W846
MANTA-1
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MANTA-1

WELL COMPLETION REPORT

GIPPSLAND BASIN, OFFSHORE VICTORIA

VIC/P19

GIPPSLAND TEAM/PETROLEUM ENGINEERING

VOL I-TEXT, VOL II FIGURES AND ENCLOSURES

Keywords:

exploration well, Rosedale Fault, Latrobe, intra-Latrobe, Strzelecki, coastal, barrier, coastal plain, alluvial, carbonaceous mudstone, coal, glauconite, Eocene, Paleocene, Upper Cretaceous, coastlines, co-ventures, Tertiary, Gippsland Limestone, volcanics, Lakes Entrance Formation.

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1. SUMMARY

Manta-1, the sixth well drilled in Permit VIC/P19, was spudded on 8 January 1984 by the semi-submersible rig Nymphea and plugged and abandoned on 20 March 1984 after reaching a total depth of 3572m.

Manta-1 was drilled approximately 4km to the NNE of Basker-1 on a similar, but smaller, intra-Latrobe fault trap. The primary objective was fluvial sandstones of Campanian age similar to those which contained hydrocarbons in Basker-1. Basker-1 proved the availability of charge from the kitchen area to the south and it was hoped sand thickness and lateral extent would improve to the north.

A total of 28.3m of oil (in 13 sandstones) and 60.6m of gas (in 17 sandstones) was interpreted from the logs. The main oil sands (the thickest being 17m with 12.9m net oil above an OWC) were in the Campanian coastal plain sequence. The deeper gas sand constitutes a new objective in this area now charge has been proved for sandstones within the volcanics.

The Upper Cretaceous stratigraphic sequence although thinner, was similar to that in Basker-1, but with the lower coastal plain section between the intra and Lower Campanian markers containing more sandstone (32% compared to 21%). Sandstone beds were up to 17m thick compared with 7m in Basker-1.

Below the predominantly volcanic sequence between 2836m and 3236m the well penetrated a mainly sandy section. The sandstones are lithologically similar to those near the base of Hammerhead-1. Palynological studies have shown that the rocks below 3050m belong to the N.senectus zone, and are Campanian to Santonian in age. This is older than ages reported from previous wells in the southern part of VIC/P19, which all reached total depth in T.lilliei Campanian age sediments.

2. INTRODUCTION

Manta-1 was the sixth well to be drilled by Shell in offshore exploration permit VIC/P19, in partnership with News (20%), TNT (20%), Crusader (15%) and Mincorp (5%).

Manta-1 is situated in the central sector of VIC/P19 and was drilled to test a fault trap within the Campanian Latrobe Group. The prospect, although smaller, is analogous to Basker-1, 4km to the SSW. Basker-1 flowed 5720 bbl/d of 43° API oil and 4.8 mmscf/d gas through a 3/4" choke from a 7m sandstone within the Campanian lower coastal plain sequence. Seismostratigraphic studies had shown a facies change just north of Manta probably corresponding to the transition from coastal plain facies to a sandy alluvial facies penetrated in Hammerhead-1. It was predicted, therefore, that sand development in the Campanian section would be better in Manta-1 than in Basker-1.

3. Well History

3.1 Summary of Well Data

Well Classification	: Expendable exploration well
Location Coordinates	: Lat 38°16'27.31"S
	: Long 148°43'19.69"E
Contractor/Rig	: Foramer/Nymphea
Derrick Floor Elevation	: 25m above MSL
BOP Stack	: 133.5.m below MSL
Water Depth	: 10,000 psi 18-3/4" Cameron
Start of Operations	: 1300 hrs 06.01.84
Spudded	: 0300 hrs 08.01.84
Abandoned	: 2230 hrs 20.03.84
End of Operations	: 1715 hrs 23.03.84
Objective	: Upper Cretaceous sandstones in the Latrobe Group
Total Depth	: 3572m
Formation at TD	: Upper Cretaceous sandstones of the Latrobe Group
Results	: Gas/Condensate discovery in a sandstone within the Latrobe Group volcanics. Oil/Gas discovery in intra-Latrobe coastal plain sands.
Casing Record	: 30" at 204m 20" at 646m 9-5/8" at 1921m 7" at 3560m

Logs

DLL/MSFL/GR/SP/CAL	1916-646m
LDL/GR/CAL	1917-646m
LSS/GR	1916-646m
DLL/MSFL/GR/SP/CAL	3296-1900m
LDL/CNL/GR/CAL	3298-1915m
BHCS/GR	3297-1912m
CBL/VDL/GR	1921-200m
WST	3297-300m (27 levels)
RFT pressures	3293-1970m (32 pre-tests)
RFT sample	2754m
DLL/MSFL/GR/SP/CAL	3572-3250m
LDL/CNL/GR/CAL	3572-3250m
BHCS	3297-3250m
HDT	3572-1921m
CBL/VDL/CCL	3535-2190m
RFT pressures	3557-1970m (50 pre-tests)
RFT samples	3315m, 3281.5m, 2738.5m, 2662.4m, 3308.3m, 2678m 2728m 2671m 2617m
CST	Fired 153 Recovered 111

Production Testing

1)	Interval	3290-3299, 3309-3315m
2)	"	2755-2761m
3)	"	2615-2618, 2623-2626m

3.2 Site Survey

The Manta-A site survey was carried out in conjunction with post-drill site clearance surveys over the Basker-1 and Hammerhead-1 locations. Arrangements had been made to carry out clearance surveys over the abandoned well sites in order to meet statutory requirements of the Victorian Department of Minerals and Energy and when it appeared likely that Manta-A would be drilled it was decided to include an area round the probable location in the survey.

As the objective of the debris survey was to locate any material dropped on the sea floor during drilling only side scan sonar was proposed. Adequate knowledge of the sea bed regarding anchor handling had already been obtained and it was considered that further shallow seismic investigations would not be necessary.

Previous use of side-scan sonar on surveys in the permit had given inadequate results due to the retrieval winch and length of tow cable used. Hence for the tender for this operation, particular attention was paid to obtain a remote controlled high speed winch with 1000m of cable. This would enable the side scan fish to be maintained at the required distance above the seabed in order to obtain the resolution required.

The contract was awarded to Geomex Surveys for the provision of the side scan, while the positioning for the line navigation was carried out under the existing positioning contract with Geometra Survey Services.

The equipment was installed on board the supply vessel "Herdentor" and timed at a period when it would not be fully utilised in its supply task. The operation was carried out between 2nd and 15th October 1983.

Problems were encountered with cross-talk between the two channels due to the poor quality and length of the cable. However the results produced were a significant improvement over those obtained previously. Chain scours and areas of slumping were clearly visible, and the method proves an economical and effective means of identifying this type of danger to drilling.

The region around the Manta site was shown to be well away from the slumped zones, with a flat, featureless sea bottom.

3.3 Navigation and Positioning

3.3.1 General

Positioning was provided by Geometra Survey Services (previously known as BTW) using a Syledis B radio positioning system interfaced to a Hewlett Packard 25 computer. Software was provided by the contractor using their "Hydropac" package. Computations were checked throughout the operation using a Hewlett-Packard 85 computer and software supplied by Shell Internationale Petroleum Maatschappij, the Hague. Details are given in Reference 3.

3.3.2 Operations

The positioning system performed well for the operation. Transmissions from shore stations were not interrupted during the period.

The equipment was assembled on board with the main antenna on the derrick top and the mobile and navigation computer on the bridge. After the retrieval of 3 of the anchors weather prevented operations continuing for a period of less than 24 hours. Once all the anchors had been lifted, the two proceeded well. The distance travelled was considerably longer than the direct distance as the rig had to actually pass the location, turn about and return travelling along a line suitable for the dropping of anchor no. 6.

As the rig was not equipped with radar, or direction pointers, the only method of obtaining the directions of the anchors was from the radar bearings obtained from the anchor handling vessels. Final anchor distances were obtained from chain lengths read from the control room indicators.

3.3.3 Syledis Maintenance

During the previous rig move the Syledis positioning system had produced some anomalous readings in error by about 110m. This was an indication that the filters were out of adjustment, and full field maintenance of the chain was carried out. On this move, these anomalies did not reoccur, and it is assumed that the measures were effective.

The procedure was adopted of taking Standing Wave Ratio measurements of the antennas and cable used. From the results it was deduced that many of the components had severely depreciated, and needed repair. Hence these tests will be included as a standard requirement for future operations.

3.3.4 Gyro Reference Marker Directions

For this purpose of gyro surveys made on the Nymphea, the direction of a line from the drill floor to a reference marker is required to be accurately determined.

From the position of this well, a number of Esso production platforms may be seen. These have been accurately surveyed by means of a laser traverse, and their co-ordinates are known to within a metre. Ideally, these should be used as reference markers as their directions from the 'Nymphea' are stable and accurate to within a minute of arc.

Using these as accurate indicators, the direction of the required line was determined using a sextant to measure the angle between the line and the bearing to the platform positions. The final direction is:

Manta-1 (drill floor) to reference marker = 268° 36'

3.4 Drilling History

Following the end of operations at Basker South-1 at 1300 hrs on 6/1/84, Nymphea was towed to the Manta-1 location.

After completing the running of the anchors and pretensioning to 180-200 tons, the temporary guide base was run and set at 158m bdf. The 36" BHA was made up, and Manta-1 spudded at 0800 hrs on 8/1/84. The 36" hole was drilled to 211m and circulated to viscous mud. Four joints of 30" casing together with the permanent guide base were run and the casing cemented with returns to the seabed.

The shoe track and pocket were cleaned with a 26" bit and then a 12-1/4" pilot hole was drilled to 655m in 23 hrs. The 26" BHA was made up and the hole opened up to 26" using seawater and viscous pills. 40 joints of 20" casing were run and landed with the shoe at 646m. The casing was cemented with returns to the seabed observed by the divers.

The BOP and riser were run, landed and tested in 24 hours. After making up the 17-1/2" drilling assembly and tagging cement at 633m, the shoe track and pocket were drilled out with seawater. The hole was displaced to mud and a leak off test performed, giving an equivalent maximum mud gradient of 1.57 s.g. A 12-1/4" assembly was made up and 12-1/4" hole drilled to 1932m in 5 bit runs and 6 days. The main problem during this section was sticky hole, and hydrating clays in the Lakes Entrance Formation.

Three logging runs were made:

1) DLL/MSFL/GR/SP/CAL
2) LDL/GR/CAL
3) LSS/GR

A checktrip was made, and the hole circulated clean. 148 joints of 9-5/8" 47 lb/ft N80 casing were run and landed with the shoe at 1921m. The casing was cemented, pressure tested to 3500 psi and the seal assembly energised. After a BOP stack test, the casing running tool was retrieved and the 9-5/8" wearbushing set. The 8-1/2" BHA was made up and the collar, shoe track and pocket to 1932m were drilled out. New formation was drilled to 1962m and a leak off test carried out (EMG 1.86 s.g.). An

Eastman gyro multishot survey was then run on Schlumberger cable from 1950m to 150m.

An 8-1/2" hole was drilled to 3300m in 9 days using 8 bit runs. No special problems were encountered during this section except for occasional overpulls (up to 50t) whilst making round trips/checktrips.

Intermediate logs were run as follows:

1) DLL/MSFL/GR/CAL/SP
2) LDL/CNC/GR
3) BHCS/GR
4) WST

After rigging down Schlumberger, a core barrel was made up and run in. The interval 3300-3309 was cored with 95% recovery. An RFT run was then made with a segregated sample taken at 2754m recovering oil.

An 8-1/2" hole was then drilled trouble free from 3309m to a TD of 3572m in 5 days, using 2 bit runs.

The following TD wireline logs were run:

1) DLL/MSFL/GR/CAL/SP
2) LDL/CNL/GR/CAL
3) BHCS/GR
4) HDT

Four RFT runs were now made with samples taken at 3315m (filtrate), 3281.5m (gas), 2738.5m (gas), and 2662.4m (oil).

A 9-5/8" RTTS packer was made up and run to 1800m to pressure test the casing. The packer was set and at 4650 psi pressure was lost and it was assumed that the casing had burst. After laying down the RTTS, four further RFT runs were made, with gas recovered from 2678m, 2728m and 2671m and oil from 2617m. Three CST runs were now made (Fired 153, recovered 111).

After rigging down Schlumberger, the 9-5/8" RTTS was made up and the casing pressure tested again, and found to be intact. The RTTS was laid down, the mud conditioned, and 286 joints of 7" casing run and landed with the shoe at 3560m. After cementing, the casing was tested to 5000 psi, the pack-off assembly was energised, and the BOPs tested.

Difficulties in setting the wearbushing were encountered. It was eventually set on the fifth attempt. The 5" drillpipe was laid down. A scraper run was made as 4-3/4" collars and 3-1/2" drillpipe were picked up, and the cement was tagged at 3536m. The hole was displaced to seawater, and then to brine, following which Schlumberger ran a CBL/CCL/VDL/GR and a junk basket/gauge ring to an HUD of 3537m.

Schlumberger next set an F-1 packer at 3238m but were unable to pull out the setting tool. The weak point was broken and the setting tool successfully fished out. It was found that a 5-1/2" releasing sleeve had been used instead of a 7" one.

Flopetrol were rigged up and 2-7/8" and 3-1/2" tubing run in and tested. The tubing was displaced to diesel following which Schlumberger perforated the interval 3309-3315m using a through tubing 2-1/8" enerjet perforating gun with four shots per foot. The well was opened on a 3/16" choke and allowed to clean up. It was then flowed on several chokes from 1/4" to 9/16", then shut in. On the 9/16" choke the production rate was 4.62 MMSCFD gas and 150 BCPD condensate.

Schlumberger perforated an additional nine metres of the same sandstone unit from 3299m to 3290m. The well was allowed to clean up again, and after that, flowed on a 3/8" choke. The well was shut in and Schlumberger ran in the PLT before the ten hour mainflow period on a 9/16" choke. The HP pressure gauge failed in the lubricator, and was replaced. This and an insulation problem resulted in five hours of lost time. After 18 hours of being shut in, the well was opened up for the multiflow period of two hours each on 3/8", 1/2", 5/8" and 3/4" chokes. On the 3/4" choke the production rate was 18.6 MMSCFD gas and 1022 BCPD condensate, with essentially no BS+W (bottom sediment plus water). The well was shut in for 4-1/4 hours before Schlumberger pulled out the PLT and rigged down. The well was squeeze killed with brine, and after pulling out the packer, reverse circulated clean.

The formation of gas hydrates required injection of Glycol and Methanol. The main limitations on increasing the production rates were tubing size and backpressure in the flowline downstream of the choke.

The test string was pulled out. Schlumberger ran a junk basket/gauge ring, then set a Baker Model N bridge plug at 3235m. Cement plugs numbers 1 and 2 were set over the intervals 3335m to 3135m and 3093m to 2993m.

Production test number two started with Schlumberger setting an F-1 packer at 2715m. Tubing was run in and displaced to diesel. The interval 2755m to 2751m was perforated with four spf using a through tubing 2-1/8" enerjet perforating gun. The well was cleaned up on a 1/4" choke beaned up to 3/8" and 5/8". The well was closed in and the PLT run to bottom, with the appropriate gradient stops en route.

The main flow period of ten hours on a 7/16" choke was followed by 8½ hours of build up. The multiflow period consisted of two hours each on four chokes up to 3/4". On this last choke the zone produced at a rate of 5157 bbl of waxy oil and 4.518 MMSCFD gas. Two hours of build up followed before the PLT was pulled out. One bottom hole sample was obtained from two Flopetrol bottom hole sampler tandem runs.

The well was killed and circulated clean and the tubing pulled. Schlumberger ran a junk basket/gauge ring and set a Model N bridge plug at 2714m. A cement plug (number 3) was set over the interval 2714m to 2650m.

For production test 3, an F-1 packer was set at 2568m. The tubing was run in and displaced to diesel. The intervals 2623-6m and 2615-8m were perforated with four spf by two runs of a 2-1/8" enerjet through tubing perforating gun. After cleaning up, the well was closed in and a PLT run in. The well was opened up on a 1-1/2" choke for an 8¼ hours main flow period followed by a six hour buildup. The well was opened up for a multiflow test for two hours on each of five chokes to 1". On this last choke it flowed 6369 BOPD oil and 5.134 MMSCFD gas. After a short build up the PLT was pulled and a Flopetrol bottom hole sampler run in. Only two samples were obtained from four runs in 21 hours due to a variety of tool and operator problems.

The well was killed and reverse circulated out and the tubing pulled. A Model N bridge plug was set at 2569m and a cement plug set over the interval 2569m to 2379m.

The 7" casing was cut at 1895m and 146 joints of it recovered in 16½ hours, of which 6¼ hours were lost to AWU meetings. A cement plug (number

5) was set across the cut to cover the interval 1950m to 1750m six joints of the stinger were cemented up. The plug was tagged at 1763m and the casing tested to 2000 psi before setting the final cement plug (number 6) over the interval 300m to 200m.

The 9-5/8" casing was cut at 174m. The riser and BOP stack had been pulled when a derrickman fell through the gap where the rathole moves back and forward - the cover plates being up while a tugger was in use. He fell into the moonpool, hitting his head on the BOPs as he went down. An air/sea search failed to locate the body.

ICI ran an explosive charge which cut the 20" and 30" casings on the first attempt but broke the wellhead. The tops of the 20" and 30" casings, the PGB and the TGB were recovered, and Solus were making a final video film of the seabed when they sighted the body of the missing derrickman. The body was recovered and another video film made. Total time lost on the search for, and the recovery of the derrickman's body amounted to 33½ hours.

While retrieving the anchors, numbers 3 and 7 anchor chains crossed and became fouled. Eventually they were separated using a grapple. The supply boats used for the anchor handling were the M/V Herdentor and the M/V Lady Penelope with the M/V E.B.Cane used on temporary charter as a standby boat. The tow from Manta-1 to the Chimaera-A location began at 1715 hours on 23.03.84.

3.5 List of Contractors, Service Companies and Main Equipment

The Nymphea was brought into Australian waters under a one year contract between Shell Development (Australia) Pty Ltd and Foramer S.A.

The following contractors and service companies had contracts with Shell Development for the duration of the one year drilling programme:

Drilling Contract	:	Foramer S.A.
Supply Vessels	:	Australian Offshore Services Vessels used - Herdentor - Lady Penelope
Helicopter Services	:	Commercial Aviation
	:	2 x Bell 212 Helicopters
Electric Logging	:	Schlumberger (Logging Unit No. 612)
Mud Logging	:	Exlog (Gemdas Unit No. 216)
Subsea Support Services	:	Solus Ocean Systems OMBV System
Surface Production Testing	:	Flopetrol Schlumberger
Cementing Services	:	Halliburton Australia (Unit No. 7534)
Mud Service and Materials	:	Baroid Australia Pty Ltd

Main Equipment

Drilling Vessel Design	:	Enhanced Pacesetter Semisubmersible
Drilling Vessel Built	:	1982 Hitachi Zosen
Derrick	:	160 ft, 1,000,000 lbs
Drawworks	:	National 1625DE 16,000-25,000 ft rating
Mud Pumps	:	National 12P-160 7" x 12"
BOP's	:	Cameron 18-3/4" 10,000 psi WP
Well Head Equipment	:	Vetco SG-5
Anchors	:	8 x 20 Stevin type anchors 8 x 3" chain 3 - breaking load 474 MT
Cementing Unit	:	Halliburton
Solids Control Equipment	:	- Harrisburg triple tandem shale shaker - Pioneer Sandmaster Desander T8-6 capacity 800 GPM - Pioneer Siltmaster Desilter T16-4 capacity 800 GPM - Thule VMS 200 Mud Cleaner 16 cones - 1 Swaco degasser

3.6 Drilling Data

3.6.1 Bit Record

See Table 1: Bit Record

3.6.2 Casing Summary

See Table 2: Casing Summary

3.6.3 Cement Summary

See Table 3: Cement Summary

3.6.4 Mud Summary

See also Table 4: Mud Record

36" and 26" Hole Section

The 36" and 26" holes were drilled with seawater and viscous pills with minimum control of properties. Before running the 20" casing, the 26" hole was displaced to viscous mud (prehydrated bentonite).

12-1/4" Hole Section

The 12-1/4" hole was drilled with a seawater-bentonite-polymer system. A mud weight of 1.09-1.11 sg was used and the MBC was kept less than 12 lb/bbl. Celpol was used to keep the yield point in the range 10-16 lb/100 sq.ft. A continuous addition of seawater was required to maintain the mud weight less than 1.11 sg (2-5 m^3/hr seawater). The mud was weighted up to 1.14 sg with barite, at the finish of the 12-1/4" hole section, in order to help stabilise the Lakes Entrance Formation.

No hole problems were experienced and the mud properties were easy to maintain.

8-1/2" Hole Section

Mud weight was run at 1.11-1.14 sg, MBC 8-13 lb/bbl, yield point 12-17 lb/100 sq.ft, and API water loss less than 5cc/30 min. Water loss and rheology were controlled by additions of Dextrid and CMC.

In general this section was trouble free. The high and fluctuating torque problem encountered whilst drilling Volador-1 was also evident, but was effectively controlled by using a six point roller reamer and shock sub in the BHA.

3.6.5 Formation Intake Tests

Formation intake tests were carried out on drilling out the 20", and 9-5/8" casing shoes. The following results were obtained:

Depth (m)	Surface Pressure (psi)	Mud (sg)	EMG (sg)	Formation
646	500	1.03	1.57	Marl
1921	2000	1.14	1.86	Paleocene SST

3.6.6 Lost Circulation

None

3.6.7 Perforations

The following intervals were perforated with four shots/foot using a through tubing 2-1/8" Enerjet perforating gun.

Production Test 1	3309-3315m, 3290-3299m
" " 2	2755-2761m
" " 3	2623-2626m, 2615-2618m

TABLE 1 : BIT RECORD SUMMARY - WELL MANTA-1

Run No.	Bit No.	Hole Size (inch)	Bit Type	Jet Size	Depth Out (m)	Metres	Hours	WOB (mt)	RPM	Flow (1/min)	Press (psi)	Mud Wt SG	Mud Vis (sec)	Dull Code T	Dull Code B	Dull Code G	Remarks
1	1	36	DSJ	20 20 20	211	53	4.25	1	30/50	4000	1000	Seawater		2	2	1	Sec H/O + 26" pilot
2	1	26	DSJ	20 20 20	217	6	0.75	5	50	4000	1000	Seawater		2	2	0	
3	2	12¼	SDGH	20 20 20	655	438	23.75	1/5	100	3800	1000	Seawater		2	5	0	
4	1	26	DSJ	20 20 20	655	438	32.75	10	75	3800	1800	Seawater				0	
5	3	17½	DSJ	20 20 20	660	5	0.5	6	60	3500	1800	Seawater					Drilled out shoe
6	4	12¼	DS23	14 13 13	866	206	25.25	5/12	150	3000	1750	1.04	40	100% New			20 h on bottom
7	5	12¼	DSJ	16 16 16	1309	443	41.25	12/15	120	3100	2600	1.10	45	3	3	0	33.3 h on bottom
8	4	12¼	DS23	13 12 12 10 11 10	1343	34	3.25	2/8	150	3650	2850	1.10	45	100% New			Balled up
9	6	12¼	DSJ	16 16 16	1869	526	47.25	15	120	2178	2650	1.10	46	2	5	0	38.3 h on bottom
10	7	12¼	DSJ	16 16 16	1932	72	5.75	12	120	2178	2650	1.14	46	2	2	0	
11	7	12¼	DSJ	16 16 16	1932									2	2	0	Checktrip
12	8	8½	SDS	11 11 10	1962	30	5	5/10	60	1175	2000	1.14	50				Drilled Shoe etc.
13	8	8½	SDS	11 11 10	2015	83	11.25	5/8	75	1566	2000	1.14	50	4	3	1/8	

TABLE 1 : BIT RECORD SUMMARY - WELL MANTA-1 (continued)

Run No.	Bit No.	Hole Size	Bit Type (inch)	Jet Size	Depth Out (m)	Metres	Hours	WOB (mt)	RPM	Flow (1/min)	Press (psi)	Mud Wt SG	Mud Vis (sec)	Dull Code T	Dull Code B	Dull Code G	Remarks
14	9	8½	F2	11 11 10	2200	185	15	10	60	1560	2000	1.12	49	2	4	1/8	11.3 h on bottom
15	10	8½	F2	11 11 10	2456	256	36	10/15	70	1500	2400	1.12	41	3	5	0	31.9 on bottom
16	11	8½	F2	11 11 10	2694	238	41.5	15	70	1500	2450	1.12	46	2	5	1/8	37.9 h on bottom, one broken insert
17	12	8½	F3	11 11 10	2885	191	49.5	15	70	1500	2500	1.12	42	2	5	1/8	45.8 h on bottom, two broken inserts
18	13	8½	F3	11 11 10	3055	170	50.75	15	70	1500	2600	1.13	41	2	6	0	Skirt worn ¼"
19	14	8½	F3	11 11 10	3209	154	48	15	70	1500	2600	1.13	46	2	6	1/8	Skirt worn ½"
20	15	8½	F3	11 11 10	3300	91	26.75	15	70	1500	2650	1.14	43	2	3	1	
21	16	8-15/32	C22				3309				9	9	5				
75	800		925	1.13 45 30% worn		Core #1, 95% rec.											
22	17	8½	F3	11 11 10	3451	142	43.25	15	70	1500	2700	1.13	42	4	4	¼	
23	18	8½	F4	11 11 10	3572	121	49.25	15	70	1550	2715	1.13	46	5	5	1/8	46.3 h on bottom
24	18	8½	F4														Checktrip 18.2
25	18	8½	F4														Checktrip 20.2
26	19	6	FDT														Scraper run

TABLE 2 : CASING SUMMARY - MANTA-1

Date Run	Size (in)	Grade	Weight (lb/ft)	Coupling	Shoe Depth (mbdf)	Remarks
08.01.84	30	B	310	ATD	204	Four Joints
12.01.84	20	X 56	133	Vetco LS	646	40 Joints. 18-3/4" 10,000 psi SG-5 Wellhead system.
22.01.84	9-5/8	N80	47	BTC	1921	148 Joints
21.02.84	7	P110/L80/N80	29	BTC	3560	66/13/207 Joints

TABLE 3 : CEMENT SUMMARY - MANTA-1

Date	Job Description	Hole Size /Depth (mbdf)	Casing Shoe (mbdf)	Cement used (mt)	Slurry Weight (S.G.)	Mix Water Additives	Remarks
08.01.84	30"	36"/211	204	6.3 Class G	1.54	2% BWOC $CaCl_2$ 2.5% BWOW Bentonite Seawater 13.5m^3	Returns to seabed Design Figures
				9.1 Class G	1.90	Neat Seawater 8.8m^3	Lead: 2.84m^3 slurry/mt cement 2.13m^3 mixwater/mt cement Tail: 1.68m^3 slurry/mt cement 0.97m^3 mixwater/mt cmt
12.01.84	20"	26"/655	646	39.0 Class G	1.48	2% BWOC $CaCl_2$ 3% BWOW Bentonite Seawater 10.6m^3	Returns to seabed observed by divers Design Figures
				10.9 Class G	1.90	Neat Seawater 10.6m^3	Lead: 3.23m^3 slurry/mt cement 2.49m^3 mixwater/mt cmt Tail: 1.68m^3 slurry/mt cement 0.97m^3 slurry/mt cement
22.01.84	9-5/8"	12¼/1932	1921	19.5 Class G	1.48	3% BWOW Bentonite Seawater 48m^3	TOC: 455m Design Figures Lead: 3818m^3 slurry/mt cement 2.46m^3 mixwater/mt cement
				2.0 Class G	1.90	0.2% BWOC HR-7 Seawater 1.9m^3	Tail: 1.69m^3 slurry/mt cement 0.97m^3 mixwater/mt cement

TABLE 3 : CEMENT SUMMARY - MANTA-1 (continued)

Date	Job Description	Hole Size /Depth (mbdf)	Casing Shoe (mbdf)	Cement used (mt)	Slurry Weight (S.G.)	Mix Water Additives	Remarks
22.02.84	7"	8½"/3572	3560	40 Class G	1.90	0.75% BWOC cfr-2 0.6% BWOC Halad 22A 0.3% BWOC HR-12	TOC 2250m Design Figures 0.76m^3 slurry/mt cement
04.03.84	Abandonment Plug 1	7" liner		2.5 Class G	1.90	1.1m^3 freshwater 0.2% BWOC HR-12	Plug 1 3235-3135m
04.03.84	Plug 2	7" liner		2.5 Class G	1.90	1.1m^3 freshwater 0.2% BWOC HR-12	Plug 2 3093-2993m
09.03.85	Plug 3	7" liner		1.4 Class G	1.90	0.6m^3 freshwater No additives	Plug 3 2714-2650m
15.03.84	Plug 4	7" liner		5 Class G	1.90	2.3m^3 freshwater No additives	Plug 4 2569-2379m
17.03.84	Plug 5	7" liner/ 9-5/8" csg		8.7 Class G	1.9	3.8m^3 freshwater No additives	Plug 5 ±950-±763m
18.03.84	Plug 6	9-5/8" liner		5 Class G	1.9	2.2m^3 freshwater No additives	Plug 6 300-200m

TABLE 4 : MUD RECORD - WELL MANTA-1

Depth (mbdf)	Weight S.G.	Vic (API) sec	PV (cp)	YP	Gels 10 sec	Gels 10 min	Filtrate (API) (cc)	Filtrate Ca++ ppm	Analysis Cl ppt	Sand (%)	Retort Water %	Analysis Solids %	pH
36" and 26" hole drilled with seawater and viscous slugs													
827	1.04	37	6	6	2	10	10.0		14	0	96	4	10.0
950	1.06	45	11	13	2	12	7.0	9	15	0.125	96	4	9.0
1236	1.08	44	11	11	2	10	8.0	16	19	0.125	96	4	9.5
1378	1.10	44	12	13	3	16	7.0	5	18	0.125	96	4	10.5
1625	1.10	44	14	14	2	15	6.0	Tr	19	0.5	95	5	10.0
1869	1.11	46	11	15	2	20	6.0	4	19	Tr	94	6	9.0
1932	1.14	46	12	16	4	18	8.0	Tr	19	Tr	93	7	10.1
1962	1.14	50	10	14	17		10.0	Tr	19	0.125	93	7	11.5
2086	1.12	49	16	22	4	25	5.0	Tr	19	Tr	94	6	10.3
2246	1.12	49	17	21	4	18	4.0	Tr	19	Tr	94	6	10.1
2383	1.12	45	13	19	2	25	5.0	Tr	19	Tr	94	6	9.5
2498	1.12	41	11	15	3	17	5.0	1.0	19	Tr	94	6	9.3
2618	1.12	44	12	15	3	18	5.0	1.0	19	Tr	94	6	9.8
2694	1.12	46	12	16	4	18	4.0	Tr	19	Tr	94	6	10.1
2742	1.13	50	13	23	7	24	4.0	Tr	19	Tr	93	7	10.6
2836	1.13	39	11	16	4	18	4.0		10	Tr	93	7	10.6
2885	1.12	42	11	15	3	18	3.8	Tr	20	Tr	94	6	9.9
2948	1.13	41	11	17	6	20	4.5	Tr	20	Tr	93	7	10.0
3031	1.12	41	11	14	6	20	4.5	Tr	20	Tr	94	6	10.0
3067	1.13	52	17	21	5	20	3.5	Tr	20	Tr	93	7	10.4
3151	1.13	49	15	15	2	17	4.0	Tr	21	Tr	93	7	10.4
3205	1.13	46	14	17	5	17	4.0	Tr	22	Tr	93	7	10.5
3248	1.14	46	16	16	5	17	4.0	Tr	22	Tr	92	8	10.6
3300	1.14	43	14	17	5	16	4.0	Tr	22	Tr	92	8	10.7
3308	1.13	45	13	15	5	15	4.0	Tr	21	Tr	93	7	10.2
3338	1.13	45	14	14	4	14	3.0	1.0	21	Tr	93	7	
2300	1.14	45	13	19	7	20	3.8	Tr	21	Tr	92	8	10.3
3451	1.13	42	11	13	5	18	4.5	Tr	21	Tr	93	7	10.1
3498	1.14	45	15	19	5	20	3.0	Tr	22	Tr	92	8	10.0
3536	1.14	42	14	15	3	17	4.8	80	21	Tr	92	8	9.3
3572	1.13	46	15	15	4	20	4.5	80	21	Tr	92	8	9.7

3.6.8 Fishing

Almost 15 hours were spent on one fishing operation. Schlumberger mistakenly ran the 7" F-1 packer for Production Test 1 with a releasing sleeve for a 5-1/2" packer. Schlumberger were unable to pull out the setting tool. The weak point was broken and a Schlumberger overshot run in on drillpipe. The fish was retrieved on the first run into the hole, the packer remaining in position on depth.

3.6.9 Side Tracking

None

3.6.10 Deviation

See Table 5 - Deviation Record

See Figure 4 - Well Path (Plan View)

3.6.11 Abandonment

See Figure 5 - Well Status

TABLE 5 : DEVIATION RECORD - MANTA-1

See Fig. 4 for the plot of the well path to 3570m.

Depth a.h.	Inclination (deg)	Remarks
170	1	Totco
211	0	"
403	1/2	"
655	1/2	"
866	1	"
1309	0	"
1869	1½	"
1932	1½	"
2199	1¼	"
2314	1¼	"
2456	1¼	"
2590	1	"
2694	1½	"
2885	2¼	"
3055	1½	"
3205	1½	"
3300	3/4	"
3451	1	"
3572	2½	"

The Eastman gyro survey to 1900m gave 1-3/4°, azimuth 014° at that depth. The plan view of the well path (Fig. 4) utilises that data to the 9-5/8" setting depth.

From 1950m to 3570m the data plotted is derived from the Schlumberger HDT log. At 3570m this shows the inclination to be 2.6° with an azimuth of 275°. Horizontal displacement at 3570m is calculated to be 32.2m along bearing 311°.

3.7 Formation Evaluation

3.7.1 Mudlogging Services

The mudlogging services on the Nymphea were provided by Exploration Logging Australia.

The unit was crewed by two mudloggers and one 24 hour Gemdas computer operator.

Services included collection, washing, drying and packing of cuttings samples, routine examination of cuttings and checking for hydrocarbon indications; continuous monitoring of drilling parameters (ROP, WOB, torque, pump rate), mud tank levels, and mud weight; continuous monitoring and chromatographic analysis of gas. These values were recorded at one metre for 8-1/2" and 5 metre intervals (in top hole) by an on-line computer which also produced real-time prints and plots (against driller's depth) of this data. Logged depths were calculated automatically by the computer.

A package of interactive programs to assist in drilling control, drilling optimisation, pressure evaluation and formation evaluation were available from the Gemdas unit. Examples of these programs include hydraulics analysis, D exponent analysis, kick analysis, fracture gradient analysis. A summary of this data can be found in Reference 4.

3.7.2 Cuttings

Ditch cuttings were collected every 10m below 20" casing (660m) down to 9-5/8" casing depth and thereafter every 3m to total depth. The samples were bagged and distributed as follows:

(a) Four sets of washed and dried samples (in 100gm packets) were prepared; one set each was sent to the Bureau of Mineral Resources and the Victorian Department of Minerals and Energy, and two sets were sent to Corelab, Perth to be stored on behalf of Shell Development.

(b) An additional set of washed and dried samples was packed into miniature plastic samplex trays and sent to Shell Development in Perth for office use.

(c) Two sets of unwashed cuttings packed in half-kilogram bags were sent to Corelab, Perth (for Shell).

Descriptions are given in Reference 5.

3.7.3 Sidewall Samples

A total of 153 shots were fired with a total recovery of 111 samples. For descriptions of samples see Reference 5.

3.7.4 Velocity Survey

The velocity survey, carried out by Schlumberger was performed at 27 levels. The results are shown in Reference 5.

3.8 Petrophysics

3.8.1 Wireline Logs

The following wireline logs were run:-

Date	Hole Size	Interval	Type
21.01.84	12 1/4"	1916-646m	DLL/MSFL/GR/SP/CAL
		1917-646m	LDL/GR/CAL
		1916/646m	LSS/GR
09.02.84	8 1/2"	3296-1921m	DLL/MSFL/GR/SP/CAL
		3298-1921m	LDL/CNL/GR/CAL
		3297-1921m	BHC/GR
	9 5/8" casing	1921-200m	CBL/CCL/VDL/GR
		3297-300m	WST 27 levels
11.02.84	8 1/2"	3293-1970m	32 RFT pre-tests
		2754m	RFT 1 Segregated sample (6 gal & 1 gal)
16.02.84	8 1/2"	3568-3250m	DLL/MSFL/GR/SP/CAL
17.02.84		3572-3250m	LDL/CNL/GR/CAL
		3569-3250m	BHC/GR
		3571-1921m	HDT
		3315m	RFT 2 Segregated sample
		3281.5m	RFT 3 Segregated sample
		1970-3557	50 RFT pre-tests
18.02.84		2738.5m;2662.4m	RFT 4,5 Non-segregated samples
19.02.84			RFT 7, 8 pretests (probe plugged)
		3308.3m	RFT 6 (cable faulty) Non-segregated sample
		2678m, 2728m	RFT 7, 8 Non-segregated samples
		2671m, 2617m	RFT 9, 10 Non-segregated samples
20.02.84			CST. 153 shot, 14 empty 3 lost, 26 misfires 111 recovered
26.02.84	7" casing	3525-2190m	CBL/CCL/VDL/GR

3.8.2. Evaluation

3.8.2.1 General

All logged intervals down to 2600m were found to be water-bearing. Hydrocarbon-bearing intervals whether rich gas or oil were calculated between 2607 to 3317m in sandy layers of varying thicknesses (0.6m to 39m net). A total of 10 RFT samples (refer 3.9.1) were attempted in order to either confirm the nature of interpreted hydrocarbons or, in two instances, to clarify their fluid type.

Derived total net hydrocarbon figures are as follows:

Total net oil 28.3m (19.1m in sandstones $\geqslant$ 3m thick)
Total net gas 73.1m (60.6m in sandstones $\geqslant$ 3m thick)

3.8.2.2 Formation Water Resistivity (R_w)

R_w values were derived from logs through clean water bearing sands rather than by measurement of the recovered water from Production Tests. The derived values tie in with the measured values from Production Tests in nearby wells.

3.8.2.3 Method of Evaluation

3.8.2.3.1 Method Used

For a description of the method used see Appendix 7.1

3.8.2.3.2 Petrophysical Parameters Used in Evaluation

Refer to Table 6 for details of petrophysical parameters.

TABLE 6 : PETROPHYSICAL PARAMETERS USED IN EVALUATION - MANTA-1

PARAMETER		INTERVAL							
		2025-2276m	2276-2480m	2480-2566m	2566-2600m	2600-2811m	2811-3211m	3211-3330m	3330-3570m
GR minimum	(API units)	24	24	24	24	24	24	24	24
GR maximum	(API units)	140	140	140	140	140	140	140	140
mf	(g/cc)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ma	(g/cc)	*2.66/2.72	*2.66/2.72	*2.66/2.72	*2.66/2.72	*2.66/2.72	*2.66/2.72	*2.66/2.72	*2.66/2.72
R_{mud}	(ohm.m)	0.8	0.8	0.8	0.7	0.07	0.067	0.066	0.066
R_{mc}	(ohm.m)	0.165	0.165	0.165	0.15	0.15	0.14	0.093	0.093
R_{sh}	(ohm.m)	10	25	25	25	25	25	25	25
R_w	(ohm.m)	0.12	0.145	0.14	0.14	0.135	0.135	0.135	0.18
m		2.098	2.098	2.098	2.098	2.098	2.098	2.098	2.098
A		0.584	0.584	0.584	0.584	0.584	0.584	0.584	0.584
n		1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83

h(g/cc) oil = 1.00

gas = 0.11

* 2.66 g/cc in sands

2.72 g/cc in dolomitic sands

GR	=	Gamma Ray Reading	m	=	Cementation Factor
mf	=	Mud Filtrate Density	A	=	Constant
mc	=	Matrix Density	n	=	Saturation Exponent
R_{mud}	=	Mud Resistivity	R_w	=	Formation Water Resistivity
R_{mc}	=	Mud Cake Resistivity	h	=	Hydrocarbon Density
R_{sh}	=	Shale Resistivity			

3.8.2.4 Evaluation Results

Refer to Table 7 for a complete tabulation of results and to Enclosure 1 for the depth plot of the evaluation.

3.8.2.5 Core Analyses

Measurements of porosity/horizontal permeability (both at atmospheric and insitu conditions), vertical permeability and grain density were performed by Corelab on plugs from core no.1 of Manta-1. Interpreted results are as follows:

3.8.2.5.1 Porosity/Permeability Relationships at atmospheric conditions (Refer figure 4)

(a) Corelab - Adelaide Laboratory

$$\log k = 17.02\,\phi - 0.495$$

where:

k = horizontal permeability in mD
ϕ = porosity in fraction

(b) Corelab - Perth Laboratory

$$\log k = 17.33\,\phi - 0.7$$

where:

k = horizontal permeability in mD
ϕ = porosity in fraction

The observed difference in measurements is within the tolerance limits (5%).

TABLE 7 : RESULTS OF PETROPHYSICAL EVALUATION : MANTA-1

Interval (M)	Net (M)	Avg. Porosity %	Avg. Hyd. Sat %	Fluid
2607.4 - 2608.2	0.8	22.2	45.0	Oil
2614.9 - 2617.9	3.0	19.9	57.6	Oil
2623.1 - 2626.3	3.2	23.0	47.5	Oil
2646.3 - 2648.7	2.4	17.9	59.2	Gas
2649.3 - 2649.9	0.6	22.7	71.6	Gas
2662.1 - 2663.3	1.2	19.9	68.9	Oil
2668.8 - 2672.8	4.0	19.4	80.7	Gas
2674.3 - 2680.7	6.4	21.4	76.3	Gas
2683.9 - 2686.9	3.0	19.2	72.2	Gas
2721.2 - 2722.0	0.8	21.7	71.8	Gas
2726.1 - 2729.4	3.3	20.9	82.3	Gas
2731.2 - 2731.9	0.7	16.6	49.4	Gas
2736.3 - 2741.2	4.9	20.4	65.0	Gas
2743.6 - 2744.5	0.9	18.4	41.3	Gas
2751.1 - 2751.7	0.6	23.5	59.8	Poss Gas
Possible Gas/Oil Contact at 2751.7m				
2751.7 - 2765.6	12.9	21.7	63.4	Oil
Oil/Water Contact at 2765.6m				
2801.4 - 2802.4	1.0	19.9	41.5	Oil
2808.7 - 2809.5	0.8	21.8	55.0	Oil
2811.9 - 2813.1	1.2	18.7	41.8	Oil
2884.0 - 2885.4	1.4	24.8	48.3	Oil
2995.9 - 2996.6	0.7	15.2	40.5	Oil
3040.2 - 3040.8	0.6	20.2	42.8	Oil
3043.7 - 3044.9	1.2	19.5	61.1	Gas
3046.0 - 3047.5	1.5	18.1	77.4	Gas
3145.4 - 3146.4	1.0	20.6	47.5	Oil
3154.5 - 3155.4	0.9	22.2	43.3	Oil
3216.9 - 3217.6	0.7	17.7	31.6	Gas
3241.8 - 3243.2	1.4	17.9	52.4	Gas
3258.3 - 3260.4	1.5	11.9	49.7	Gas
3261.0 - 3261.9	0.9	11.8	31.1	Gas
3273.5 - 3317.0	39.0	13.5	56.6	Gas

Inferred Gas/Water Contact from Log Evaluation at 3317.0m

Inferred Gas/Water Contact from Pressure Data at 3320.0m

TOTAL NET OIL: 28.3m (19.1m ⩾ 3m THICK) CUT-OFFS : POR - 13%; HYD SAT - 40%

TOTAL NET GAS: 73.8m (60.6m ⩾ 3m THICK) CUT-OFFS : POR - 10%; HYD SAT - 30%

3.8.2.5.2 Porosity/Permeability Relationship at insitu conditions - 5000 psi (Refer figure 5)

$$\log k = 20.52 \phi - 0.88$$

where:

k = horizontal permeability in mD
ϕ = porosity in fraction

3.8.2.5.3 Vertical Permeability

Measured values varied between 0 - 83mD which tend to indicate low vertical mobility

3.8.2.5.4 Grain Density

An average value of 2.665 g/cc for matrix density was derived which is in line with the 2.66 g/cc used in the Parasol evaluation.

3.9 Repeat Formation Tests

3.9.1 RFT Sampling Results

The following samples were taken:

1.	Depth	:	2754m
	Type	:	Segregated (6 gal & 1 gal) sample
	Recovery	:	10.2 1 oil, 79.24 cu.ft gas, 3.0 1 filtrate and 1.6 1 emulsion
	R sample	:	0.178 ohm.m @ 28°C, Cl^- : 21,000 ppm
2.	Depth	:	3315m
	Type	:	Segregated (6 gal & 2-3/4 gal) sample
	Recovery	:	0.5 cu.ft gas and 22 1 filtrate
	R sample	:	0.183 ohm.m @ 21°C, Cl^- : 20,000 ppm
3.	Depth	:	3281.5m
	Type	:	Segregated (6 gal & 1 gal) sample
	Recovery	:	1.15 1 oil, 175 cu.ft gas and 0.9 1 contaminated filtrate
	R sample	:	0.289 ohm.m @ 18°C, Cl^- : 15,000 ppm
4.	Depth	:	2738.5m
	Type	:	Non-segregated sample (6 gal)
	Recovery	:	1.0 1 oil, 165 cu.ft gas and 0.75 1 contaminated filtrate
	R sample	:	0.337 ohm.m @ 22°C, Cl^- : 10,000 ppm
5.	Depth	:	2662.4m
	Type	:	Non-segregated sample (2-3/4 gal)
	Recovery	:	6.5 1 oil, 20 cu.ft gas, 2.2 1 filtrate
	R sample	:	0.184 ohm.m @ 22°C, Cl^- : 20,000 ppm
6.	Depth	:	3308.3m
	Type	:	Non-segregated sample (6 gal)
	Recovery	:	2 cu.ft gas and 20.8 1 filtrate
	R sample	:	0.174 ohm.m @ 32°C, Cl^- : 20,000 ppm

7. Depth : 2678m
   Type : Non-segregated sample (6 gal)
   Recovery : 1.0 l oil, 165 cu.ft gas and 0.6 l contaminated filtrate
   R sample : 0.340 ohm.m @ 19°C, Cl^- : 10,000 ppm

8. Depth : 2728m
   Type : Non-segregated sample (2-3/4 gal)
   Recovery : 0.7 l oil, 75 cu.ft gas and 0.5 l contaminated filtrate
   R sample : 0.331 ohm.m @ 18°C, Cl^- : 10,000 ppm

9. Depth : 2671m
   Type : Non-segregated sample (2-3/4 gal)
   Recovery : 0.5 l oil, 73 cu.ft gas and 0.5 l contaminated filtrate
   R sample : 0.237 ohm.m @ 20°C, Cl^- : 17,000 ppm

10. Depth : 2617m
    Type : Non-segregated sample (6 gal.)
    Recovery : 14 l oil, 80 cu ft gas and 0.5 l contaminated filtrate
    R Sample : 0.24 ohm.m @ 24°C, Cl : 16,000 ppm

Filtrate of Samples Nos. 3, 4, 7, 8 and 9 appears to be contaminated with vapourisation water from condensate.

Typical properties of mud filtrate while drilling the 8-1/2" hole were:

R_{mf} : 0.267 @ 23°C
Cl^- : 21,000 ppm

3.9.2 RFT Pressure Interpretation

A total of 82 pressure tests were made in the interval 1970m to 3557m, with 5 of these repeat tests (Table 8). In this interval there were two clearly different gradients (see Figure 7). From 1970m to approximately 3275m the gradient was 1.0 s.g. and from approximately 3275m to T.D. it was 1.19 s.g. or above.

The gradient of 1.00 s.g. is valid for the entire intra Latrobe oil-bearing intervals. This gradient indicates that the system is not a closed system as in Basker-1 and Basker South-1 where the same sands had a gradient of 1.054 s.g. The gradient in the lower part from approximately 3275m is a clear overpressure gradient.

From the pressure measurements the length of the oil and gas columns were determined (see Figs 8 and 9). Knowing the oil water contacts/gas water contacts and assuming sands of constant thickness closed at the Manta fault the STOIIP was estimated (see table below). The total GIIP in the interval 2600m - 3320m was estimated to be in the order of 35-50 Bcf with 2.1 - 3.0 MMbbl of associated condensate.

Estimated STOIIP

Interval mbdf	Net Sand m	STOIIP MMbbl
2615.0 - 2618.0	3.0	1.3
2623.0 - 2626.0	3.0	0.4
2661.0 - 2663.5	2.5	0.7
2751.0 - 2768.0	16.0	3.7
		6.1

TABLE 8 : MANTA-1 - RFT PRE-TEST RESULTS

(Corrected for Shift of Pressure Between Runs)

DEPTH M	B.U.P. PSI	DEPTH M	B.U.P. PSI	DEPTH M	B.U.P. PSI
1970	2817	2990.5	4298	3441	4950
2215	3159	3040.7	4363	3444.5	4954
2403	3430	3048	4371	3450	4965
2500	3570	3146	4515	3464.5	4994
2511.5	3588	3155	4520	3472	5033
2595	3704	3217.2	4625	3481.5	5010
2607.8	3724	3242.4	4698	3486	5026
2617	3739	3248.8	4702	3489.3	5020
2625	3746	3259.2	4731	3497	5070
2630.4	3752	3274.2	4735	3550	5204
2647	3791	3281.5	4738	3557	5236
2661.5	3811	3285.8	4739		
2662.5	3809	3293	4740		
2663	3813	3300	4745		
2671	3832	3310	4748		
2678	3836	3313	4749		
2686	3838	3315	4750		
2706.9	3858	3316	4750		
2728	3920	3319	4750		
2731.5	3921	3321	4753		
2738.5	3929	3322	4754		
2740	3930	3325	4762		
2744	3932	3328	4760		
2751.5	3933	3328	4763		
2754	3936	3372	4845		
2758	3939	3377	4854		
2763	3943	3386	4870		
2767	3947	3395.5	4883		
2772.5	3955	3405.5	4902		
2779.5	3963	3413	4914		
2794	4000	3420	4921		
2809.4	4029	3426	4940		
2829.5	4053	3431	4944		

3.10 Production Testing

3.10.1 Test No. 1 Results

Test No. 1 was carried out over the interval 3290-3299m, and 3309-3315m. A maximum flow rate of 18.6 MMSCFD of gas and 1022 bbl/d of condensate was achieved on 3/4" choke.

Reservoir Data

Sand Interval	:	3274-3330m
Net hydrocarbon-bearing sand	:	43m
CGR	:	60-75 bbl/MMSCF
API condensate	:	54°
Water production	:	15 bbl/d
Permeability (Horner analysis)	:	3.25-3.5 md
Skin	:	-ve 2
Initial reservoir pressure	:	4799 psig
Initial reservoir temperature	:	253° F.

PVT Data

Dewpoint	(dp)	:	4810 psig at 253 F
Z compressibility	at dp	:	0.994
viscosity	at dp	:	0.0249 cp
Gravity (air = 1)	at dp	:	0.854 sg
MW		:	27.7
CO_2 content		:	2.9 pct vol
N_2 content		:	0.5 pct vol

The volume of GIIP cannot be calculated from the test data as there was no evidence of depletion. The volume of GIIP calculated from pure volumetrics is of the order 20 bcf for the small culmination drilled.

3.10.2 Test No. 2 Results

Test No. 2 was carried out over the interval 2755-2761m. A maximum flowrate of 5157 bbl/d oil with a GOR 876 scf/bbl was achieved on 3/4" choke.

Reservoir Data

Sand interval	:	6m
GOR scf/bbl	:	960-980
API	:	42
Water production	:	negligible
Permeability (Horner analysis)	:	1500-2000 md
Skin factor	:	90
Initial reservoir pressure	:	3970 psig (2761m)
Initial reservoir temperature	:	227° F.

PVT Data

Bubble point pressure	:	3910 psig
Oil volume factor	:	1.695 r bbl/st bbl
	:	Sep condits T = 125 F; P = 360 psig
Shrinkage	:	0.883 st bbl/sep. bbl Sep condits. As above.
Viscosity of reservoir fluid	:	0.24 cp
Compressibility of reservoir fluid	:	22.5×10^{-6} psi $^{-1}$
Pour point of crude	:	32°C

Interpretation of Test No. 2 is difficult as the buildup is very rapid. The oil is slightly undersaturated and a gas cap is unlikely to exist. Calculation of volumes based on depletion and assuming the entire reservoir to be oilfilled with a uniform oil saturation results in 16 MMBBL STOIIP. This is far higher than the 3.7 MMBBL STOIIP calculated from maps and RFT data. This discrepancy is best explained by the existence of an aquifer below the oil helping to maintain reservoir pressure, resulting in a too large a volume calculated with the depletion method.

3.10.3 Test No. 3 Results

Test No. 3 was carried out over the interval 2615-2618m, 2623-2626m. A maximum flowrate of 6369 bbl/d oil with a GOR 806 scf/bbl was achieved.

Reservoir Data

Sand Interval	:	6m
GOR scf/bbl	:	806 - 940
API	:	43
Water production	:	negligible
Permeability (Horner analysis)	:	900 - 1200 md
Skin factor	:	15
Initial reservoir pressure	:	3735 psi
Initial reservoir temperature	:	222° F

PVT Data

Bubble point pressure	:	3775 psig
Oil volume factor	:	1.716 r bbl/st bbl
		Sep condits: T = 125° F
		P = 320 psig
Shrinkage	:	0.920 st bbl/sep bbl
		T = 125° F
		P = 320 psig
Viscosity of reservoir fluid	:	0.26 cp
Compressibility of reservoir fluid	:	23.8×10^{-6} psi
Pour point of crude	:	29 °C.

The buildup during Test No. 3 was extremely rapid. The volume calculated from depletion is 6.6 MMBBL STOIIP. As in the case for Test No. 2, this volume is far higher than that calculated by mapping (1.7 MMBBL). The discrepancy between the two figures is best explained by an active water-drive or gas drive resulting in too large a volume calculated with the depletion method. The reservoir fluid has a bubble point close to the initial reservoir pressure, and a gas cap may be present.

For further details on Manta-1 production testing refer to section 3.4, and Reference 5.

3.11 Geopressure Engineering

Pore pressures were essentially normal throughout all but the last two hundred metres of the hole. A maximum gradient equivalent to 1.19 s.g. over this bottom section of the hole can be derived from the plot of RFT pressures in Fig. 6. These pressures did not manifest themselves while drilling as the measurements showed them to be well below the hydrostatic pressure in use: the balance gradient for the bottom pressure measurement being 1.04 s.g. No hole problems were encountered. The mud densities used (1.10 - 1.14) were high principally for shale stabilisation and to supply a safety margin for any gas columns encountered.

For further details on pore pressure analysis of Manta-1 refer to reference 7.

3.12 Well Cost, Time Allocations

See Figure 9	:	Drilling Time Graph
See Table 9	:	Chemical Consumption Cost
See Table 10	:	Time Allocation
See Table 11	:	Well Cost

TABLE 9: CHEMICAL CONSUMPTION COST MANTA-1

Interval : Surface - 211m

Casing size 30"

Product	Quantity
Gel	9 mt
Caustic	1 drum
Soda Ash	3 sacks
Lime	5 sacks
CMC EHV	2 sacks

Total Cost : $2,440.37
Cost/metre : $ 46.04

Interval : 211-655m

Casing size 20"

Product	Quantity
Gel	17 mt
Caustic	26 drums
Soda Ash	31 sacks
Lime	21 sacks
CMC EHV	26 sacks
CMC LV	63 sacks

Total Cost : $10,500.17
Cost/metre : $ 23.64

Interval : 655-1932m

Casing size 9-5/8"

Product	Quantity
Barite	49 mt + 124 sacks
Caustic	58 drums
Lime	3 sacks
CMC EHV	42 sacks
CMC LV	10 sacks
Q Broxin	6 sacks
Dextrid	40 sacks
Celpol	69 sacks
Condet	2 drums

Total Cost : $25,920.77
Cost/metre : $ 20.30

TABLE 9 : CHEMICAL CONSUMPTION COST (continued)

Interval : 1932-3572m
Casing size 7"

Product	Quantity
Gel	7 mt
Barite	20 mt
Caustic	98 drums
CMC EHV	12 sacks
CMC LV	181 sacks
Lime	14 sacks
Q-Broxin	57 sacks
Dextrid	370 sacks
Celpol	55 sacks
Soda Ash	4 sacks
Sodium Bicarbonate	10 sacks
Whiting	5 sacks

Total Cost : $47,656.72
Cost/metre : $ 29.06

Abandonment Phase

Product	Quantity
Bentonite	7 mt
Caustic	4 drums

Total Cost : $1,981.06

Production Test Chemicals

Product	Quantity
Rock Salt	915 sacks
C448	1 drum
Methanol	9 drums
Glycol	3 drums

Total Cost : $9,063.00

Cement/Cement Chemicals

Product	Quantity
Cement G class	263 mt
NF-1	6 cans
HR-7	7 sacks
HR-12	8 sacks
Halad 22A	20 sacks
$CaCl_2$	108 sacks
Gel	50 sacks

Total Cost : $90,246

Stock adjustment not obviously consumed on this well.

Mica	22 sacks	Cost : $ 294.80
Coat 45	10 sacks	$1,200.00
		$1,494.80

TABLE 10 : TIME ALLOCATION : MANTA-1

		Hours	%
I.	**Preparation**	-	-
II.	**Mobilisation/Moving etc.**		
	Rigging up/down	38	2.05
			2.05
III.	**Making Hole**		
	Drilling	556	30.02
	Adding Pipe	7.75	0.42
	Surveys	13.25	0.72
	Checktrip	16.5	0.89
	Round Trip - Bit Change	122.5	6.61
	Circulation	18.75	1.01
	Reaming/Washing	7.5	0.40
	Rig Service	18	0.97
	Repairs	1.5	0.08
	Miscellaneous	9	0.49
			41.61
IV.	**Securing Hole**		
	Drilling Cement	5.5	0.30
	Checktrip	9.75	0.53
	Round Trip - Cement Drilling	4.75	0.26
	- Before Casing	10.25	0.55
	Circulation	8.25	0.45
	Rig Service	0.75	0.04
	Miscellaneous	7.25	0.39
	Casing - Run and Cement	60.5	3.27
	Flanging-up (BOP)	30.5	1.65
	Standing Cement	4.75	0.26
			7.70
V.	**Formation Evaluation**		
	Casing	9	0.49
	Surveys	0.5	0.03
	Checking	14.25	0.77
	Round Trip - Coring	11.25	0.61
	- Logging	5	0.27
	Circulation	4.5	0.24
	Formation Strength Test	1.75	0.09
	Rig Service	1	0.05
	Miscellaneous	0.25	0.01
	Logging - Open Hole	118.75	6.41
			8.97

TABLE 10 : TIME ALLOCATION (continued)

		Hours	%
VI	Completion/Suspension		
	Circulation	54.5	2.94
	Reaning/Washing	11	0.59
	Fishing	12	0.65
	Rig Service	2.5	0.13
	Wait-time	4	0.22
	Miscellaneous	35.25	1.90
	Logging - Completion	8.5	0.46
	Testing (& perforating)	145.75	7.87
	Running - Tubing	93.75	5.06
	- Production Packer	26.75	1.44
	- Wireline	33.5	1.81
	Pressure Surveys	66	3.56
			26.63
VII.	Plug-Back Abandonment		
	Wait-time	11.75	0.63
	Miscellaneous	68.25	3.68
	Abandonment	161.5	8.72
			13.03

TABLE 11 : WELL COST : MANTA-1

Cost Type		$ Million
0	Preparation/Mobilisation	0.068
1	Drilling - Installation	6.313
2	Mud	0.110
3	Bits	0.088
4	Casing and Cement	0.761
5	Evaluation	1.104
6	Production Testing	0.860
7	Abandonment	0.032
8	Transportation	2.856
		12.195

Note: Rig contractor cost = 5.28 million
Open hole logging cost = 0.88 million

4. GEOLOGY

4.1 Regional Setting

Permit VIC/P19 lies at the north-eastern margin of the Gippsland Rift (Fig. 1), a failed rift arm associated with the opening of the Tasman Sea.

The geological history of the rift is interpreted as follows:

- Early Cretaceous: deposition of continental Strzelecki Group sediments in a 'pre-' or 'infra-rift' basin.
- Cenomanian to Mid-Campanian: deposition of 'rift-phase' alluvial plain and fan facies and volcanogenic lower Latrobe Group sediments (cf. the Upper Cretaceous Golden Beach Fm 100km west).
- Mid-Campanian: culmination of volcanic activity immediately preceding the Tasman Sea break-up (c. 78 m.y. BP).
- Mid-Campanian to Mid-Late Maastrichtian: coastline transgressed north-westwards from the newly opening Tasman Sea (i.e. 'Tasman Drift' phase). Paludal, coastal plain facies were deposited landward of back-barrier and lagoonal sediments. The existing rift faults continued to grow slightly, but probably as a result only of compaction of the underlying rift phase sediments. This phase could be described as a 'failed-rift' stage.
- Late Maastrichtian: first major marine transgression into southern VIC/P19.
- Paleocene: transgressive/regressive cycle sedimentation with a net transgressive effect. Tasman Sea drift ceased in Late Paleocene.
- Early Eocene: Southern Ocean began to open ('Southern Drift'); submarine channelling of the eastern seaward margin of the Gippsland Basin.
- Early Eocene to Early Oligocene: limited subsidence and deposition during the 'early Southern Drift' phase.
- Mid-Oligocene to present: rapid subsidence recommenced during the 'late Southern Drift' phase; bioclastic marls and carbonates prograded across the area during the Miocene and Pliocene.

4.2 Stratigraphic Table

Age	Biozone	Formation	Depth bdf (m)	Depth ss (m)
		Sea level	25	0
		Sea floor	158	133
Pliocene - Miocene		GIPPSLAND LIMESTONE	158-1534	133-1509
Mid Miocene - Late Eocene		LAKES ENTRANCE FORMATION	1534-1956	1509-1931
Eocene	M.diversus	Flounder Formation	1956-2038	1931-2013
		LATROBE GROUP		
Paleocene	L.balmei	Latrobe Coarse Clastics	2038-2313	2013-2288
Maastrichtian	T.longus		2313-2590	2013-2565
Campanian	T.lilliei		2590-3050	2565-3025
Campanian/ Santonian	N.senectus		3050-3572(TD)	3025-3547(TD)

4.3 Stratigraphy

The stratigraphic sequence in Manta-1 is shown on Enclosures 2 and 3 and summarised in Section 4.2. Formation tops and ages are based on lithological, palaeontological and palynological information from cuttings and sidewall samples, together with wireline log characteristics.

4.3.1 Gippsland Limestone — 158 - 1534m

158 - 800m — Light to medium grey calcarenite, very fine-grained, argillaceous and fossiliferous (common forams and traces of ostracods, echinoderms, sponge spicules and bryozoa) with traces of glauconite and pyrite, grading to grey, soft fossiliferous marl.

800 - 1534m — Grey, soft, marl with common forams and traces of ostracods, echinoderms, coral, glauconite and carbonaceous detritus becoming less calcareous with depth and interbedded with minor calcarenite.

The marls and calcarenite of the Gippsland Limestone were deposited as shelf and slope sediments, in some cases as canyon fill.

4.3.2 Lakes Entrance Formation — 1534 - 1956m

1534 - 1932m — Marl with minor interbedded calcarenite becoming less calcareous with depth.

1932 - 1956m — Claystone, grey, soft, silty, glauconitic and fossiliferous.

4.3.3 <u>Latrobe Group</u> 1956 - 3572m (T.D)

<u>Flounder Formation</u> 1956 - 2038m

1956 - 1995m White to light grey sandstone, very fine to very coarse-grained, poorly sorted and glauconitic with traces of pyrite.

1995 - 2038m Siltstone, grey, soft, with traces of glauconite and pyrite, becoming argillaceous with depth and containing thin, interbedded sandstone.

<u>Latrobe Coarse Clastics</u> 2038 - 3572m (T.D)

2038 - 2082m Neritic sandstone, white, unconsolidated coarse-grained, glauconitic and pyritic.

2082 - 2123m Interbedded neritic siltstone, grey, argillaceous and sandstone, medium to coarse-grained, pyritic and glauconitic.

2123 - 2291m Beach barrier sandstone, white, unconsolidated, medium to very coarse-grained, well sorted becoming silty and dolomite cemented with depth.

2291 - 2313m Claystone, greenish grey, silty, becoming glauconitic with depth. The base of this shallow marine transgressive unit is the Lower Paleocene seismic marker.

2313 - 2401m Interbedded siltstone, argillaceous and slightly carbonaceous and micaceous, claystone, brownish grey, silty and carbonaceous in part, sandstone, light grey, unconsolidated, medium to coarse-grained and moderately sorted and minor coal, brownish black and silty in part. These are interpreted to be back barrier, possibly lagoonal sediments.

2401 - 2435	Beach barrier sandstone, white, coarse to very coarse-grained, becoming finer with depth, unconsolidated and moderately sorted.
2435 - 2445m	Shallow marine siltstone, brownish to greenish grey, argillaceous, glauconitic and carbonaceous in part. The base of this unit is the seismic Maastrichtian marker.
2445 - 2590	Interbedded back barrier/lagoonal sandstone, siltstone, claystone and minor coal. The sandstone is light grey, fine to medium-grained, subangular to sub-rounded, moderately sorted with silica and dolomite cement. The siltstone is light to brownish grey, argillaceous, micaceous, and carbonaceous in part while the claystone is grey, silty and carbonaceous. The coal is brownish black, hard and silty.
2590 - 2836m	Lower coastal plain interbedded sandstone, siltstone, claystone and coal as above, with a higher proportion of coal. Sandstone beds in this section are up to 17m thick, generally fine to medium-grained, moderately sorted silica and dolomite cemented with traces of lithic grains. The intra and Lower Campanian markers correspond to the top and bottom respectively of this unit.
2836 - 2987m	Volcanics, green to reddish brown, flow banded, intermediate to basic in composition with phenocrysts of olivine and amygdales filled with carbonate minerals in a fine-grained matrix of feldspar, pyroxene and olivine.
2987 - 3274	Interbedded siltstone, brownish grey, micaceous and argillaceous; claystone, brownish grey, silty and carbonaceous in part; sandstone, light grey very fine to medium-grained, argillaceous, well sorted with silica and dolomite cement; and volcanics, as above.

3274 - 3333 sct.

~~3274~~ 3333 - 3382m Volcanics, light greenish grey to brown, weathered in part, amygdaloidal and flow banded and minor claystone, grey, silty.

3382 - 3432m Sandstone, grey, hard to friable, fine to coarse-grained, angular to rounded, traces of silica and dolomite cement, lithic and moderately sorted.

3432 - 3572m Interbedded sandstone, as above, siltstone, as above and volcanics, as above, although more tuffaceous.

The sequence below the Lower Campanian marker is interpreted to have been deposited in a continental to near coastal environment during the rift phase of basin development.

4.4 Structure and Seismic Markers

The results of Manta-1 have not changed the pre-drill structural interpretation of the area (Fig. 10). The major seismic markers were penetrated close to the prognosis and depths and times to these are listed below. Figure 11 gives the seismic time/depth relationship for Manta-1.

Marker	Time (secs)	Depth (m, bdf)
Base Gippsland Limestone	1.210	1534
Top Flounder Formation	1.491	1956
Base Flounder Formation	1.540	2038
Mid Paleocene Shale	1.592	2123
Lower Paleocene Shale	1.700	2313
Maastrichtian Marker	1.770	2445
Intra-Campanian marker	1.858	2590
Lower Campanian Marker	1.992	2836
Top Volcanics	1.992	2836
Top Gas/Condensate Sand	2.205	3274

4.5 Hydrocarbon Indications & Interpretation

The top of significant ditch readings within the Latrobe Group occurred at about 2588m bdf. In the section 2588 - 2836m background levels were 0.1 - 0.2%, with peaks up to 1 - 2% opposite sandstone beds. The gas is wet with an approximate average composition of 86% C1, 9% C2, 4% C3, 1% C4 and traces of C5. Background gas levels within the volcanics were similar to the upper section, declining to less than 0.1% below 3480m. Peaks up to 6.4% were reported from the volcanics (probably associated with fractures), and 5.6% from some of the thin interbedded sandstones. The sandstone from 3274 - 3328m had readings up to 10.6%. Approximate gas composition is 90% C1, 7% C2, 2.5% C3, 0.5% C4 and traces of C5. At total depth the gas was 99.5% C1.

Spotty to even blue-white sample fluorescence and weak cut were reported from some sandstones below 2618m. Weak fluorescence associated with the condensate was also present in samples from the sandstone between 3274m and 3317m. Sample fluorescence was found to tie up closely with those zones interpreted as being oil bearing on logs.

4.6 Reservoir Potential

Sandstones in the coastal plain section above the volcanics are mainly fluvial point bar deposits 2 - 5m thick. These are generally fine to coarse-grained and have fining upwards trends on the gamma-ray log. Sandstones with a blocky log character, such as the 17m sandstone at 2751m, are probably channel deposits. Porosity values in these sandstones range from 17 - 25%.

Sandstones within the volcanic section are lithic, fine-grained to conglomeratic, moderately sorted with angular and subangular grains in an argillaceous matrix. Lithologically they are similar to sandstones near the base of Hammerhead-1.

Porosity values from logs range from 10 to 20% with values up to 17% in the gas/condensate sand from 3274 - 3329m. Analysis of core samples between 3300m and 3307m give measured porosity values of 10% to 17.5% with vertical permeabilities of 0 - 83 mD and horizontal values of 8.5 to 222 mD (see Appendix 7.3). Production test data from the interval 3290 - 3299m and 3309 - 3315m indicated permeabilities of 3.25 - 3.5 mD for this sandstone. The most likely explanation for this difference in permeability between the core analyses and the production test data is that during drying of the cores the matrix clays collapsed, increasing the permeability tenfold or more. Results of x-ray diffraction examination of two core samples (whole rock) to determine the matrix clay type are as follows:-

Sample	Chlorite	Illite	Kaolinite	Talc	Feldspar	Quartz	Dolomite
3303.3	tr	5	5	tr	tr	85	tr
3307.5	5	10	10	tr	tr	70	tr

4.7 Seals

Vertical seals for the oil and gas accumulations in the Campanian coastal plain sequence are provided by the interbedded shales and argillaceous siltstones. The gas/condensate sand at 3274m is overlain by finely interbedded sequence of siltstones, sandstones and volcanics. Lateral seals for the hydrocarbon-bearing sandstones are more difficult to explain as it was thought that the stratigraphic sequence would be sandier to the north of Manta-1. The drilling of Chimaera-1 in the next fault block to the north provided information on lateral sealing and it showed that:-

i) the Campanian coastal plain sequence in Chimaera was not sandier than that in Manta, and the fine-grained sediments in this sequence acted as a seal for the sandstones in the Manta block.

ii) the gas-condensate sand in Manta-1 was juxtaposed across the fault with a largely sandy sequence, which was water-wet, indicating that the fault plane is acting as a seal. There is a possibility that a small closure exists independent of the fault, but it is probably not large enough to account for the height of the hydrocarbon column. If the fault is sealing at this depth it probably also acts as a seal for the section above the volcanics.

4.8 Well Correlation

The major stratigraphic units are easily correlated between Manta-1 and the other VIC/P19 wells (Encl. 4). The proportion of sandstone in the coastal plain sequence between the intra and Lower Campanian markers was higher in Manta-1 than Basker-1 (32% compared to 21%) and individual bed thickness was also greater (17m compared to 7m)

The section below the top of the volcanics thins from Basker-1 to Manta-1. The proportion of volcanics is higher in Manta than Basker (the total thickness of the volcanics penetrated in both wells is about the same) indicating the sequence is thinning at the expense of the sediments. The predominantly siltstone sequence above the volcanics in Basker-1 and Basker South-1 (from which marginal marine dinoflagellates were recovered) was not present in Manta-1, presumably indicating this well was in a more landward position at the time these sediments were deposited.

4.9 Conclusions and Contributions to Geological Knowledge

1) Manta-1 found 24.1m of oil and 27.6m of gas in the Campanian coastal plain sandstones above the volcanics. A 54m sandstone within the volcanics contained a 39m gas/condensate column. This forms another objective for the central part of VIC/P19, now charge into the interbedded volcanic/sediment section has been proved. A further 4.6m of oil and 7.2m of gas were found in sandstones within the volcanics.

2) No stratigraphic enhancement of hydrocarbon trapping is apparent and accumulation size appears to be controlled by the size of the structure.

3) Sediments penetrated below 3050m have been determined as belonging to the N.senectus palynological zone (Campanian to Santonian in age). This is older than ages from other wells in the southern part of VIC/P19.

4) The Manta fault appears, at lease partly, to be acting as a seal for the hydrocarbon accumulations found in Manta-1.

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APPENDIX 7.1

PETROPHYSICAL EVALUATION

APPENDIX 7.1

7.1 Petrophysical Evaluation

7.1.1 Method Used

The Waxman-Smit technique rather than the Simandoux method was used due to the absence of core data.

1) $$S = \left[A.Rw \quad \phi^{-m} \left(\frac{1}{R_t} - \frac{V_{sh} S_w}{R_{sh}} \right) \right]^{1/n}$$

2) $$Sh = 1 - S_w$$

where:

S_w = water saturation in the virgin zone as fraction of pore volume

S_h = hydrocarbon saturation in the virgin zone as fraction of pore volume

A = constant from Archie's formula

R_w = formation water resistivity in ohm.m

ϕ = porosity as fraction of bulk volume

m = cementation factor

R_t = true resistivity in ohm.m

V_{sh} = fraction of shale

R_{sh} = shale resistivity in ohm.m

n = saturation exponent

7.1.2 <u>Deck Card Structure</u>

The following steps were used in the petrophysical evaluation of Manta-1:

- Calculation of shale content (V_{sh}) by means of Gamma Ray log.

- Identification of dolomitic sands, coal layers and volcanics based on the response of the density and neutron logs together with ditch cuttings/sidewall samples description.

- Differentiation of sands and shales based on a 50% cut off of shale content (after elimination of dolomitic sands, coal and volcanics).

- Correction for borehole effect of the Dual Laterolog deep and shallow readings as well as the Microspherical focused log.

- True resistivity (R_t) determination.

- Porosity calculation from density log over the water/oil bearing zones in sand layers.

- Porosity calculation from density log/neutron log over the gas zones in sand layers (corrected for gas and shale effects).

- Calculation of hydrocarbon saturations by means of Simandoux equation over the sand intervals.

APPENDIX 7.2

PALYNOLOGICAL ANALYSIS

APPENDIX

PALYNOLOGICAL ANALYSIS OF MANTA-1
(GIPPSLAND BASIN, PERMIT VIC/P19)

BY

JAN van NIEL

1. SUMMARY

DEPTH(M)	DINOFLAGELLATE ZONES	SPORE-POLLEN ZONES	AGE
1935-1954	-	-	post EOCENE
1980	(a mixture of mostly PALEOCENE and some EOCENE palynomorphs)		prob. EOCENE
1989	prob. D. WAIPAWAENSIS	-	Early EOCENE
2006-2040	prob. A. HYPERACANTHUM	M. DIVERSUS	(Late PALEOCENE)/ Early EOCENE
2084	A. HOMOMORPHUM	Upper L. BALMEI	Late PALEOCENE
2210-2296	Upper T.EVITTII/ E.CRASSITABULATA	Lower L. BALMEI	Early to Middle PALEOCENE
2311	T.EVITTII		Early PALEOCENE
2322-2538	-	T. LONGUS	MAASTRICHTIAN
2382-2442	I. DRUGGII	-	Late MAASTRICHTIAN
2564-2653	-	T. LONGUS or T. LILLIEI	MAASTRICHTIAN or CAMPANIAN
2700.5-3036	-	T. LILLIEI	CAMPANIAN
3051-3160	-	T. LILLIEI or N. SENECTUS	CAMPANIAN or SANTONIAN
3167-3437	-	N. SENECTUS	SANTONIAN-CAMPANIAN
3441-3572	-	prob. N. SENECTUS	prob. SANTONIAN-CAMPANIAN

(T.D. at 3572m, bdf)

SPORE COLOUR/DEGREE OF ORGANIC METAMORPHISM (D.O.M.)/ SOURCE ROCK QUALITY

Transmitted (white) light: from pale yellow (1935m) to deep yellow or light brown (3437m).

Incident U.V. light: bright yellowish-white to golden yellow and orange to dull light brown.

D.O.M.: from immature at 1935m to perhaps just reaching early mature near T.D. (3572m).

ENVIRONMENT OF DEPOSITION

1935-2311m: (marginal) marine.

2322-3437m: mostly non-marine (swamp, lake or fluvial deposits), with the exception of 2382-2442m, 2538m, 3036m, 3094.5m and 3167-3210m which are brackish-lagoonal or marginal marine.

2. INTRODUCTION AND METHODS

The interval examined palynologically ranged from 1935m down to 3572m (T.D. is at 3572m, bdf). A total of 2 conventional cores, 61 sidewall cores and 12 ditchcuttings were selected on the basis of lithology. Grey to black, fine-grained sediments (mudstones, shales) are generally richer in palynomorphs than sediments such as silts and sands deposited in higher energy environments. Where mudstones or shales were not available, siltstone samples were prepared. The quality of the sidewall cores was poor to fair. No sidewall cores were available over the deepest 135m and ditchcuttings had to be used instead.

Samples were prepared in Perth by Exploration Consultants Ltd (ECL) using the "standard" technique for siliciclastic sediments, i.e. hydrochloric and hydrofluoric acid treatment followed by heavy-liquid separation to remove mineral matter; controlled oxidation with nitric acid to reduce unwanted organic constituents and thus concentrate the palynomorphs; and finally washing with sodium hydroxide to remove humic acids. The resulting acid-insoluble residue was mounted in Elvacite to produce permanent microscope preparations. A slide of the non-oxidised residue was used for palynomaceral studies. Most of the oxidized preparations were stained using Bismarck Brown to enhance contrast of the palynomorphs.

All samples yielded an organic fraction but some proved to be poor to very poor in organic microfossils and did not contribute to the overall interpretation. Preservation was excellent to reasonable in most samples. Diversity of assemglages varied but was generally good in the Tertiary and good to poor in the Cretaceous part of the examined section.

The palynomorphs were recorded semi-quantitatively. To provide continuity with the work of Harris, 1983, the biostatigraphic interpretation of assemblages follows the zonal characteristics given in his "Biostratigraphic Summary" (Harris, undated). The range charts in this "Summary" are largely based on published and unpublished work of Stover and Evans (1974), Stover and Partridge (1973), Partridge (1975), (1976) and Helby, et al. ("in press").

Reworked palynomorphs were regularly encountered, mostly as single occurrences only. Most were Permo-Triassic in age, with an occasional Jurassic grain. It is not clear how to interpret the regular occurrences of Early and Mid Cretaceous Spores. They could be reworked, but, although found in younger sediments than their published ranges would indicate they may in fact belong.

Some contamination from the drilling mud was found in a few samples. Although all material used was carefully cleaned before preparation, a fractured or broken-up sidewall sample cannot always be fully trusted and some contamination with palynomorphs from the mud is unavoidable.

3. ANALYSIS OF ZONES

A. DINOFLAGELLATE ZONES

1935-1954m (2SWS): post EOCENE

A well preserved, rich and diverse assemblage, dominated by chorate cysts. Sporomorphs are present, but not common.

1980m (1 SWS): probably EOCENE

This assemblage is a mixture between common PALEOCENE and rather rare EOCENE markers. The original sample material could not be cleaned properly and was therefore suspect. On the strength of the interpretation at 1989m and below, the common PALEOCENE markers are regarded as reworked or as contaminants and the assemblage is therefore considered to be of EOCENE age.

1989m (1 SWS): probably DRACODINIUM WAIPAWAENSIS Zone, Early EOCENE

A number of cysts closely related to if not identical with D. waipawaensis together with Hafniasphaera septata and Ceratiopsis dartmooria form the basis of the zonal interpretation. The assemblage, although fairly rich in specimens (mostly proximate dinoflagellate cysts) was not diverse and contained few sporomorphs.

2006-2040m (4 SWS): probably APECTODINIUM HYPERACANTHUM Zone, Early EOCENE

Both dinoflagellates and sporomorphs are common in these fairly diverse assemblages. Apectodinium hyperacanthum, A. homomorphum and chorate cysts were the most abundant; Deflandrea truncata occurred as a single specimen while Hafniasphaera septata, Muratodinimum cf. fimbriatum and Spiniferites sp. were present as well. Of interest was an unknown Glaphyrocysta with a very complex distal network of trabeculae between the processes. It was quite common at 2040m.

Several "microforams", chitinous inner linings of foraminifera, were present also.

2084m (1 SWS): APECTODINIUM HOMOMORPHUM Zone, Late PALEOCENE.

The nominate species was common, together with Spinidinium spp.. Ceratiopsis dartmooria and Paralecaniella indentata occurred also. A single specimen of Senegalinium dilwynensis was found.

(2116m: too poor in palynomorphs).

2210-2296m (3 SWS) Upper TRITHYRODINIUM EVITTII/EISENACKIA CRASSITABULATA Zone, Early to Mid PALEOCENE.

The most common dinoflagellate cysts were Spinidinium spp., followed by Palaeocystodinium sp. and Ceratiopsis speciosa. Also present: Senegalinium dilwynensis, a few specimens of Palaeoperidinium pyrophorum, Alisocysta cf. circumtabulata and Glaphyrocysta retiintexta. Of the 2 nominate species only a single fragment of Eisenackia crassitabulata was found.

2311m (1 SWS): TRITHYRODINIUM EVITTII Zone, Early PALEOCENE

The nominate species was commonly present, although, because of its fragile nature, often as broken specimens. An unknown Oligosphaeridium was the only other common cyst. A few specimens of Ceratiopsis speciosa and Paralecaniella indentata and one rather worn looking Palaeoperidinium pyrophorum complete this short list.

(2322m: No dinoflagellates present, sample rather poor).

2382-2442m (2 SWS): ISABELIDINIUM DRUGGII Zone, Late MAASTRICHTIAN.

Apart from I. druggii and related species only two other dinoglagellate species were present: Palaeocystodinium sp. and an unknown proximate cyst with an apical archeopyle. An acritarch, Nummus cf. similis, was found also.

(2479-2488m: no dinoflagellates present).

2538m (1 SWS): Several specimens of a simple, proximate cyst with an apical archeopyle were present, as were the acritarch Nummus cf similis and one specimen of a Pediastrum, a colonial algae of probable freshwater environments.

(2564-3000m: no dinoflagellates, although Nummus is present in several samples).

3036m (1 SWS): in addition to Nummus cf. similis this sample contained 3 specimens of Xenascus ceratioides and one of

Oligosphaeridium cf pulcherrimum. The sidewall core was, however, contaminated by mud.

(3051-3090m: no dinoflagellates).

3094m (1 SWS): two specimens of a Chatangiella, but too poorly preserved for a specific determination although they could well be C. victoriensis.

3167m (1 SWS): in addition to common leiospheres of the Nummus type the assemblage contained a number of a fairly small, thinwalled dinoflagellate cysts, remarkably like Morkallacysta pyramidalis (Harris, 1974) and described from the Renmarks Beds, Victoria, of Paleocene age. Because of its thinwalled nature, most cysts are folded and distorted, obscuring its morphology. In fact, more than one species or even genus may be present. M. pyramidalis is a non-marine dinoflagellate (Harris, 1974) and nothing in the present assemblage would seem to contradict this. It is quite possible that Nummus is another non-marine aquatic organism, as it occurs regularly in assemblages that lack marine indicators and have all the marks of a non-marine environment of deposition (See Section 5).

3205-3210m (2 SWS: two types of chorate cysts were present, of which only Oligosphaeridium aff. pulcherrimum could be determined.

(3215-3437m: no dinoflagellates present)

B. SPORE-POLLEN ZONES

1935-1954m (2 SWS): the assemblages are dominated by dinoflagellate cysts and sporomorphs are uncommon. Most noteworthy was a single specimen of "Psilodiporites pertritus" described by Partridge, 1971 from the Lakes Entrance Oil Shaft at 352 ft. According to his Table 1, P.pertritus was present in the PROTEACIDITES TUBERCULATUS and the TRIPOROPOLLENITES BELLUS Zones, OLIGOCENE and MIOCENE.

1980-2040m (6 SWS): MALVACIPOLLIS DIVERSUS Zone, Early EOCENE.

The base of this Zone was determined by the present of Proteacidites grandis, P.leightonii, P. incurvatus, Spinizonocolpites prominatus and Verrucosisporites kopukuensis. Pollen and spores were quite common in this interral and some of the other types present were Ischyosporites gremius, several species of Nothofagidites and the smaller Proteacidites, Malvacipollis diversus,and a reticulate megaspore. The top of the zone is not easily determined since it relies on the base of markers for the overlying zone. None were seen, and additional evidence comes from the dinoflagellates (See Section 3A).

2084m (1 SWS): Upper LYGISTEPOLLENITES BALMEI Zone, late PALEOCENE.

The combined presence of Malvacipollis diversus, Australopollis obscurus and Matonisporites gigantis indicates the presence of this zone at this level. Amongst the many other sporomorphs found were Gambierina edwardsii, G.rudata, Lygistepollenites balmei, Notofagidites spp, Proteacidites spp, a.o. P. annularis and many more.

(2116m: too poor, virtually no sporomorphs).

2210-2311m (4 SWS): Lower LYGISTEPOLLENITES BALMEI Zone, Early to Mid PALEOCENE.

Although this interval is not particularly poor in sporomorphs, characteristic markers are absent and its age has been largely determined by the dinoflagellates.

2322-2538m (6 SWS): TRICOLPITES LONGUS Zone, MAASTRICHTIAN.

Most samples are rich in sporomorphs although diversity is not high. Types present and important for a zonal determination were the nominate species and Triporopollenites sectilis, Tricolpites lilliei, Quadraplanus brossus and "Grapnelispora evansii". Nothofagidites spp. and Proteacidites spp. occurred commonly. The latter group includes P. "gemmatus", P."reticuloconcavus" and P. "otwayensis". Other common species were Tricolpites confessus, T. gillii, Phyllocladidites spp, Microcachryidites antarcticus, Ceratosporites equalis, Kraeuselisporites spp, Stereisporites regium and Lygistepollenites balmei"

2564-2653m TRICOLPITES LONGUS or TRICOLPITES LILLIEI Zone, MAASTRICHTIAN or CAMPANIAN.

The base of the T. LONGUS Zone is a.o. defined by the dominance of Gambierina specimens over Nothofagidites spp. In the interval under discussion dominance of G.spp. or N.spp. is not readily apparent because both tend to be poor.

Other useful markers such as T.longus, Q.brossus and Stereisporites (Tripunctisporis) sp. were absent. Tetracolpites verrucosus was present in the deepest sample but as a single specimen only. Evidence for either one or the other zone is therefore not strong and the interpretation given reflects this.

2700.5-3036m (14 SWS): TRICOLPITES LILLIEI Zone, CAMPANIAN.

Although 14 sidewall cores were available, only 7 were fully examined as the others proved too poor in palynomorphs to be of any use.

In all examined samples Nothofagidites spp. were much more common than Gambierina spp.. The nominate species (T. lilliei) and Triporopollenites sectilis were both present. Some of the other common sporomorphs: Proteacidites spp, Tricolpites gillii, T. confessus, Phyllocladidites spp, Microcachryidites antarcticus, Lygistepollenites balmei, Baculatisporites comaumensis and Ceratospora equalis. Less common, present in only a few, or single specimens: Proteacidites "reticuloconcavus", P. "clinei", P. palisadus, P. amolosexinus, P. scaboratus, Kraeuselisporites sp., Ornamentifera sentosa, Cicatricosisporites sp, Gephyrapollenites wahooensis, Cyclosporites hughesii, Tricolpites sabulosus and a reticulate megaspore. Of particular interest was a species of "Grapnelispora", not with anchor-shaped processes like "G. evansii" but with strongly curled tips. Permian reworking occurred in several samples, but as single specimens only. Several types of the list above are very likely reworked as well.

3051-3160m (7 SWS): TRICOLPITES LILLIEI or NOTHOFAGIDITES SENECTUS Zone, CAMPANIAN or SANTONIAN.

The boundary between these two zones relies on the absence of certain markers in the lower, N. SENECTUS, Zone. It was therefore unfortunate that only one (at 30494m) out of 7 samples proved to be rich enough to be reliable in this respect. And even here results proved to be ambiguous. It contained a single specimen of Triporopollenites sectilis, (which would indicate the T. LILLIEI Zone), but not the nominate species for that zone. Gephyrapollenites wahooensis and Proteacidites palisadum, both present at this level, have been used as accessory evidence for the base T. LILLIEI Zone. However, the evidence is considered to be too weak and the interval determined accordingly. In general composition the assemblage found is not sufficiently different to repeat the list of palynomorphs founds.

3167-3437m (2 core - and 9 SWS) NOTHOFAGIDITES SENECTUS Zone, SANTONIAN-CAMPANIAN.

Nothofagidites spp, including N. senectus are present throughout while both Tricolpites lilliei and Triporopollenites sectilis are absent. Many of the types present in the overlying zones, such as Ceratospora equalis, Tricolpites confessus, T. gillii, T. sabulosus, Proteacidites spp., Phyllocladidites spp., Microcachryidites antarcticus, Lygistepollenites balmei, Baculatisporites comaumensis and Lycopodiumsporites circiniidites are present in this zone as well. Uncommon, and perhaps partly reworked, are Foraminisporis wonthaggiensis, Kraeuselisporites sp., Cicatricosisporites spp., Dictyotosporites speciosus, Gephyrapollenites wahooensis, Stereisporites viriosus, "Chomotriletes", Ornamentifera sentosa and Clavifera triplex. Of interest was a monosulcate pollengrain, very coarsely reticulate away from the sulcus. It seems closely related to, but not identical with Retimonocolpites peroreticulatus (Brenner) Doyle. It is unlikely to be reworked. It was also found in a stratigraphically similar position in Chimaera-1. A few Permian reworked grains were present in some of the samples.

3441-2572m (12 ditchcuttings) probably NOTHOFAGIDITES SENECTUS Zone, SANTONIAN-CAMPANIAN.

No sidewall cores being available, a series of ditchcuttings were prepared and examined over the deepest 130m. No indications of any of the older zones were found. N. senectus was present in all samples but of course these could have been caved from higher levels. The assemblages looked clean, however, and it seems not unlikely that the well bottomed in the NOTHOFAGIDITES SENECTUS Zone.

4. SPOROMORPH COLOUR, DEGREE OF ORGANIC METAMORPHISM (D.O.M.) AND SOURCE ROCK POTENTIAL

The colour of palynomorphs changes when subjected to the increasing or prolonged temperatures such as occur during burial. These changes in colour are irreversible and therefore indicate the maximum level of maturity reached. The different stages, yellow to golden-yellow through orange and brown to black can be correlated with changes in chemical composition as hydrocarbons are generated from the organic matter (see Fuchs, 1979; standard Legend, 23.5.10). The sporomorph colour scale is more subjective than the more commonly used vitrinite reflectance scale. Ideally, a long-ranging sporomorph type should be selected as different types of sporomorph within the same sedimentary section show variations in colour. As observed in transmitted white light the change in colour from light yellow to golden-yellow or orange corresponds with the onset of oil generation, whereas the onset of gas generation is associated with a change in colour from orange to brown. Post-mature source rocks contain black sporomorphs and organic fragments only.

In incident ultraviolet light palynomorphs (and some palynomacerals) exhibit fluorescence colours that no only help in their identification but also increase and decrease according to rank. Fluorescence is maximal at the threshold of the "oil window", decreases with increasing rank and disappears at the end of the "oil window" (1-1.3% R_o, see Robert, 1981).

In MANTA-1 sporomorph-colour in transmitted (white) light ranged from pale-yellow at 1935m to yellow at 3437m. Over the same interval fluorescence-colours of sporomorphs ranged from light yellow to golden yellow or orange and dull light brown. Both estimates (and that is all they are) seem to indicate immature conditions over most of the section studied. It is possible that from about 3200m early mature conditions existed. Palynomaceral determination was carried out on a sieved, non-oxidised preparation. The sieving (with a 10 micrometer mesh sieve) was necessary to concentrate the large palynomacerals that otherwise would be diluted by fine, amorphous organic matter. This fine fraction is undoubtedly important for source rock characterisation but its nature and origin cannot be determined by ordinary means.

In MANTA-1 a rough estimate during preparation (i.e., after the acid treatment but before oxidation) showed that between 1935 and 2311m total organic matter varied from 0.1 to 1.0 millilitre per 10 grams of sample, and from 2322 to 3437m from 01 to 6.0 millilitre per 10 grams of sample. It should be remembered that these estimates may not reflect the true picture, as they are based on samples selected for palnology (e.g. disregarding coarser grained sediments on the one hand and coals on the other). The interval 1935m to 2311m is rich in inertinite while plant tissues, pollen, spores and dinoflagellates are present in various amounts, but the low estimates for total amount of organic matter per 10 grams of sample classifies them as poor source rocks. The interval 2322m-3437m (again, considering the palynological samples only) shows higher organic matter estimates and probably contains good source rocks. The types of palynomacerals present suggest gas-prone rather than oil-prone sourcerocks.

5. ENVIRONMENT OF DEPOSITION/PALYNOFACIES

The relationship between organic matter and grainsize of the sediments has been well-documented and is used to deduce depositional environment (palynofacies) from the type of palynomorphs and palynomacerals present.

The palynomorphs can be divided into marine organisms such as dinoflagellates and Tasmanites (both algae) and foraminiferal test linings; fresh and brackish water organisms such as Botryococcus and acritarchs; and land derived pollen and spores (sporomorphs).

Breakdown products of plants (woody fragments, epidermal tissues, cork cells, resin), algal and bacterial remains, animal tissue and many indeterminate organic fragments are collectively known as palynomacerals.

Although wind transport is an important aspect of the initial dispersal of sporomorphs, water transport then carries the sporomorphs and palynomacerals until they settle out of the water column. A continuous process of mechanical abrasion, biological degradation and wave and current action sorts and grades the particles during this transportation phase. Less buoyant, heavy or larger organic particles tend to characterise environments close to source while lighter, more buoyant and smaller particles are carried further afield. Very low sporomorph diversity indicates authochthonous environments (marsh, swamps); allochthonous environments are characterised by more diverse assemblages. Marine microplankton diversity increases in an offshore direction (Whitaker, 1979).

In MANTA-1 the interval 1935-2311m is clearly marine because dinoflagellates, reasonably diverse, are present in almost all samples;

a fairly rich and diverse pollen flora, together with plant tissues indicate an environment near a source of land-derived organic matter. Between 2322m and 3437m only a few intervals with dinoflagellates occurred, namely: 2382-2442m; 2538m; 3036m; 3094m; 3167m and 3205-3210m. Low diversity and high content of land-derived material makes it unlikely that any of these intervals are open marine. At least one interval (3167m) contains dinoflagellates that could well be of freshwater origin. See Section 3A: Dinoflagellates zones, for more details.

From 2322 to 3437m, and excepting the depths mentioned above, assemblages are considered to be non-marine. Not only are marine indicators lacking, but the variety and size range of the plant tissues indicates limited water transport and size-sorting. Swamp, lake or some fluvial deposits are suggested.

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PE900474

This is an enclosure indicator page.
The enclosure PE900474 is enclosed within the container PE905618 at this location in this document.

The enclosure PE900474 has the following characteristics:

ITEM_BARCODE = PE900474
CONTAINER_BARCODE = PE905618
NAME = Distribution Chart
BASIN = GIPPSLAND
PERMIT = VIC/P19
TYPE = WELL
SUBTYPE = DIAGRAM
DESCRIPTION = Manta-1 Distribution Chart, enclosure from appendix 7.2 from WCR vol 1
REMARKS =
DATE_CREATED =
DATE_RECEIVED = 18/08/86
W_NO = W846
WELL_NAME = MANTA-1
CONTRACTOR =
CLIENT_OP_CO = SHELL DEVELOPMENT (AUSTRALIA) PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

APPENDIX 7.3

CORE ANALYSIS RESULTS

CL-811-1

Att. 5

CORE LABORATORIES, INC.

Petroleum Reservoir Engineering

DALLAS, TEXAS

CORE ANALYSIS RESULTS

Company SHELL DEVELOPMENT (AUSTRALIA) Formation ______ File WA-CA-293
Well MANTA No. 1 Core Type CONVENTIONAL Date Report MARCH 26,
Field ______ Drilling Fluid ______ Analysts GK, AF
County AUSTRALIA State W.A. Elev. ______ Location GIPPSLAND BASIN

SAMPLE No.	DEPTH METRES	PERMEABILITY MD HORIZ KA	PERMEABILITY MD VERT KA	POROSITY % HE	POROSITY % INJ	GRAIN DENSITY
1	3300.28	222	83	17.5		2.66
3	3300.84	73	-	13.9		2.66
5	3301.58	113	30	16.0		2.66
7	3302.10	20	-	13.0		2.66
9	3302.60	18	1.3	13.3		2.66
11	3303.20	8.5	-	11.9		2.67
13	3303.90	26	3.4	12.5		2.67
15	3304.44	44	-	12.6		2.82
17	3305.0	24	6.8	9.9		2.68
19	3305.8	95	-	14.8		2.67
21	3306.34	95	17	13.8		2.66
23	3307.3	21	-	12.1		2.67
25	3307.9	107	40	15.5		2.67

ANALABS
A division of Macdonald Hamilton Pty. Ltd.
Perth Head Office.
52 Murray Road Welshpool, Western Australia 6106.
Tel: (09) 458 7999, 458 7154. Telex: Analab AA92560.
P.O. Box 210 Bentley, W.A. 6102.

GDM:tm

June 22nd 1984

Ms L Taylor
Shell Company of Australia Ltd
Shell Development (Aust)
140 St George's Terrace
PERTH W A 6000

Our Ref 145.2 01 33366
Your Order ITC 48316/EXH/4

Dear Ms L Taylor

Herewith the results of the x-ray diffraction examination of the two samples of core marked Manta 1, 3303.3 and 3307.5.

Sample	Chlorite	Illite	Kaolinite	Talc	Feldspar	Quartz	Others
3303.3	TR	5	5	TR	TR	85	TR
3307.5	5	10	10	TR	TR	70	TR

Others - material not positively identified but possibly dolomite.

These results refer to the sample as a whole. For the analysis a separation of the clay fraction (less than 2 micron) was analysed separately. All mineral excepting quartz reported in this fraction.

Yours faithfully

G D MOORE.
Operations Manager.