matrix which outcrop north of the Gardiner Range. These outcrops were originally considered to be Mesozoic (Wells et al., 1965), but are more likely to be Early Tertiary (Wells et al., 1970).

Seismic sections in the vicinity of Undandita No. 1 indicate significant channelling into older rocks. The lower part of the section here regarded as Cainozoic possibly infills one of these channels.

The overlying 45 metres are probably later Tertiary to Recent in age and are considered here to be deposits of mixed alluvial and aeolian sedimentary cycles.

Illara Sandstone 106-190.4 metres (Thickness 84.4 metres)

The top of the Illara Sandstone has been selected at 106 metres, which coincides with a marked slowing down of the penetration rate and an increase in the gamma ray count. This depth also marks the change from white to pale buff, clean sandstone to clayey, glauconitic and feldspathic sandstone, medium grey shales and green, glauconitic siltstones.

The sandstones are clear, white, pale buff, pale yellow and pale orange and pale brown above 155 metres, but below this depth pale to medium green colours are introduced and reddish hues become more common in the lower 15 metres. Grainsize varies from very fine to medium with minor coarser grained zones. The section is occasionally poorly, but generally moderately, sorted with a clay or silica matrix. Siliceous cement is prevalent below 152 metres. Accessories below 145 metres include glauconite, feldspar, mica and pyrite in varying abundance. High angle crossbedding, climbing ripples and slumping are features of the sandstone.

The siltstones are pale green to grey green above 174 metres and are often very glauconitic and micaceous, in part pyritic or sandy and grade to shale. Below 174 metres brown and red colouration appears.

The upper part of the unit above 145 metres contains abundant clay which may represent the weathering product of the original glauconite, mica and feldspar within the sandstones.

The unit is generally tight and no shows of either gas or oil were present.

The unit is correlated with the Illara Sandstone as described from outcrop 18 kilometres to the south in the Gardiner Range. The Illara Sandstone is described by Wells et al. (1965) as mainly red brown, fine to medium grained, moderately sorted, crossbedded, ferruginous, feldspathic, micaceous sandstone and red brown laminated micaceous siltstone. Many of the crossbed sets have slumped and convolute bedding. Clay minerals are also common.

Fossils have not yet been described from outcrop of the Illara Sandstone, but from its stratigraphic position conformably overlying the Early Cambrian Tempe Formation (Cook, 1982), its age is probably Middle Cambrian.

No dating of the unit from Undandita No. 1A has been made, but badly corroded material from 126-128 metres in the waterbore for the well was regarded as possibly Cambrian in age (Appendix H). Cuttings from 142-152 metres in Undandita No. 1A proved barren (Appendix H).

Because of the lithological similarities with the described Illara Sandstone outcrop, the stratigraphic position overlying the Tempe Formation in Undandita No. 1A, and the presence of possible Cambrian microfossils in the waterbore, the unit is correlated with the Illara Sandstone.

<u>Tempe Formation</u> 190.4-328.8 metres (Thickness 138.4 metres)

The Tempe Formation, as mapped in the Gardiner Range, 18 kilometres south of Undandita No. 1A, consists mainly of siltstone and shale with variable amounts of sandstone, limestone and dolomite. The siltstone and shale are red brown, purple brown or grey green and laminated. The sandstone ranges from white to dark purple brown, is thin-bedded, crossbedded, slump-folded, fine to medium grained, moderately friable, micaceous and glauconitic. Some beds contain clay pellets, some are calcareous and others are rich in feldspar. The limestone is yellow brown, grey, grey green and is usually partly glauconitic.

Dark grey to light grey foetid dolomite and limestone with laminae and 'biscuits' of chert which occur towards the base of the formation are a development of the Chandler Formation (Wells et al., 1965).

In Undandita No. 1A, a sequence of shale and carbonate between 190.4 and 328.8 metres is correlated to the upper part of the Tempe Formation as measured in the Gardiner Range by Wells et al. (1965) and Ranford et al. (1965). Between 109.4 metres and 306.8 metres the section is dominantly shale with minor limestone and dolomite. The shale is dark red brown near the top, becoming grey green and brownish grey below about 200 metres, becomes red brown, chocolate brown about 255 metres and assumes medium to very dark grey and black colouration below 270 metres. The grain size varies from shale to minor siltstone and sandstone, which is red brown or white, fine to medium grained and arkosic. Bedding varies from laminated to flaser and other sedimentary structures include dewatering structures, climbing ripples, microfaulting and slumping. Calcite veins are common and cut the 15-30° bedding at various angles.

The carbonate beds are generally thin and gradational with the surrounding shales. Colour ranges from light to dark grey and minor brownish grey to dark brown and grey green. Silty and possibly carbonaceous inclusions impart the darker colouration to the carbonates. Grain size is generally micritic but sparry patches are present. The carbonates are generally hard and brittle with conchoidal fractures and often contain vuggy or fracture porosity, although the latter is often infilled with calcite. Bedding is either thin or massive up to 40 cm and the carbonate becomes brecciated in part.

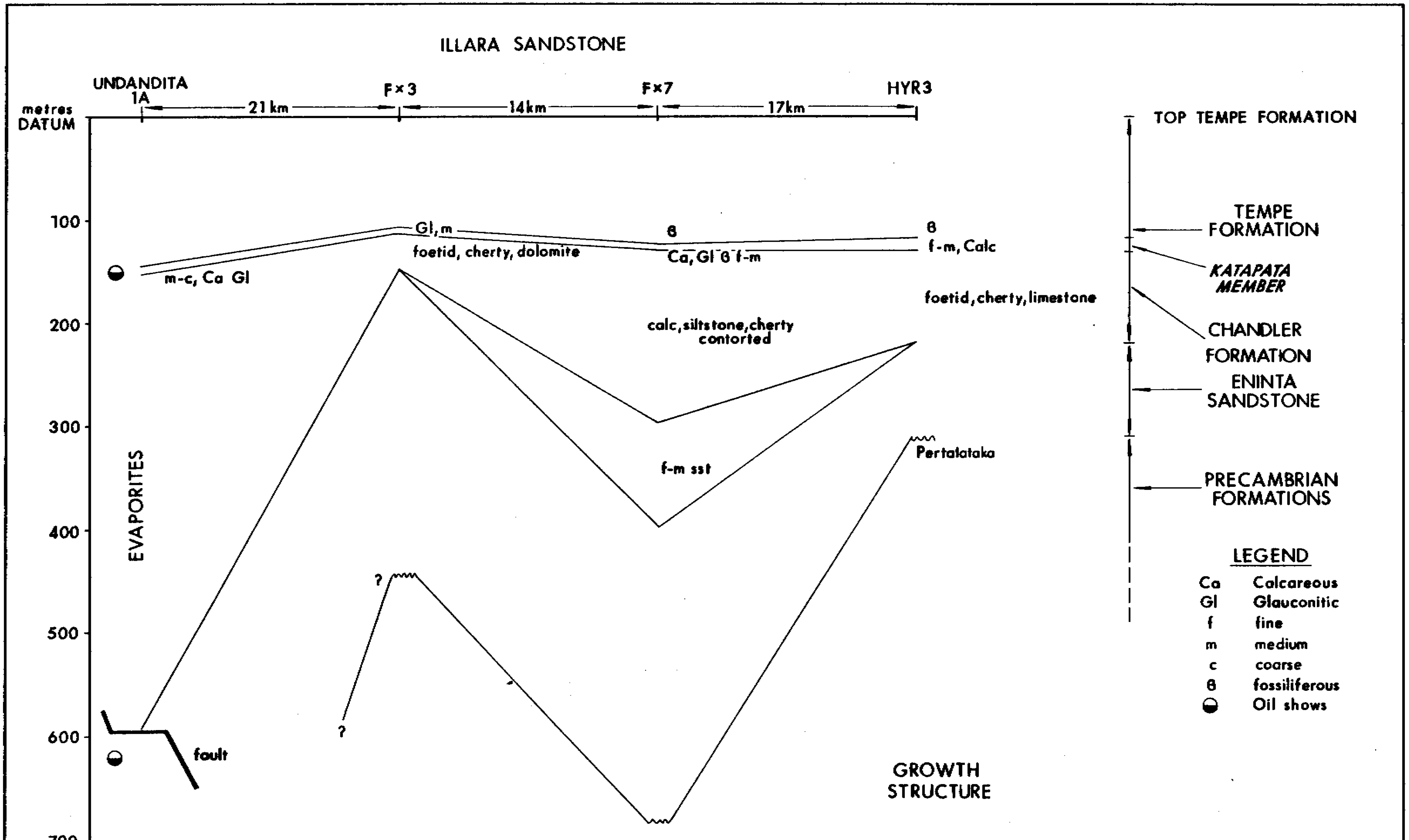
Below 306.8 metres to 328.8 metres the section is dominantly dolomitic limestone and dolomite. From 306.8 to 309 metres the lithology is argillaceous grey, green and brown to dark brown dolomitic limestone with fair to good vuggy porosity and calcite infilled fractures. Between 309 to 314 metres the section includes dolomitic limestone, as described above, and interbedded light grey clay and shale. The shales and clays are very calcareous (marl) and contain minor glauconite. Porosity is generally poor, but the section is vuggy and highly fractured. Fractures are again infilled with calcite. A massive white to medium grey dolomite occurs between 314 and 314.8 metres. The dolomite is sucrosic, sandy and clayey, with dark carbonaceous partings and trace red brown ferruginous leached zones. The matrix is tight but fracturing is present.

Below 314.8 metres the rocks assume a highly chaotic appearance forming a melange of highly fractured sucrosic dolomite as sub rounded clasts to 4 cm in diameter in a sandy and clayey matrix. The colouration is generally white, pale to dark grey, becoming blue grey below 324 metres with ferruginous and carbonaceous patches. The clay matrix is calcareous and often contains medium grained sub angular to rounded quartz grains. The porosity of the interval ranges from poor to fair with fracture porosity in part.

Several samples from the unit were processed for acritarchs and conodonts (Appendix H). All the limestone sampled for conodonts proved barren of any phosphatic remains. Similarly, most of the palynological samples were barren or contained acritarchs of no biostratigraphic significance. Although some of the filamentous organic remains from 220 metres resemble Late Proterozoic forms, in the absence of corroborating evidence the age remains uncertain (Appendix H).

<u>Katapata Member</u> 328.8-343.6 metres (Thickness 14.8 metres)

The Katapata Member is correlated with a thin sandstone unit that is mapped in the Gardiner Range (Wells et al., 1965; Ranford et al., 1965) as shown in Figure 5.



CORRELATION OF EARLY-MIDDLE CAMBRIAN SEQUENCE GARDINER RANGE TO UNDANDITA 1A

FIGURE 5

In Undandita No. 1A the sandtone is white to grey, occasionally buff, very fine but becoming medium to coarse grained with depth, poorly to moderately sorted, occasionally siliceous but also argillaceous and with a calcareous or dolomitic matrix. Accessories include glauconite and pyrite with minor ferruginous material and rare dark red shaly beds. Porosity increases downward, becoming very good in the basal 4 metres, where traces of dull medium yellow non cutting fluorescence were noted.

In the Gardiner Range the possible correlative sandstone (Figure 5) occurs in the Katapata Gap area (Ranford et al., 1965, Plate 10, Section HyR3) where it is 24 metres thick. At this location the sandstone is white, red brown, purple brown, fine to medium grained, micaceous, calcareous and kaolinitic, thin bedded to crossbedded, friable and porous (Ranford et al., 1965). The top of the Katapata Member is 134 metres below the mapped top of the Tempe Formation and underlies grey green and red brown shale and siltstone, yellow brown and grey fossiliferous limestone and calcareous and glauconitic sandstone.

Further west, at MLFx7 (Wells et al., 1965, Plate 8), an 11 metre thick white, medium grained, moderately sorted, thin bedded, glauconitic sandstone outcrops about 113 metres below the top of the Tempe Formation. This unit is correlated with a similar sandstone 14 kilometres to the northwest at section MLFx3 (Wells et al., 1965, Plate 8) where the 12 metre thick sandstone outcropping 109 metres below the top of the Tempe Formation is yellow brown, fine to medium grained, moderately sorted and contains mica, glauconite and unidentified fossils. At both the latter sections the unit is slightly to moderately friable and poorly porous.

?Chandler Formation 343.6-773.2 metres (Thickness 429.6 metres)

Underlying the Katapata Member in the Gardiner Range is a sequence of poorly exposed sediments which contain foetid cherty limestones and dolomites with contorted bedding. These sediments were mapped as Tempe Formation by Wells et al. (1965) and Ranford et al. (1965) although similar occurrences further south were provisionally correlated with the Chandler Formation.

The unexpected presence of a thick evaporitic sequence at shallow depth in Undandita No. 1A presents problems in correlation: previously the Chandler Formation evaporites were not thought to occur so far northwest (although they are mapped in the Parana Hill anticline 70 kilometres due south of the well site) and had not been recognised in the Gardiner Range. Moreover, Early Cambrian age evaporites have not been recognised in the MacDonnell or Idirriki Ranges, although the ample sand covered intervals between Cleland Sandstone and Arumbera Sandstone outcrops north of Idirriki Range may accommodate them (Mt. Liebig 1:250,000 Geological Sheet).

The closest mapped evaporites occur in the Bitter Springs Formation in the Gardiner Range (BMR Mt. Liebig No. 1) and north of the MacDonnell Ranges (Goyder Pass Diapir). While the presence of evaporites in the Undandita Structure has long been predicted on the basis of gravity work (McNaughton et al., 1968), it was expected that these would be Bitter Springs derived. However, no compelling evidence is available from seismic data to suggest diapiric piercement of Late Proterozoic Bitter Springs Formation evaporites into Early Cambrian strata. To the contrary, evidence suggests that the divergence apparent on the seismic sections is indigenous to the Early Cambrian horizons (Enclosure 4), ie. at the same stratigraphic level of the known Chandler salt in the eastern part of the Amadeus Basin.

Reinterpretation of the basal Tempe Formation in the Gardiner Range as Chandler Formation, a view not inconsistent with the field evidence, suggests a viable alternative correlation of the evaporitic sequence in Undandita No. 1A with the Chandler Formation.

Thinning of the basal Tempe Formation eastward along the Gardiner Range (Figure 5) towards the Areyonga Native Settlement is not incompatible with thinning in the same direction noted by Phillips (1983) in the underlying Eninta Sandstone. Phillips postulated a growth structure in the vicinity of Areyonga, a view also suggested by thinning of the Pacoota Sandstone (Deckleman, 1983, in prep.) in the same area. Seismic data have long indicated a northeast-southwesterly ridge running from the Areyonga area through Gosses Bluff and beneath Tyler No. 1 toward the MacDonnell Ranges, culminating in the known growth structure at Goyder Pass. All the available evidence thus supports the presence of a high to the east of the Undandita structure during Late Proterozoic to at least Early Ordovician time. It is conceivable that this high localized an Early Cambrian evaporitic basin west of the main depocentre.

The lithology of the evaporitic sequence is variable. The dominant lithology is gypsiferous breccia with subordinate anhydrite, dolomite, claystone and quartz sand (Appendix D), all in chaotic bedding and shot through with random fractures infilled with satin spar. Detail petrographic descriptions by Australian Mineral Development Laboratories (AMDEL) are provided in Appendix D.

AMDEL reports the rocks to be typical evaporitic gypsum after anhydrite with appreciable syngenetic dolomite content. The dolomitic rock clasts could have been produced by either of two processes:-

(i) It could be an intraformational breccia with disruption of the dolomite prior to induration and incorporation of fragments in a relatively pure anhydrite precipitate. This was followed by some ?diagenetic low-grade metamorphic recrystallisation and ultimate hydrolysis of the anhydrite.

(ii) The brecciated clasts could have been formed tectonically and incorporated into the anhydrite during a process such as the diapiric intrusion of a salt plug.

AMDEL further comments that in some ways the brecciation textures seen in the clasts appear to be tectonic rather than intraformational, and suggested that they were incorporated into the anhydrite/gypsum during intrusion of a salt plug or similar body. In this case the dolomite crystals must be regarded as porphyroblasts produced after tectonism.

There is ample seismic evidence to suggest growth over the Undandita Structure. Geological mapping of thinning of the Larapinta section to the west at section WC2 (Wells et al., 1965) and during Pertnjara Group deposition (Jones, 1972) supports this conclusion.

The sample at 439.7 metres is reported by AMDEL to be a gypsum rich evaporite rock that has later been crystallised or hydrated to gypsum along sub-parallel shear surfaces.

Such recrystallization probably accompanied the tectonism associated with the Alice Springs Orogeny in the Late Devonian. It is also probable that the random fractures now infilled with satin spar were generated during this diastrophism. Movement of relatively fresh water along these fractures may have resulted in much of the original anhydrite precipitate converting to gypsum. This transformation requires addition of water to the anhydrite lattice and results in contortion and brecciation of the beds to accommodate the larger gypsum crystals.

In the lower part of the evaporite (eg. 705.3 metres) a change of depositional style is indicated. The rocks are described as medium to dark grey, fine grained, massive carbonate rock with oblique contacts to a coarse grained, lighter coloured conglomerate or ?breccia with an assortment of variously coloured pebbles or clasts of different rocks.

The conglomeratic phase is completely different from the overlying evaporites as it suggests a massive incursion of detrital, partially water-rounded and sorted sediment.

A sample of dark grey shaly siltstone was submitted for palynological examination but proved barren (Appendix H), as did a limestone sample from 639.7 - 639.8 metres.

<u>Unnamed Arkosic Marl Section</u> 773.2-896.2 metres (Thickness 123.0 metres)

This unit is clearly defined on the gamma ray log by high gamma counts below the overlying evaporitic sequence and above the underlying dolomitic sandstone below 896.2 metres, and lower density and slower sonic transit times than the enclosing formations.

Three core samples with different log responses were thin-sectioned and examined petrographically (Appendix D). The lithology is not easy to categorize: the rock appears to have been extensively brecciated, almost myolinitized in part, and undergone pervasive diagenesis in which some of the original rock components, principally the feldspars, have been degraded and later been redeposited as semicontinuous dolomite. While at the well site the rocks were considered to be brecciated calcareous sandstones and siltstones, the section can best be described as arkosic dolomitic marl and breccia.

The section is dominantly a sandy dolomitic marl grading to dolomitic sandstone and siltstone which shows abundant brecciation. The colour ranges from white, pale to dark grey to pinkish brown, pale orange, buff and earthy. Grain size of the quartz and feldspar grains ranges from fine to medium to occasionally coarse. The grains are sub angular to sub rounded and exhibit corroded and embayed margins in part. Accessories include feldspar, anhydrite, sulphides (pyrite), clays, chlorite, leucoxene, tourmaline and carbonaceous material in varying amounts.

Visual porosity over the section ranges from fair to good and the more sandy intervals are extremely friable. Both the density and sonic logs suggest good porosity but their reliability is questionable because of the varying clay and accessory mineral contents.

Core analysis (Appendix C) over the interval 755 to 801.9 metres showed the porosity to range from 6.9 to 22.9% with permeabilities ranging from 0.14 to 438.7 millidarcies.

Good oil shows were encountered in this section, with 30-70% of the rock exhibiting solid to patchy, medium to bright yellow fluorescence with a fair streaming cut and thick residual ring. A strong petroliferous odour was also present. Despite these good shows and up to 7.5% oil saturation (Appendix F) in seal peeled core, two drill stem tests and subsequent swabbing of the interval failed to yield any show of hydrocarbons, producing only brackish formation water.

Geochemical analyses of core plugs between 793.1 and 800.6 metres (the highest oil saturation zone reported from core analyses) showed that contained oils are residual aromatic - napthenic crudes which have undergone differing degrees of water-washing and biodegradation (Appendix F). This result is in accord with the recovery of brackish water from the 780 to 783 metres and 784 to 790 metres intervals in the well.

A siltstone sample from 781.8 metres submitted for palynological examination was barren.

?Pacoota Sandstone (P4) 896.2-1020 metres (Thickness 123.8 metres)

This section is delineated from the overlying sequence by relatively featureless sonic and density curves and slower sonic transit time, and from the underlying section by a comparatively featureless and lower reading gamma ray curve. The lithology is monotonous arkosic dolomitic sandstone and minor siltstone. It is distinguished from the underlying unit by the absence of black shale, oolitic dolomite and dolomite.

From 896.2 to 946.2 metres the lithology is pale brown to buff coloured, very fine to medium grained sandstone. The sandstones are well sorted, very pyritic, clean, and cemented with slightly calcareous dolomite and ?silica. Minor vugs are developed with calcite crystal infill and irregular veins of calcite and pyrite are present. Very poor visual porosity was reported from this interval.

Between 946.2 and 955 metres the rock becomes silty in part and dark red brown or grey green in colour with sandy intraclasts showing reduction haloes in the more ferruginous sections. Overall the grain size is extremely fine to medium, sub angular, poorly to moderately sorted, and with traces of pyrite and glauconite. Other accessories include feldspar, muscovite, tourmaline, ?zircon, leucoxene and sericitic clays (Appendix D). Colour mottling visible in part of the rock is due to saccharoidal aggregates of carbonate minerals, which sometimes have vuggy porosity developed in the core. Similar lithology persists to 984.75 metres but red brown (ferruginous) and grey green mottling is more noticeable, possibly due to variations in dolomitic cement apparent on the sonic and density curves.

Between 984.75 and 1020 metres the section is dolomitic, pale to medium grey green, extremely fine to occasionally medium grained sandstone with minor silty partings. Minor pyrite is present and the rock is generally non ferruginous. Worm burrows are present in the siltier section between 986 and 1002 metres and climbing ripples are developed in the lower part.

Visual porosity throughout the sequence is very poor although sporadic, unconnected vugs are present in the more carbonate rich sections. No shows of hydrocarbons were encountered.

The section is correlated with the P4 unit of the Pacoota Sandstone (Huckaba, 1970) because of lithological similarity and wireline log characteristics. However, it may also be correlated with the upper part of the Goyder Formation.

<u>?Goyder Formation</u> 1020-1201.6 metres (Thickness 181.6 metres plus)

The sequence is characterized by interbedding of the various lithologies, abundant carbonates as indicated by the density log, and oolitic dolomite.

The top of the section (1020-1040 metres) is marked by the incoming of dark grey to black dolomitic shale with minor grey green shale, interbedded in part with medium dark grey siltstone. The shale is micromicaceous, carbonaceous thinly laminated and subfissile with abundant nodular and laminated pyrite. The carbonaceous matter is highly altered (Appendix H) and no identifiable microfossils were seen. The siltstones are also pale pink in part, sandy and grade in part to very fine grained dolomitic sandstone showing evidence of bioturbation or slumping. There is also minor flaser bedding. Thin section petrography suggests much of the siltstone is in fact marl and contains up to 40% sericitic clay and 20% chlorite (Appendix D).

Interbedded lithologies as above continue down to 1065.6 metres with a predominance of dark grey and black colouration. The logs reflect variations in the sand or carbonate content throughout the section.

Below 1065.6 metres mottled white and pink and dark red oolitic dolomites appear interspersed with the medium to dark grey siltstones and sandstones as described above. The dolomites are clearly demarcated on the density and sonic logs with generally sharp tops and usually gradational bases. Thin sections from 1067.15 metres show the lithology to be composed of dolomitic oolite with inter-oolitic spaces infilled with quartz and feldspar detrital grains in dolomitic cement. A thin section at 1088.3 metres (Appendix D) suggests that some of these dolomite beds may have originally been intraformational breccias.

The section appears to become more iron rich and arkosic with depth and red brown or dark grey and grey green shaly intervals become more common below 1146 metres.

No shows were recorded throughout the interval and the only visual porosity reported is in scattered vugs and poor intergranular spaces. Scattered calcite-filled veinlets throughout the section show that all previous fracture porosity is now occluded.

The section is questionably correlated with the Goyder Formation because of the presence of oolitic dolomite, black shale and the stratigraphic position below the overlying ?P4 unit of the Pacoota Sandstone. Wireline log correlations are difficult because of the steeply dipping beds, but the high sonic log readings and the interbedded nature of the lithologies is reminiscent of the log motif of the Goyder Formation at East Mereenie No. 4 and West Walker No. 1.

Some organic material was present in a palynological preparation from 1031.32 metres (Appendix H) but proved unsuitable for biostratigraphic purposes. However, the thermal alteration of the organic matter is estimated to be about 3, appreciably less than organic maturation from the 250-300 metre level in the well (TAI 3.5-3.8). This discrepancy in colouration tends to support the assignment of a younger age (ie. less deeply buried) for the section below 1020 metres compared to the presently much shallower section. If the formation assignment of this upper section is correct, Tempe Formation, it suggests that the section presently below 1020 metres is younger - eg. younger than early Middle Cambrian. This would be consistent with section below 1020 metres being Goyder Formation (late Middle to early Late Cambrian).

4.4 Structure

The objective of Undandita No. 1 was to test an anticline at Pacoota Sandstone level located on the sub-thrust block of the Deering Fault. The prospect was located by a grid of 343 kilometres of seismic data situated along a gravity and seismic anomaly northwest of Gosses Bluff (Froelich & Kreig, 1969). The anticline has limited surface expression with hanging wall exposures of Cambro-Ordovician 24 kilometres to the west (Wells et al., 1965) and 12.5 kilometres to the east of the proposed drilling location.

Undandita No. 1A was drilled at the predicted crest of the anticline on seismic line P82-U16. Seismic data quality deteriorated to the north of the prospect and strike line data were consistently poor along its axis. The axial crest was located by an extrapolation of strike information down dip from the prospect.

The well bottomed in steeply dipping Goyder Formation with the lower P4 unit of the Pacoota Sandstone encountered below a major splay of the Deering Fault (Enclosure 4). Seismic data quality on the hanging wall of the thrust sheet was too poor to identify seismic horizons with any degree of confidence and the counter regional dip evident on the seismic section was in fact part of the thrust fault zone.

The Undandita Prospect is interpreted as a thrust faulted growth structure, with growth from the Cambro-Ordovician to the Early Devonian (Enclosure 4). The pre-drill seismic interpretation had the Deering Fault located further north with the Mereenie Sandstone dipping counter regionally to the north. Despite inaccuracies in the location of the fault, seismic data show that the prospect has undergone a complicated structural history.

Thinning occurs within the Larapinta Group and Mereenie Sandstone with a significant period of erosion prior to the deposition of the latter. Conversely, during the Early to Late Cambrian depositional thickening towards the fault zone is indicative of down-warping and possible half graben development across the Deering Fault zone.

Halokenitic forces must certainly have contributed to the development of the Undandita structure and thickening of the Early Cambrian units is consistent with possible salt growth within the Chandler Formation. Gravity data also suggest an evaporitic core to the structure. The abnormally low Bouguer Anomaly over the core of the anticline can only be modelled by introducing low density halite into its core (Pratt, 1983).

The Early Cambrian, Late Proterozoic formations and sub-Bitter Springs Formation units have been overthrust by high angle reverse faults. Fault planes flatten out up structure with the shallower Cambro-Ordovician and Devonian beds uplifted but not faulted. Growth across these faults shows many of the characteristics common to normal faults and it is possible that the deeper thrust is a rejuvenated normal fault.

The most recent movement occurred during the Alice Springs Orogeny with uplift of the uniformly thick Hermannsburg

Sandstone. Movements during the Alice Springs Orogeny do not appear to have occurred along pre-existing faults but may have been localised along the older growth structure. The shallower of the two fault styles evident at Undandita, is low angle thrusting which appears to 'sole out' within the Chandler Formation, the evaporites of which may have behaved as a local plain of décollement during the Alice Springs Orogeny.

The oil shows encountered within the fault zone warrant serious investigation and the seismic data from the 1981 and 1982 Undandita surveys should be carefully reprocessed and reinterpreted as soon as possible.

4.5 Relevance to the Occurrence of Hydrocarbons

Hydrocarbon Shows

Significant oil shows were encountered in the 774.75 to 802 metre interval immediately below a thick evaporitic sequence in Undandita No. 1A (Enclosure 5). Two drill stem tests and subsequent production testing of the interval failed to recover hydrocarbons, and proved the rocks water wet. Geochemical analysis of the oil in sealed core plugs from the bottom part of the oil column indicated that section contained water-washed and partially biodegraded oil (Appendix Fa).

According to AMDEL the Undandita No. 1A oil is isotopically more similar to the Cambrian oil show from the Giles Creek Dolomite in Alice No. 1 than it is to the Ordovician Horn Valley - sourced oils from East Mereenie No. 4 and BMR AP No. 1. However, comparative GC-MS analysis of the Undandita No. 1A and Alice No. 1 crudes would be necessary to validate this tentative oil-oil correlation (Appendix Fb).

Minor fluorescence and cut were reported from the Katapata Sandstone Member (330-343 metres) with no associated gas recorded. The maximum total gas readings recorded from Undandita No. 1A occurred while drilling the Tempe Formation. The highest values were encountered at 283 metres and associated with fracture porosity immediately above a zone of higher total organic carbon measurements (see below). Intermittent break downs of the gas detection apparatus and lost circulation problems make the continuous gas logs unreliable. Below 343 metres 100% lost circulation rendered the gas trap inoperable. Circulation was regained after setting the 4.7" casing at 544 metres, but no more gaseous hydrocarbons were detected in the well.

Source Rocks

The richest potential source rock encountered in Undandita No. 1A occurs in the Tempe Formation. Total organic carbon measurements (Appendix G) indicate maximum TOC values between 285.3 to 286.3 metres with values ranging from 1.43 wt% to 5.45 wt% recorded.

Core Laboratories (Appendix Ga) found that the very organic rich sample at 286.3 metres consisted predominantly of amorphous organic matter which was thermally marginally mature based on Rock-Eval pyrolysis T_{max} data (439^{o}C) and a thermal alteration index of 2+. However, the low hydrogen index (50.9) and relatively low extraction levels of 705 ppm extractable organic matter and 241 ppm hydrocarbons obtained from the organic rich sample suggest that the amorphous organic matter may have been partially oxidised. The C_{10}+ saturated hydrocarbon distribution, with a predominance of paraffins in the C_{14} to C_{24} range and no odd carbon preference, confirms the marine origin of the organic matter and suggests that it is at a thermally marginally mature to mature level. Based on the above data, and in particular the low hydrogen index and extraction levels, the sample at 286.3 metres is thought to have only poor to fair liquid hydrocarbon potential at optimum thermal maturity.

The detailed study by AMDEL (Appendix Gb) generally supports the Core Laboratories conclusions as to the source rock potential (mostly gas prone) and the attained maturity (near the top of the oil generation window) of the section. On the other hand, Marchioni (Appendix Gc) provided non-conclusive evidence from fluorescing organic bodies and maximum reflectance measurements to suggest a much higher maturity of the organic matter than indicated by the Core Laboratories or AMDEL Rock-Eval pyrolyses.

The AMDEL study concluded that, at its present maturation level, kerogen in the carbonaceous siltstone from 285-286 metres depth was dry gas prone, but since this kerogen comprises mainly residual micrinite, it could imply prior release of liquid hydrocarbons from primary, oil prone, algal/bacterial organic matter (Appendix Gb).

Palynological analysis of samples deeper in the well revealed high maturation levels (Appendix H) and the section appears barren of potential source rocks (Appendix Gb).

4.6 Porosity, Permeability & Formation Fluids

Visual porosity estimates were made on core and cuttings from Undandita No. 1 (Enclosure 2) and supplemented by later core analyses (Appendix C). Log derived porosity determinations have proved difficult because of the exotic rock types encountered below 343 metres and the uncertainties inherent in the use of logging tools developed for coal exploration.

Relatively good intergranular porosity was encountered in poorly consolidated intervals in the Cainozoic section, and rig water was drawn from a water well drilled into this unit.

The Illara Sandstone proved generally tight although the upper weathered part had good intergranular porosity.

The Tempe Formation section showed only moderate vuggy limestone/dolomite porosity and fractured zones, but no significant hydrocarbon shows were encountered. Maximum total gas reading of 10 units was recorded.

Circulation was lost at 330 metres, where the extremely porous, medium to coarse grained Katapata Sandstone was penetrated. Poor core recovery and no returns continued to 343 metres. Minor fluorescence and cut were reported in the unit.

The overall porosity of the ?Chandler sequence was moderately good intercrystalline and occasionally vuggy. No hydrocarbons were monitored as far as the 4.7" casing point at 543.35 metres, due to the total loss of circulation. Similar porosity continued to a depth of 773.2 metres, and although circulation was regained from 543.35 metres to this depth, no hydrocarbons were detected. Hydrogen gas to a maximum of 10 units was recorded by the 'hotwire' total gas detector and occurred whenever circulation was sufficient to monitor returns.

Immediately below the evaporites at 773.2 metres an arkosic marl was encountered with an associated drill break from average 16 min/m to average 8 min/m. The section is friable in part with overall fair to good porosity. A more dolomitic section with poorer porosity was noted between 787 metres and 790.2 metres. Core recovery was approximately 50%, indicating the poorly consolidated nature of the section.

The unit 774.75 metres to 801.3 metres showed 30-70% medium bright yellow fluorescence, fair streaming cut and a thick residual ring. Fresh samples exuded a strong petroliferous odour but no increase in gaseous hydrocarbons was evident. This zone was associated with severe lost circulation which continued to total depth. Later testing showed this zone to be underpressured and water saturated (Appendix E).

Extensive core analyses (Appendix C) were carried out on the oil bearing interval with porosities ranging from 6.9% to 22.9% being measured. Permeabilities ranged from less than 1 to 438.7 millidarcies and oil saturations up to 7.5% were recorded in the lower part of the oil zone (Appendix C and F).

Preliminary log calculations for Undandita No. 1A were reported as follows:-

Depth	V Clay	Porosity	RT	SW
776	.339	.1562	2.54	.8877
777	.4375	.1461	3.38	-
780	.3482	.1811	4.6	.713
782	.3393	.1854	5.8	.795
786	.2411	.2290	6.45	.8012
787	.2813	.2028	5.3	.8825
788.5	.2589	.2269	5.16	.7885
790.5	.3036	.19	4.4	.9087
792	.4018	.1592	5.4	-
793	.375	.15	5.63	.75
798.5	.375	.1267	7.64	.73
800.5	.4107	.1972	5.8	.77

All levels below 802 metres indicate high water saturations and reduced porosities resulting from increasing silicification and calcitization. Clay content values were originally thought pessimistic due to possible increased gamma response from glauconite and potash feldspar, consequently, porosity estimates may be artificially too low. However, the high clay content was proven to be correct by petrographic examination of the core (Appendix D) and the log derived porosity estimates are close to core porosity measurements (Enclosure 5).

The interval 802 metres to 1020 metres is generally of tight to moderate porosity. No hydrocarbons were evident in the drilling fluid returns. This section was cored with varying degrees of lost circulation, averaging around 80% loss.

From 1020 metres to total depth at 1201.6 metres the formation penetrated had very tight porosity. No gaseous hydrocarbons were liberated over this interval.

4.7 <u>Contribution to Geological Concepts</u>

The objective of Undandita No. 1 was to test an anticline at Pacoota Sandstone level located on the sub-thrust block of the Deering Fault. The well was the first in the basin designed to test a Pacoota Sandstone sub-thrust target and to investigate the quality of fault seals. Drilling showed that faulting extended further south than was predicted and that the major reverse fault was not sealing, but that the area had significant oil bearing potential.

Significant hydrocarbon shows were encountered within the fault zone from 774.75 to 802 metres with fluorescence and cut in fair to good porosity. Two DSTs and a production test of this zone failed to produce hydrocarbons. Geochemical analysis showed that the oils were residual and had undergone water washing and biodegradation which was consistent with the recovery of brackish water from the production test.

The best source rock encountered in the well was a very organic rich sample at 286.3 metres in the Tempe Formation. Geochemical analysis showed the organic matter to be of marine origin, thermally mature and gas prone. This interpretation is consistent with the minor gas shows that were detected from fracture porosity within the Tempe Formation and intergranular porosity from the Katapata Member.

Most significantly, geochemical analyses of the oil from the fault zone show that it is similar to the Cambrian oil show from the Giles Creek Dolomite at Alice No. 1. The possibility of a Tempe Formation source has far-reaching implications for exploration of Cambrian and younger targets in this part of the basin.

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