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MARTHA-1

INTERPRETED DATA REPORT

PREPARED BY:
J.Pitman
(Consultant)
March 2005

MARTHA-1

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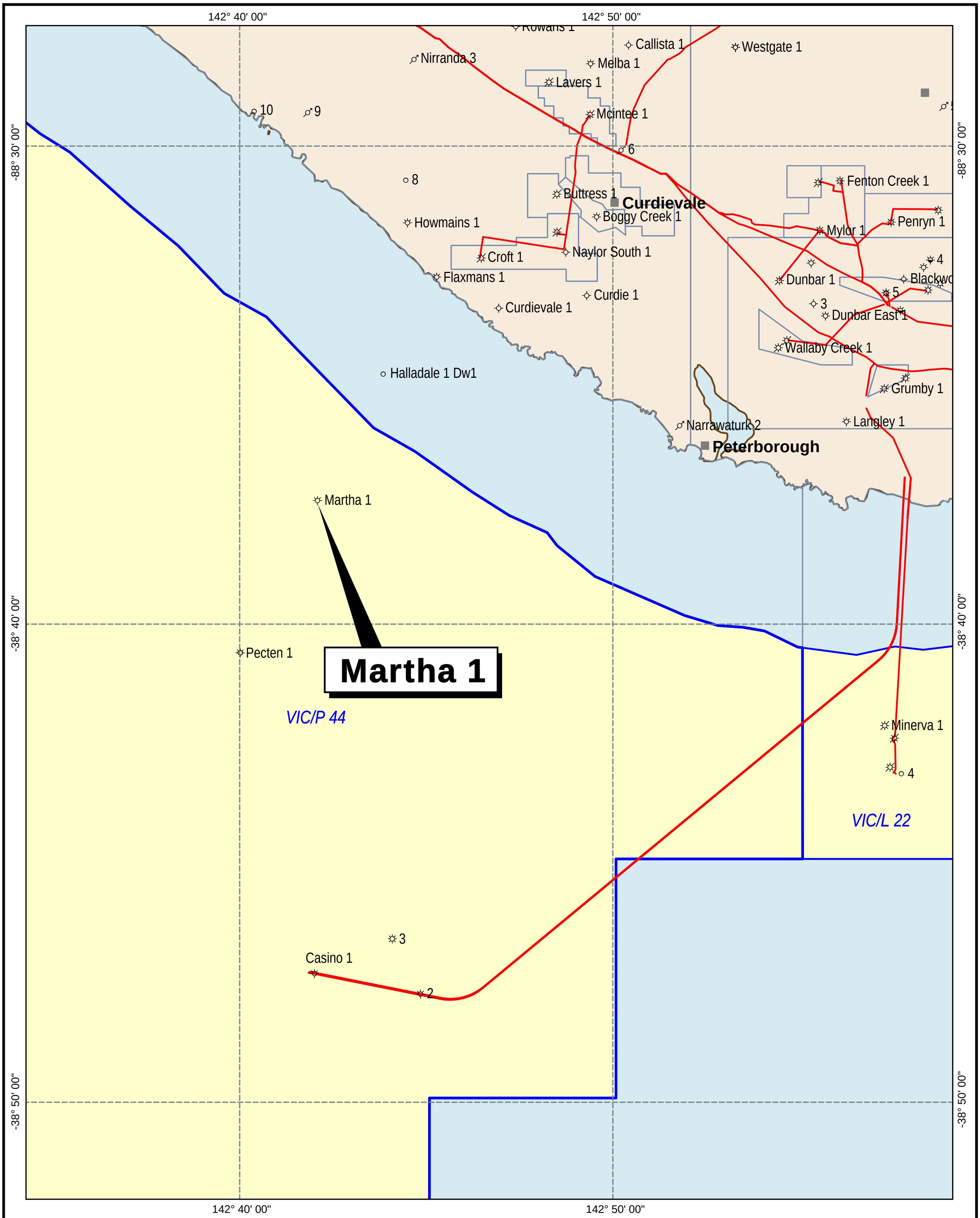
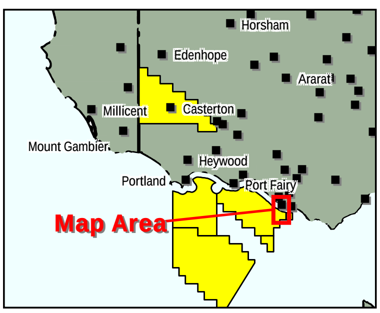
LOCATION MAP





Legend

Santos Permit

Santos

VIC/P 44 - Victoria

Martha 1

Location Map

5 0 5

Kilometres

Scale: 1:200 000

GDA

Date: April 2005, File No. OTWAY 639

WELL CARD

WELL: MARTHA-1	**WELL CATEGORY:** OFFSHORE GAS EXP **WELL INTENT:** GAS	**SPUD:** 20/10/04 **TD REACHED:** 29/10/04 **RIG RELEASED**: 5/11/04 **CMPLT**: **RIG**: OCEAN PATRIOT
SURFACE LOCATION: **LAT:** 38° 37' 24.33" S **LONG:** 142° 42' 05.02" E (GDA94) **NORTHING:** 5 723 638.2m **EASTING:** 648 109.3m		**STATUS**: ABANDONED WELL GAS SHOWS (ABGS) **REMARKS**: PAY INDICATED IN THE PAARATTE AND WAARRE FORMATIONS. NO DST CONDUCTED.
SEISMIC STATION: 2001 Casino-3D, 17418 X3290		
ELEVATION SEA FLOOR: -54.7m LAT **RT** +21.5m LAT		
BLOCK/LICENCE: Otway Basin - VIC / P 44		
TD 1800 m (Logr Extrap) 1800 m (Drlr)		
PBTD m (Logr) m (Drlr)		
TYPE STRUCTURE: Tilted Fault Block		
TYPE COMPLETION:		
ZONE(S): WAARRE / PAARATTE FORMATIONS		

HOLE SIZE	CASING SIZE	SHOE DEPTH	TYPE
914mm	762mm	121m	461.3 kg/m N80
445mm	340mm	620.8	101 kg/m L80

AGE	FORMATION OR ZONE TOPS	DEPTH (M) LOGGERS RT (m)	SUBSEA (m)	THICK-NESS (m)	HIGH (H) LOW (L)
RECENT – OLIGOCENE	SEABED (UNDIFFERENTIATED CARBONATES)	76	-55		
EOCENE – OLIGOCENE	NIRRANDA GROUP				
EOCENE – OLIGOCENE	MEPUNGA FORMATION	671	-650	62	1 H
EOCENE	WANGERRIP GROUP:				
EOCENE	DILWYN FORMATION	733	-712	210	56 H
PALAEOCENE	PEBBLE POINT FORMATION	943	-922	45	22 L
MAASTRICHTIAN	SHERBROOK GROUP				
MAASTRICHTIAN	MASSACRE SHALE	988	-966	15	88 H
MAASTRICHTIAN	TIMBOON SANDSTONE	1003	-981	131	84 H
CAMPANIAN	PAARATE FORMATION	1134	-1112	263	67 H
CAMPANIAN	SKULL CREEK	1396	-1375	88	43 L
EARLY - LATE CRETACEOUS	SHIPWRECK GROUP				
EARLY - LATE CRETACEOUS	WAARRE FORMATION	1484	-1463	22	6 L
EARLY CRETACEOUS	OTWAY GROUP				
EARLY CRETACEOUS	EUMERALLA FORMATION	1506	-1484	294	176 H
	TOTAL DEPTH (LOGGER EXTRAP)	1800	-1778		72 H

LOG	SUITE/ RUN	INTERVAL (M)	BHT/TIME COMMENTS
GRAND SLAM GR DLL MLL ZDL CN SP MAC CAL	**1 / 1**	 1756 - Surface 1785 - 621 1790 - 621 1766 - 621 1766 - 621 1747 - 621 1771 - 621 1790 - 621	 66ºC / 8 hours 30 minutes
RCI-GR	**1 / 2**	1258.6 - 1613	71.1ºC / 24 hours 35 pretests attempted, 17 normal, 9 lost seal, 2 tool plugged, 6 curtailed, 1 failure. 4 x 850cc samples @ 1488.6m, 2 x 850cc samples @ 1258.7m
Velocity Survey	**1 / 3**	1785 - Seabed	Total levels 115 at 15m intervals
RCOR-GR	**1 / 4**		Run aborted due to tool failure
Sidewall Cores	**1 / 5**	1728.9 – 1307.2	25 cores attempted, 25 recovered (100%)

LOG INTERPRETATION					
INTERVAL(M)	**Ø %**	**SW %**	**INTERVAL(M)**	**Ø %**	**SW %**
Inter Paaratte "A"			Inter Paaratte"C"		
1257 – 1263 (4.7)	26.1	54	1281 – 1283(1.8)	26.9	58
Inter Paaratte "B"			Waarre "A"		
1272 – 1278 (4.6)	23.1	53	1484 – 1498(9.2)	23.3	53

PERFORATIONS	
FORMATION	**INTERVAL**

CORES				
FORM	**NO.**	**INTERVAL**	**CUT**	**REC**

PRODUCTION TEST RESULTS
No production tests were conducted at the Martha 1 location.

SUMMARY:

Martha-1 was proposed as an Otway Basin gas exploration wildcat well in the VIC/P44 Licence. The well is located approximately 26 km west of Port Campbell, 24km WNW from of the Minerva gas field, and 18 km north of the Casino gas field. The proposed location is 9.5 km from the nearest coastline in approximately 55 metres of water. The nearest well control is the onshore Flaxmans-1 (9.8 km NNE) and Pecten-1A (6.5 km SSW).

The objectives of Martha-1 were to:

1. Discover a new hydrocarbon resource within the Waarre Formation
2. Determine whether thick, potentially good productivity Waarre Unit C sands are present as prognosed
3. Test whether the seismic flatspot is indicative of a gas-water contact within the Waarre Formation. DST this interval to establish productivity and gas composition
4. Determine whether an Intra-Belfast seismic event is indicative of a gas-charged reservoir (secondary target)

Martha-1 was spudded at 23:00 hrs on 20/10/04. A 914mm (36") hole was drilled from the seabed at 76.2m to 122.5m. The 760mm (30") casing was then run and set at 121m. A 445mm (17.5") hole was drilled from 122.5m to 628m with returns to the seafloor and 340mm (13-3/8") casing run and set at 620.8m. The blow out preventers was installed and pressure tested. The 311mm (12 ¼") hole was drilled in two bit runs to total depth at 1800m. Total depth was reached at 22:30 hours on the 29th October 2004. Baker Atlas was run into the hole however due to tight hole conditions a wiper trip was required prior to the continuation of logging. Baker Atlas were again rigged up and the following wireline logs were conducted. Run 1: DLL-MLL-ZDL-CN-GR-SP-MAC, Run 2: RCI-GR (35 pretests attempted, 17 normal, 9 lost seal, 2 tool plugged, 6 curtailed, 1 failure), Run 3: Velocity Survey 115 levels at 15m intervals, Run 4: RCOR-GR, tool failed, Run 5: SWC-GR, 25 cores attempted, 25 recovered (100%).

Following wireline logs the well was plugged and abandoned as per program. Plug 1: 1790m to 1600m, Plug 2: 1600m to 1400m and Plug 3: 1400m to 1200m, Plug 4: 655m to 570m, cement retainer set at 166m, Plug 5: 166m to 114m. The rig was released at 24:00 hours on 5th November, 2004.

Martha 1 intersected the top of the Waarre Formation at 1484m RT (-1462.6m SS) which was 6m low to prognosis. The well reached total depth at 1800m RT after penetrating 294m of the Eumeralla Formation.

No hydrocarbon fluorescence was observed while drilling. Good gas shows were observed from ditch cuttings gas while drilling through the Waarre Formation. Log analysis indicates 12.2m of net gas pay for an Inter Paaratte Sandstone with an average porosity of 23.8% and an Sw of 55%. 9.2m of net gas pay is indicated for the Waarre "A" sandstone with an average porosity of 23.3% and an Sw of 53%. No production tests were conducted at the Martha 1 location.

The following objectives of Martha 1 were met:

1. Hydrocarbons were discovered within the Waarre Formation
2. Sandstones prognosed as Waarre Unit C were identified as Waarre Unit A
3. The secondary target was determined to be gas pay in the Inter Paaratte Formation.

AUTHOR: J.PITMAN **DATE**: March 2005

1. GEOLOGY

1.1 INTRODUCTION

Martha-1 was proposed as an Otway Basin gas exploration wildcat well in the VIC/P44 Licence. The well is located approximately 26 km west of Port Campbell, 24km WNW from of the Minerva gas field, and 18 km north of the Casino gas field. The proposed location is 9.5 km from the nearest coastline in approximately 55 metres of water. The nearest well control is the onshore Flaxmans-1 (9.8 km NNE) and Pecten-1A (6.5 km SSW).

The Martha Prospect lies within the interpreted Waarre Play fairway, and is situated on the northern edge of the greater Pecten High and the western flank of the Shipwreck Trough. The prospect is partially covered by the 01Casino3D seismic survey and partially by the OH94, OH91 and OE80a 2D seismic surveys.

The primary target of Martha-1 was the Waarre Formation, which has been proven as a petroleum play in the vicinity of the Shipwreck Trough by the discoveries at Casino, Minerva and La Bella. The top Waarre Sandstone seismic reflector in the Martha Prospect exhibits a strong Class 3 AVO anomaly, which has proven a good indicator of gas accumulations within this reservoir interval throughout the region.

The Martha structure is a tilted fault block with three way dip closure and up dip fault closure, and forms the highest point on the greater Pecten High. The Martha structure has vertical relief from crest to structural spill point of 380m over an area of up to 6,675 acres (27.0 km2) at the Waarre Formation primary target. The Martha-1 location is near crestal, and has also been located to test a seismically imaged “flatspot” which may be indicative of a gas-water contact in the primary objective.

The objectives of Martha-1 were to:

1. Discover a new hydrocarbon resource within the Waarre Formation
2. Determine whether thick, potentially good productivity Waarre Unit C sands are present as prognosed
3. Test whether the seismic flatspot is indicative of a gas-water contact within the Waarre Formation. DST this interval to establish productivity and gas composition
4. Determine whether an Intra-Belfast seismic event is indicative of a gas-charged reservoir (secondary target)

The risks on Martha-1 were:

1. The amplitude anomaly or the flat spot observed in the Waarre section is a function of residual gas saturations, due to seal breach
2. The greater closure as mapped on 2-D seismic data is not present, limiting potential pool volumes
3. The high productivity Waarre C interval is not as prognosed, but is thin or absent

The impact of a successful well as prognosed is:

1. A mean OGIP of approximately 246 BCF (133 BCF Recoverable) could be defined – this equates to the deterministic volumetric mapping down to the flatspot using mean rock property parameters.
2. The possibility of an early tie-back into the proposed Casino development could be realised.

Martha 1 was drilled by the semi-submersible drilling rig "Diamond Offshore Ocean Patriot".

1.2 FIELD DESCRIPTION

General Background

The Martha Structure is located on the northern and western flanks of the Pecten High and Shipwreck Trough respectively and is the present-day highest point on the greater Pecten High. The greater Pecten High consists of a series of NW-SE oriented tilted fault blocks which probably initiated during deposition of the Waarre Formation with the onset of Late Cretaceous rifting and the high has been further segmented by later growth faulting and possible oblique-slip reactivation of the earlier fault system. The adjacent Shipwreck Trough formed a major depocentre during deposition of the Waarre Formation, with the section thinning and onlapping onto the Pecten High. The Waarre Formation is also truncated in places on the greater Pecten High by subsequent erosion during the K85 unconformity.

Mid-Late Tertiary inversion has resulted in gentle east-west folding of the greater Pecten High, similar to that observed over the Minerva structure to the east, though of lesser magnitude. As observed at Minerva, there is little evidence for reverse faulting on the greater Pecten structure. Instead, deep seated fault reactivation has been expressed as a compressional growth fold, with the Mid-Late Tertiary section thinning over the crest. The greater Pecten High is hence a large focal point for hydrocarbons in an active petroleum system which is recently generative.

The Martha structure formed part of a larger tilted fault block during Waarre deposition, with thinning and onlap occurring south of Martha towards Pecten-1A. The Waarre Formation was also truncated to the south of Martha during the K85 unconformity, however the K85 event is not interpreted to truncate the Waarre Formation over the Martha Prospect itself. Subsequent growth faulting during deposition of the post-K85 sequence has resulted in a thickened section of Sherbrook Group to the south of Martha, and has also separated the Martha Prospect from the Pecten East fault block to the south and east. As a result, the highest point on the greater Pecten High is interpreted to have a full Waarre Formation preserved, updip of the thin and truncated section intersected by Pecten-1A.

Pecten-1A is not considered an adequate test of the hydrocarbon potential of the greater Pecten High, due to the potential for variable Waarre preservation and fault compartmentalisation of the greater structure. In addition, there is approximately 30,000 acres of closure updip of Pecten-1A on the top of the Waarre Formation untested on the greater Pecten High. The Martha Structure is considered one of the critical tests of the greater Pecten High, both in terms of the interpreted thicker reservoir presence on the northern flank of the high, and also the potential for multiple accumulations with different gas-water contacts to be present on the greater structure due to compartmentalisation by growth faulting post-Waarre deposition.

Geophysical Summary

The crestal portion of the Martha Prospect exhibits some strong Class 3 AVO anomalies. AVO is seen in the interpreted Waarre C unit as well as the shallower event, nominally called the Thylacine Member. The very crest of the structure appears to be in a “fault shadow” whereby amplitude effects are diminished through this zone of disturbance. Downdip, the edge of the Casino 3D is rapidly encountered and is replaced with a sparse 2D grid of multiple vintage (1980, 1991 and 1994) and variable spacing (1x2.5 km to 2x2.5 km). There are also numerous line-ends in this vicinity. This produces an element of not only structural uncertainty, but also limits the ability to produce amplitude and derivative products. The crestal AVO anomaly has been used as a guide on the lowside of the resource computations.

A flatspot appears on the seismic at the Martha prospect and this is strong evidence for a gas-water contact (GWC) as well as evidence for a thick, good porosity reservoir, as occurs at the nearby Minerva Gas Field. It is also evident in the seismic traverse which heads east from the Martha Prospect to Minerva. The only downside of the flatspot is that it may represent a palaeo-GWC, with breaching of the seal having occurred either through faulting (eg as occurred at the onshore Melba-1 well; the relative thinness of the vertical seal (eg. as compared to Minerva); &/or cross-fault juxtaposition of thief beds (eg as occurred at Conan-1). The flatspot has been used as a guide to the P50-Mean part of the resource distribution.

Interpretative uncertainty is an element of the Martha prospect. This applies to the actual picking of seismic events and the assignation of a specific age and characteristics to them. This occurs as a result of operating on the edge of the 3D; the lack of well ties possible due to either significant faulting &/or being on the edge of the coastal/onshore interface; and finally being in a virtually unknown trough on the western portion of the prospect area. Depth conversion may also arise as an issue, as the location is at the shallowest part of the Pecten High. If velocities have been over-estimated, it would be anticipated that the Cretaceous section in particular would come in higher to prognosis.

Play

The Martha Prospect lies on the north-western flank of the Shipwreck Trough within the proven gas-prone Eumeralla-Waarre Petroleum System play fairway. The Martha Prospect exhibits seismic characteristics similar to existing offshore gas discoveries at Casino and La Bella to the south, and Minerva to the east, as well as the smaller accumulations to the north in the onshore fields of the Port Campbell Embayment.

Closure

The Martha Prospect is a northwest-southeast trending tilted fault block which is partially covered by the 01Casino3D seismic survey, and partially by a 2-3km grid spacing defined by the OH94, OH91 and OE80a 2D seismic surveys. The structural closure is a faulted 3-way against the northwest-southeast striking, south-dipping normal fault on the southern side of the prospect. Whilst the tilted fault block is a robust structure, there is some uncertainty in the lowest closing contour and hence structural spill point of the prospect due to the prospect being mapped on the edge of the 3-D survey and onto the surrounding 2-D grid, which also consists of numerous line ends.

Reservoir

Martha-1 was expected to intersect a full Waarre section, with good quality reservoir in the Waarre C_A and C_B units prognosed to be present. This section is expected to be significantly better developed than intersected by Pecten-1A, and more akin to that intersected by Flaxmans-1, although the Waarre section is interpreted to onlap and thin between Flaxmans-1 and Pecten-1A, hence the section is expected to be thinner than Flaxmans-1.

The presence of a flatspot on seismic is interpreted to be indicative of good porosity reservoir sands that are above tuning thickness (i.e. >25 m). However, the difficulties in mapping the Waarre around the complex faulting of the greater Pecten High, particularly on the edge of the 3-D survey, does introduce some uncertainty as to what potential reservoir section will be encountered.

Seal

Cross-fault seal was considered the primary risk for the Martha Prospect. The Belfast Mudstone, which forms the top seal to the Waarre primary target, thins over the crest of the Martha Prospect. The Belfast

Shale (pre-K85) was interpreted to be approximately 80-100 metres thick at Martha, whilst the trap defining fault on the southern side of the structure has significantly greater throw of up to 250 metres near the crest of the structure. However the fault on the southern side of Martha has significant growth of section on the downthrown side between the K85 and the K90, which is the base of the sand-prone Paaratte Formation. This section, which comprises the Belfast "C" Mudstone and/or Skull Creek Mudstone and forms the top seal for the Casino Field, is generally sand poor, and is juxtaposed against the Waarre Formation along the length of the main fault. However, this section also includes the Nullawarre Greensand equivalent, which although was expected to be thin to absent in this area, could form a cross-fault thief zone.

An additional risk in possible cross-fault sand-sand juxtaposition occurs near the crest of the Martha structure, where the top of the Waarre is almost juxtaposed against the mapped base of the Paaratte Formation. The presence of any thin sands in the top of the Skull Creek Mudstone or a mis-pick in the base of the Paaratte Formation could also result in sand-sand cross-fault juxtaposition and hence trap breach. Sand-sand cross-fault juxtaposition has proven adequate for sealing in a number of onshore fields such as McIntee and Seamer, probably due to shale smear in the fault plane. However, this scenario may be more prone to leakage and/or trap breach, particularly if there is late stage movement on the trapping faults. Whilst the seismic flatspot and AVO effects are good indicators of potential charge, these can also be related to residual hydrocarbons, and hence the possibility of a breached trap cannot be discounted.

There is some evidence of hydrocarbon leakage into the section above the primary target in the Martha area, with the interpreted "Thylacine Member" showing increased seismic amplitude and a distinct AVO response indicative of hydrocarbon charge. This is not however definitive evidence for breach of the primary trap, as similar partial charge of the overlying section is evident in existing offshore pools such as Casino (Nullawarre), Minerva (Flaxmans), and La Bella (Flaxmans), and onshore fields such as Seamer (Nullawarre). There is also evidence for amplitude brightening and AVO effects in the Mepunga Formation over the Martha Prospect, which may be indicative of gas leakage into the Lower Tertiary section. This could be evidence that at least some of the Martha fault block has been breached, and may explain why the flatspot at -1626mSS is not present over the whole structure, and does not correspond to the lowest closing structural contour of -1800mSS.

The top seal thickness of 80-100 m is significantly thinner in comparison with the top seal of proven offshore pools such as Casino (Skull Creek Mudstone = 169m) and Minerva (Belfast Shale = 188m). However, onshore field examples such as McIntee (Belfast Shale = 77m) demonstrate that thicknesses equivalent to the interpreted top seal thickness at Martha are sufficient to form an effective top seal, hence top seal is not expected to be an issue.

Charge

Charge was not expected to be a significant issue for the Martha Prospect. The prospect lies within a proven play fairway, is the highest point on the greater Pecten High, and exhibits seismic amplitude and AVO effects that are generally indicative of gas charge within the Waarre Formation in adjacent discoveries as previously discussed.

However, there is considered to be a 20% possibility of a gas composition with greater than 8% inerts, such as encountered at La Bella, and in onshore fields such as Buttress, Boggy Creek, and Langley. As such a gas composition cannot be tied back through the Casino development, the risk of >8% inerts has been incorporated into the charge risk, rather than the shrinkage distribution.

There is also minor uncertainty in the timing of charge versus the timing of final trap configuration, as well as possible migration pathways, due to both the complex nature of the faulting in the vicinity of Martha, and the difficulties in accurately mapping the structure on the edge of the 3-D survey.

1.3 WELL LOCATION

Martha-1 was proposed as an Otway Basin gas exploration wildcat well in the VIC/P44 Licence. The well is located approximately 26 km west of Port Campbell, 24km WNW from of the Minerva gas field, and 18 km north of the Casino gas field. The proposed location is 9.5 km from the nearest coastline in approximately 55 metres of water. The nearest well control is the onshore Flaxmans-1 (9.8 km NNE) and Pecten-1A (6.5 km SSW).

The Surface Surveyed Location for Martha-1 is :

Latitude:	38° 37' 24.33" South
Longitude:	142° 42' 05.02" East (GDA-94).
Easting:	648109.28 m
Northing:	5723638.23 m (MGA-94)
Rig	Diamond Offshore - Ocean Patriot

The Seismic Location for Casino-3 is:

Inline 17418, X3290.
2001 Casino 3D survey.

2. RESULTS OF DRILLING

2.1 STRATIGRAPHY & GEOPHYSICAL PROGNOSIS

Formations at the Martha 1 well location were intersected from 176m high for the Eumeralla Formation to 43m low for the Skull Creek Formation. The top of the Waarre Formation at 1484m RT (-1462.6m SS) was 6m low to prognosis. The well reached total depth at 1800m RT after penetrating 294m of the Eumeralla Formation.

Waarre Formation Unit C sandstones which were prognosed were not present. Log analysis indicates pay within Waarre Unit A sandstones.

A prognosed Intra-Belfast seismic event was identified as Inter Paaratte Formation gas pay.

TABLE 1: SUMMARY OF SEISMIC MARKERS

SEISMIC HORIZON	AGE	FORMATION	ACTUAL mRT	ACTUAL TVDSS	HIGH (H) LOW (L)
SEA FLOOR					
	RECENT – OLIGOCENE	SEABED (UNDIFFERENTIATED CARBONATES)	76	-55	
	EOCENE – OLIGOCENE	NIRRANDA GROUP			
	EOCENE – OLIGOCENE	MEPUNGA FORMATION	671	-650	1 H
	EOCENE	WANGERRIP GROUP:			
	EOCENE	DILWYN FORMATION	733	-712	56 H
	PALAEOCENE	PEBBLE POINT FORMATION	943	-922	22 L
	MAASTRICHTIAN	SHERBROOK GROUP			
	MAASTRICHTIAN	MASSACRE SHALE	988	-966	88 H
	MAASTRICHTIAN	TIMBOON SANDSTONE	1003	-981	84 H
	CAMPANIAN	PAARATE FORMATION	1134	-1112	67 H
	CAMPANIAN	SKULL CREEK	1396	-1375	43 L
	EARLY - LATE CRETACEOUS	SHIPWRECK GROUP			
	EARLY - LATE CRETACEOUS	WAARRE FORMATION	1484	-1463	6 L
	EARLY CRETACEOUS	OTWAY GROUP			
	EARLY CRETACEOUS	EUMERALLA FORMATION	1506	-1484	176 H
		TOTAL DEPTH (LGR EXT)	1800	-1778	72 H

2.2 STRATIGRAPHY & DEPOSITIONAL ENVIRONMENT (Drillers MDRT Depths)

The well card at the front of this report tables the subsea elevations and thickness of formations penetrated in Martha 1. A brief description of lithology and interpreted environments of deposition follows. More detailed descriptions can be found in Section 2.1 of the Basic Data Report.

The well reached total depth at 1800m (Drl) after penetrating 294m of the Eumeralla Formation (Early Cretaceous). The Eumeralla Formation at the Martha 1 location consists of interbedded sandstones and siltstones. The sandstones are clear, translucent, light greenish grey, fine to medium occasionally coarse grained with moderately strong siliceous cement, trace glauconite and lithics and exhibit poor porosity. Siltstones are light to medium grey, brownish grey, arenaceous, micro micaceous and are moderately hard.

The Waarre Formation (Early-Late Cretaceous) was the primary target for Martha 1 and was intersected at 1494m RT (-1463mSS) 6m low to prognosis. The Waarre Formation which was deposited as the initial post-rift sequence at the commencement of Turonian time. Microplankton at the base of the Waarre formation record the first evidence of wholesale marine incursion into the Otway Basin. The Waarre Formation is sub-divided into three sub-groups Units "A", "B" and "C". Only Unit "A" was intersected at the Martha 1 location.

Martha 1 intersected 22m of Waarre Unit "A" which represents a basal transgressive system characterised by flooding of an incised valley with sediments deposited under marginal marine / estuarine conditions. The unit is similar lithologically to the underlying Eumeralla Formation from which the sediments are sourced. The unit is typically comprised of fine to coarse grained lithic sandstone, interbedded with thin beds of silty carbonaceous mudstone. Onshore the sandstones are dominantly fluvial, but offshore marine conditions are indicated by coarsening upward beds. Log analysis indicates 9.2m of net gas pay for the Waarre A sandstone with an average porosity of 23.3% and an Sw of 53%.

The Skull Creek Mudstone, (sometimes considered part of the Paaratte Formation), unconformably overlies the Waarre Formation. The Skull Creek Mudstone was intersected at 1396m RT and is 88m thick. The formation was intersected 43m low to prognosis. It is typically comprised of comprises a medium to dark brownish-grey, grading to brown black siltstone which is argillaceous and grades to a silty claystone. The Skull Creek Mudstone commonly has dispersed fine to medium quartz grains, trace glauconite and trace disseminated pyrite. It is soft to firm and generally amorphous to subblocky. A pro-delta environment of deposition is interpreted for the Skull Creek and an age of Santonian has been attributed to the Skull Creek Mudstone.

The Paaratte Formation (Campanian) overlies the Skull Creek Mudstone and was intersected at 1134m RT, 67m high to prognosis. Log analysis indicates 12.2m of net gas pay for the Paaratte Formation with an average porosity of 23.8% and an Sw of 55%. Gas pay is allocated to three Inter Paaratte Units. Unit A 1257-1263m (NP 4.7m, Av.Por. 26.1%, Sw 54%), Unit B 1272-1278m (NP 4.6m, Av. Por 23.3%, Sw 53%) and Unit C 1281-1283m (NP 1.8m, Por. 26.9% Sw 58%). The formation typically consists of interbedded sandstones and siltstones. Sandstones are clear, translucent, fine to very coarse grained, weak siliceous cement, common carbonaceous specks and glauconite and exhibit poor to fair porosity. Siltstones are olive grey black, arenaceous in part with trace glauconite and carbonaceous specks and are moderately hard.

The youngest formation of the Sherbrook Group, the Timboon Sandstone was intersected at 1003mRT, 84m high to prognosis. The formation is 131m thick at the Martha 1 location and consists of sandstone with interbedded siltstone. The sandstone is typically light to medium grey, clear to translucent, fine to predominantly medium grained, moderately well sorted, subrounded to occasionally sub angular with weak siliceous cement, trace lithic fragments and disseminated pyrite, friable to loose and occasionally in moderately hard aggregates. No hydrocarbon fluorescence was observed. The interbedded siltstone is light to medium brown to brownish grey, arenaceous, slightly calcareous with minor disseminated pyrite and is firm to moderately hard and subblocky. The Timboon Sandstone was deposited in a deltaic environment and has been dated to be Campanian to Maastrichtian in age in the Otway Basin.

The Massacre Shale overlies the Timboon Sandstone. It was intersected at 988mRT and is 15m thick. The formation typically consists of siltstone interbedded with minor sandstone. The siltstone is medium grey, medium to dark brown, arenaceous and grades to silty sandstone, carbonaceous in part, has rare white argillaceous laminations, has common disseminated pyrite and is moderately hard to occasionally very hard and generally sub blocky. The interbedded sandstones are light to medium grey, clear to translucent, off white, medium to coarse grained. The sandstone is poorly sorted with sub angular to minor angular grains. The sandstone has moderately strong calcareous and dolomitic cement, minor white argillaceous matrix and occasional medium grey silty matrix. Disseminated pyrite is common and the aggregates are hard to occasionally very hard aggregates. There are loose grains in part and no hydrocarbon fluorescence was observed. The Massacre Shale forms the boundary between the Cretaceous and the Tertiary.

Overlying the Massacre Shale is the oldest unit in the Wangerrip Group, the Pebble Point Formation. At the Martha 1 location the Pebble Point Formation 45m thick and was intersected at 943mRT, 22m low to prognosis. The formation typically consists of interbedded sandstone and siltstone. The sandstone is light grey, clear to translucent, fine to very coarse, predominantly medium grained, moderately well sorted, trace weak calcareous cement, friable to moderately hard, generally loose and has fair inferred porosity but no hydrocarbon fluorescence. The interbedded siltstone is medium grey and medium to dark brown, slightly arenaceous, soft to firm, sub blocky. The environment of deposition for the Pebble Point is interpreted to be shallow water, nearshore, restricted marine with periodic influxes of coarse detrital material. Various megafossils and microfossils have been identified in the formation that indicate an age ranging from Maastrichtian for the oldest strata, to Palaeocene.

The Dilwyn Formation conformably overlies the Pebble Point Formation and was intersected at 733mRT 56m high to prognosis. The formation is 210m thick and typically consists of sandstone with minor interbedded siltstone. The sandstone is light to medium grey, clear, translucent, fine to medium occasionally coarse grained, moderately sorted, sub angular to predominantly sub rounded, with trace pyrite cement, trace lithic fragments and commonly loose. The sandstone has fair inferred porosity and no hydrocarbon fluorescence. The siltstone is medium to dark grey, brownish grey, soft to firm, occasionally hard, with trace pyrite and is blocky.

The Dilwyn Formation has been dated at Early Eocene. The environment of deposition is interpreted to be shallow marine, with the cleaner sandy portions representing shoreface deposits of a coastal barrier system and the interbedded section possibly back beach lagoon sediments, with some breaching occurring.

The Dilwyn Formation is the youngest unit of the Wangerrip Group, and is unconformably overlain by the Mepunga Formation, the oldest formation of the Nirranda Group. The Mepunga Formation was intersected 1m high to prognosis at 671mRT and is 62m thick. The formation typically consists of massive sandstone which is white to very light grey, light brownish yellow, medium grained, well sorted, with grains that are sub rounded to occasionally rounded and minor sub angular. The sandstone has a weak siliceous cement and common Fe-staining. There are traces of glauconite and trace pyrite. The sandstone is predominantly loose and partly friable to moderately hard. The porosity is inferred to be fair with no hydrocarbon fluorescence. There is minor interbedded siltstone / claystone which is light to medium greenish grey with trace glauconite, trace to common pyrite and is very soft and dispersive. The Mepunga is Middle Eocene to Early Oligocene in age. The sandstones have been interpreted as being deposited in beach and nearshore locations as barrier islands.

Recent to Oligocene sediments overlie the Mepunga Formation and were not differentiated at the Martha 1 location. These formations lie behind the 340mm casing which was set at 621m. These include carbonate formations of the Heytesbury Group. All returns were to the seafloor prior to running the marine riser and blow out preventer.

2.3 <u>**HYDROCARBON SUMMARY** (Logger's MDRT Depths)</u>

Ditch gas values were monitored and recorded in units (U) by F.I.D (flame ionisation detector) Total Gas detector, where one unit is equivalent to 200 ppm (parts per million) of methane gas in air. The ditch gas was also monitored for hydrocarbon gas composition by a F.I.D. chromatograph. Gas composition refers to percent components of the hydrocarbon alkane series: (methane, ethane, propane, butane and pentane). Gas compositions are quoted as the percentage ratios of these five gases (i.e. 94/2/1/1/1 denotes 94% C1, 2% C2, 1% C3, 1% C4 and 1% C5). Ditch cuttings were tested for hydrocarbon fluorescence by using an ultra-violet fluoroscope.

All returns were to the seafloor prior to running the 340mm (13 3/8") casing at 628m. After drilling out the 340mm (13-3/8") casing shoe at 620.8m returns were to the surface and real time gas monitoring was possible. Background gas was first observed from 930m and ranged from 2 – 10 U (92/4/2/1). Gas peaks up to 80 U (92/5/2/1) were observed through the Timboon Sandstone. Background gas increased through the lower Timboon Sandstone from 1060m reaching 40-100 U 97/3/tr/tr at the top of the Paaratte Formation at 1134mRT.

Background gas ranged from 40-70 U (94/5/1/trace) through the Paaratte Formation. Log analysis indicates 12.2m of net gas pay for the Paaratte Formation with an average porosity of 23.8% and an Sw of 55%. Gas pay is allocated to three Inter Paaratte Units. Unit A 1257-1263m (NP 4.7m, Av.Por. 26.1%, Sw 54%), Unit B 1272-1278m (NP 4.6m, Av. Por 23.3%, Sw 53%) and Unit C 1281-1283m (NP 1.8m, Por. 26.9% Sw 58%). Refer to Table 2 for log analysis and gas breakdowns. No hydrocarbon fluorescence was observed through the Paaratte Formation.

TABLE 2: PAARATTE FORMATION GAS SHOW AND LOG ANALYSIS SUMMARY

INTERVAL /SAND	*NET PAY*	*GAS PEAK/ BACKGROUND*	*BREAKDOWN*	*AVE POR*	*AVE SW*	*COMMENTS*
Unit "A" 1257 – 1263 m	4.7	150 / 30 U	96/3/1/trace	26.1	54	
Unit "B" 1272 – 1278 m	4.6	180 / 40 U	96/3/1/trace	23.1	53	
Unit "C" 1281 – 1283 m	1.8	100 / 40 U	94/5/1/trace	26.9	58	
SAMPLE CHAMBER 369205 DEPTH: 1258.7m PAARATTE FM AMBIENT TEMPERATURE: 17degC SURFACE PRESSURE 4500 PSI Sample chamber bled down 1.6 cuft to purge lines. After taking samples a total of 2.1 cuft had been bled down FINAL CHAMBER PRESSURE: 3000 PSI The sample chamber was not fully bled down and was transported to Petrolab for further analysis. Final gas analysis 96/3/1/TR/TR.						

Background gas ranged from 30-50 U (93/5/2/trace) through the Skull Creek Formation. Gas peaks were observed at 1367m, 200 U (96/3/1) and 1384m, 500 U (94/5/1/trace) through interbedded sandstones however no pay is assigned.

The Waarre Formation was the primary target for the well and was intersected at 1484mRT, 6m low to prognosis. Gas peaked at 910 U (92/5/2/1/trace) (ABG: 30 U) from 1484m to 1495m upon penetrating the Waarre Formation. No hydrocarbon fluorescence was observed. 4 x 840cc RCI samples were taken at 1488.6m and were forwarded for analysis. Field results indicate a gas analysis of 94/4/1.4/0.6. The Waarre A sandstone is described as clear to translucent, fine to medium grained, predominantly loose with fair to good inferred porosity. Log analysis indicates 9.2m of net gas pay for the Waarre A sandstone (Por. 23.3%, Sw 53%) over the interval 1484-1498m. Waarre Units B and C were not identified at the Martha 1 location.

TABLE 3: WAARRE FORMATION GAS SHOW AND LOG ANALYSIS SUMMARY

INTERVAL /SAND	*NET PAY*	*GAS PEAK/ BACKGROUND*	*BREAKDOWN*	*AVE POR*	*AVE SW*	*COMMENTS*
Waarre A 1484-1498m	9.2	910 / 30 U	92/5/2/1/trace	23.3	53	
SAMPLE CHAMBER 189733 DEPTH: 1488.6m WAARRE FM. AMBIENT TEMPERATURE: 17degC SURFACE PRESSURE 4500 PSI Sample chamber bled down 1.5 cuft to purge lines. After taking samples a total of 2.7 cuft had been bled down FINAL CHAMBER PRESSURE: 3000 PSI. The sample chamber was not fully bled down and was transported to Petrolab for further analysis. Final gas analysis: 94/4/1.4/0.6/TR						

The Eumeralla Formation was penetrated at 1506m, 176m high to prognosis. Background gas ranged from 20-40 U (95/4/1) through the upper Eumeralla Formation from 1506m to 1575m. A drilling break from 1579m to 1581m yielded a peak of 300 U (95/4/1/trace) (ABG: 40 U). Through the remainder of the Eumeralla Formation background gas ranged from 30-70 U (96/3/1/trace). No hydrocarbon fluorescence was observed. Martha 1 reached total depth at 1800m after penetrating 294m of the Eumeralla Formation.

2.4 SUMMARY

Martha-1 was proposed as an Otway Basin gas exploration wildcat well in the VIC/P44 Licence. The well is located approximately 26 km west of Port Campbell, 24km WNW from of the Minerva gas field, and 18 km north of the Casino gas field. The proposed location is 9.5 km from the nearest coastline in approximately 55 metres of water. The nearest well control is the onshore Flaxmans-1 (9.8 km NNE) and Pecten-1A (6.5 km SSW).

The objectives of Martha-1 were to:
1. Discover a new hydrocarbon resource within the Waarre Formation
2. Determine whether thick, potentially good productivity Waarre Unit C sands are present as prognosed
3. Test whether the seismic flatspot is indicative of a gas-water contact within the Waarre Formation. DST this interval to establish productivity and gas composition
4. Determine whether an Intra-Belfast seismic event is indicative of a gas-charged reservoir (secondary target)

Martha-1 was spudded at 23:00 hrs on 20/10/04. A 914mm (36") hole was drilled from the seabed at 76.2m to 122.5m. The 760mm (30") casing was then run and set at 121m. A 445mm (17.5") hole was drilled from 122.5m to 628m with returns to the seafloor and 340mm (13-3/8") casing run and set at 620.8m. The blow out preventers was installed and pressure tested. The 311mm (12 ¼") hole was drilled in two bit runs to total depth at 1800m. Total depth was reached at 22:30 hours on the 29th October 2004. Baker Atlas was run into the hole however due to tight hole conditions a wiper trip was required prior to the continuation of logging. Baker Atlas were again rigged up and the following wireline logs were conducted. Run 1: DLL-MLL-ZDL-CN-GR-SP-MAC, Run 2: RCI-GR (35 pretests attempted, 17 normal, 9 lost seal, 2 tool plugged, 6 curtailed, 1 failure), Run 3: Velocity Survey 115 levels at 15m intervals, Run 4: RCOR-GR, tool failed, Run 5: SWC-GR, 25 cores attempted, 25 recovered (100%).

Following wireline logs the well was plugged and abandoned as per program. Plug 1: 1790m to 1600m, Plug 2: 1600m to 1400m and Plug 3: 1400m to 1200m, Plug 4: 655m to 570m, cement retainer set at 166m, Plug 5: 166m to 114m. The rig was released at 24:00 hours on 5th November, 2004.

Martha 1 intersected the top of the Waarre Formation at 1484m RT (-1462.6m SS) which was 6m low to prognosis. The well reached total depth at 1800m RT after penetrating 294m of the Eumeralla Formation.

No hydrocarbon fluorescence was observed while drilling. Good gas shows were observed from ditch cuttings gas while drilling through the Waarre Formation. Log analysis indicates 12.2m of net gas pay for an Inter Paaratte Sandstone with an average porosity of 23.8% and an Sw of 55%. 9.2m of net gas pay is indicated for the Waarre "A" sandstone with an average porosity of 23.3% and an Sw of 53%. No production tests were conducted at the Martha 1 location.

The following objectives of Martha 1 were met:

1. Hydrocarbons were discovered within the Waarre Formation
2. Sandstones prognosed as Waarre Unit C were identified as Waarre Unit A
3. The secondary target was determined to be gas pay in the Inter Paaratte Formation.

3. REFERENCES

Santos, 2004	Martha-1 Well Proposal, Prepared for Santos Ltd, (unpublished).
Pitman, J., 2004	Martha-1 Basic Data Report, Prepared for Santos Limited, (unpublished).
Santos, 2003	Casino-3 Well Proposal, Prepared for Santos Ltd, (unpublished).
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Abele, C., Pettifer, G., Tabassi, A. 1995	The Stratigraphy, Structure, Geophysics, and Hydrocarbon Potential of The Eastern Otway Basin. Department of Agriculture, Energy And Minerals of Victoria. Geological Survey Of Victoria, Geological Survey Report 103.
Partridge, A., 1997	New Upper Cretaceous Palynology of The Sherbrook Group Otway Basin. Biostrata Pty. Ltd. In PESA News, April/May.

APPENDIX I : ELECTRIC LOG EVALUATION RESULTS

Log analysis indicates 12.2m of net gas pay for an Inter Paaratte Sandstone with an average porosity of 23.8% and an Sw of 55%. 9.2m of net gas pay is indicated for the Waarre "A" sandstone with an average porosity of 23.3% and an Sw of 53%.

A summary of the Log analysis is presented overleaf.

MARTHA 1

LOG ANALYSIS

MARTHA 1 - LOG ANALYSIS

Martha 1 wireline logs were analysed over the interval 1250m -1800m (L). Conventional Gas pay was identified in the Basal Paaratte and Waarre A Formations. Martha 1 was plugged and abandoned as it failed to meet the minimum economic pool size.

A 914mm surface hole was drilled to 121.3m and 762/500mm casing set at 121.3m. A 444mm hole was then drilled from 121.3m to 645m and 340mm casing set at 635.8m. A 311mm hole was drilled with KCl/Polymer mud from 635m to a total depth of 2135m (D). Wireline logging was carried out as described below.

Unless otherwise specified, all depths mentioned below are logger's depths referenced to the drill floor.

Conventional Pay Summary

Inter Paaratte Sand	Gas Pay **11.0m** Ave Por 25.2%, Ave S_w 54%
Waarre A	Gas Pay **9.2m** Ave Por 23.3%, Ave S_w53%

Logs Acquired

Run 1	GR	1756m – Surface.
	DLL	1785m – 621m
	MAC	1771m – 621m
	ZDL	1766m – 621m
	MLL/CAL	1790m – 621m
	CN	1766m – 621m
	SP	1747m– 621m

Run 2 RCI-GR 35 Pretests, 17 normal, 9 lost seal, 2 plugged, 6 curtailed, 1 failure. 4 x 850 cc samples @ 1488.6m and 2 x 850 cc samples at 1258.7m

Mud Parameters

Mud Type	KCl Polymer
KCl Content	4%
Barite content	5.7%
Mud Density	1260 K/M3
Rm	0.158 ohmm @ 23.89 DEGC
Rmf	0.112 ohmm @ 23.72 DEGC
Rmc	0.315 ohmm @ 23.61 DEGC
Max. Recorded Temperature	66DEGC

Log Processing Remarks

Wireline log quality above 1480m is severely affected by bad borehole. Pad tools such as the Density and MLL are unreliable in severely washed out borehole. The high barite content affects the PEF to such an extent that it is a spurious value. Beneath 1480m the log quality is less affected by bad borehole but the high PEF values are still evident and as a result was not used in the analysis.

Interpretation Procedures and Parameters

An interpretation over the Permian intervals was conducted using a combination of Density-Neutron Crossplot porosity (DPHIX) and Raymer-Hunt-Gardner Sonic porosity (SPHI) to produce PHIT. A gamma-ray derived volume of shale was calculated with water saturations computed using a pseudo-Archie Equation (Parameters used for the interpretation are detailed in Table 1).

- Borehole corrections for the Dual Laterolog RS and RD curves were applied (Table 1). These are ratios used to emulate the algorithms illustrated in the Baker Atlas charts 7-18 and 7-15 respectively.

- The borehole corrected deep resistivity curve (RD_{BC}) was further corrected for shoulder effects (RDc).

- The invasion corrected R_T was derived using the following relationship:

  $R_T = (1.8*RD_C - 0.75*RS\_{BC})$
  where:
  RD_C = Deep resistivity response borehole and shoulder bed corrected.
  RS_{BC} = Shallow resistivity response borehole corrected.

- A porosity curve was calculated from the Raymer-Hunt-Gardner equation:
  *SPHI = ((DTH - 55.5) / (DT))*0.58*
  where:
  DTH = 6” sonic transit time (µs/ft), smoothed.

- A density porosity curve was calculated:
  DPHI = ((2650-ZDEN) / (2650-1650))
  where:
  ZDEN = Bulk Density reading

- Density-neutron crossplot porosity curve was calculated:
  PHIX = (DPHI+CNC)/2
  where:
  CNC = Corrected, Compensated Neutron log

- A shale compensated Density-neutron crossplot porosity was calculated using:
  DPHIX = min(PHIX,DPHI)

- PHIT was produced primarily from Nuclear Cross Plot porosity with subsequent edits to density and sonic porosity (using SPHI).

- A shale corrected total porosity (PHIE to be used in the Archie equation) was calculated as follows:

$$PHIE = PHIT-(VSH*PHIsh)$$

Where,
VSH = Volume of shale,
PHIsh = porosity of shale

- Water saturations were calculated using a pseudo-Archie equation.

$$SW = \sqrt[n]{\frac{aRw}{\phi^m Rt}}$$

where:
R_w = Resistivity of formation water at formation temperature.
RT = True resistivity, i.e. resistivity of the non-invaded reservoir (i.e. LLD corrected for borehole, invasion and resistive shoulder beds).
PHIT= Input as shale corrected PHIE (derived above).
a = Porosity coefficient (default = 1).
m = Cementation factor or exponent
n = Saturation exponent

Conclusions

1. Martha 1 log analysis identified conventional pay in the Inter Paaratte Sand and the Waarre A. However, these failed to reach the MEPS for subsequent development.
2. Conventional pay, porosity and water saturations for Martha 1 are tabulated in Table 2. Cut off's used are (PHIE>10% and S_w<70)
3. Pay sensitivity plots have been produced at 2 % increments for the Paaratte and Waarre A are found attached (Table 4).
4. Martha 1 was plugged and abandoned.

Attached is the well evaluation summary (WES) plot for Martha 1
/data/wes_ot/martha1_04127.wes

TABLE 1
Log Analysis Parameters

PARAMETERS	PAARATTE FORMATION	WAARRE A FORMATION
R_w (ohmm) @ 25 DEGC	0.38	0.38
a	1	1
m	2	1.85
n	2	2
Borehole cor RD	0.82	0.84
Borehole cor RS	0.92	0.9
RD Shoulder Corr.	0.73	0.77
GR matrix (API)	30	30
GR shale (API)	165	165
PHISH	0.27	0.27

TABLE 2

Conventional Pay Summary

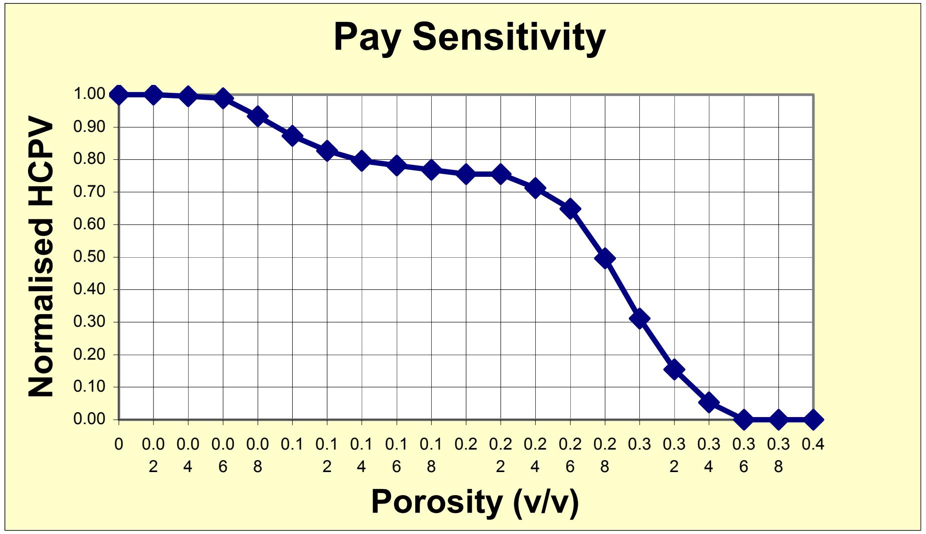
FORMATION	SAND INTERVAL	GROSS SAND (m)	NET SAND (m)	AVG PHIs (%)	NET PAY (m)	AVG PHIp (%)	WT.AVG SW (%)
INTER PAARATTE SAND	1250-1396	130.5	50.7	15.6	12.2	23.8	55
SKULL CREEK MUDSTONE	1396-1484	83.4	22.2	11.7	0	-	-
WAARRE A	1484-1505	17.8	13	20.9	9.2	23.3	53
EUMERALLA FORMATION	1505-1759	108	1.4	10.8	0	-	-

FORMATION	SAND	SAND INTERVAL	GROSS SAND (m)	NET SAND (m)	AVG PHIs (%)	NET PAY (m)	AVG PHIp (%)	WT.AVG SW (%)
INTER PAARATTE SAND	A	1257-1263	6.5	5.5	24	4.7	26.1	54
INTER PAARATTE SAND	B	1272-1278	5.9	4.8	22.8	4.6	23.3	53
INTER PAARATTE SAND	C	1281-1283	2.5	2.2	24.6	1.8	26.9	58
WAARRE A	D	1484-1498	13.7	12.7	21.1	9.2	23.3	53

Net Pay identified where PHIE>8% & S_w<70%, Net Sand identified where PHIE>10%

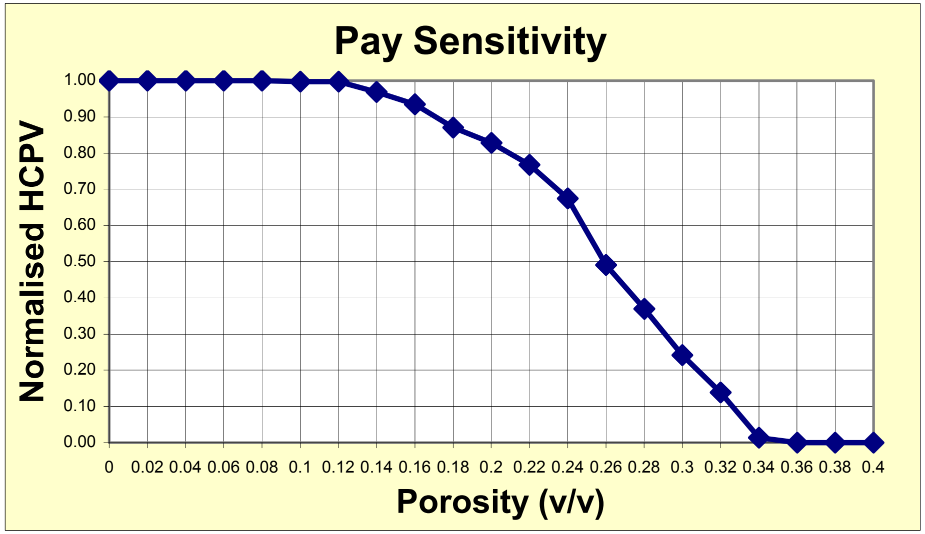
MARTHA_1
INTER PAARATTE

PHIT Cutoff	SWT Cutoff	AVG PHIE V/V	AVG SWT V/V	Phie*H	HCPV Sg*Phie*H	NET (ft)	NHCPV
0	0.7	0.176	0.56	3.433	1.51	19.5	1.00
0.02	0.7	0.177	0.56	3.431	1.51	19.4	1.00
0.04	0.7	0.181	0.559	3.411	1.503	18.8	1.00
0.06	0.7	0.186	0.558	3.38	1.493	18.2	0.99
0.08	0.7	0.209	0.554	3.162	1.409	15.1	0.93
0.1	0.7	0.238	0.545	2.902	1.319	12.2	0.87
0.12	0.7	0.26	0.538	2.704	1.249	10.4	0.83
0.14	0.7	0.274	0.532	2.573	1.203	9.4	0.80
0.16	0.7	0.279	0.53	2.515	1.181	9	0.78
0.18	0.7	0.283	0.529	2.464	1.161	8.7	0.77
0.2	0.7	0.287	0.526	2.407	1.14	8.4	0.75
0.22	0.7	0.287	0.526	2.407	1.14	8.4	0.75
0.24	0.7	0.291	0.526	2.267	1.076	7.8	0.71
0.26	0.7	0.296	0.521	2.044	0.98	6.9	0.65
0.28	0.7	0.307	0.501	1.503	0.75	4.9	0.50
0.3	0.7	0.319	0.473	0.893	0.47	2.8	0.31
0.32	0.7	0.335	0.421	0.401	0.233	1.2	0.15
0.34	0.7	0.343	0.416	0.137	0.08	0.4	0.05
0.36	0.7	0	0	0	0	0	0.00
0.38	0.7	0	0	0	0	0	0.00
0.4	0.7	0	0	0	0	0	0.00



MARTHA_1
WAARRE A

PHIT Cutoff	SWT Cutoff	AVG PHIE V/V	AVG SWT V/V	Phie*H	HCPV Sg*Phie*H	NET (ft)	NHCPV
0	0.7	0.232	0.534	2.154	1.003	9.3	1.00
0.02	0.7	0.232	0.534	2.154	1.003	9.3	1.00
0.04	0.7	0.232	0.534	2.154	1.003	9.3	1.00
0.06	0.7	0.232	0.534	2.154	1.003	9.3	1.00
0.08	0.7	0.232	0.534	2.154	1.003	9.3	1.00
0.1	0.7	0.233	0.534	2.144	1	9.2	1.00
0.12	0.7	0.233	0.534	2.144	1	9.2	1.00
0.14	0.7	0.24	0.529	2.064	0.972	8.6	0.97
0.16	0.7	0.246	0.524	1.972	0.938	8	0.94
0.18	0.7	0.258	0.515	1.803	0.873	7	0.87
0.2	0.7	0.264	0.508	1.689	0.831	6.4	0.83
0.22	0.7	0.272	0.495	1.523	0.77	5.6	0.77
0.24	0.7	0.281	0.476	1.294	0.677	4.6	0.67
0.26	0.7	0.299	0.452	0.897	0.492	3	0.49
0.28	0.7	0.31	0.456	0.682	0.371	2.2	0.37
0.3	0.7	0.321	0.462	0.45	0.242	1.4	0.24
0.32	0.7	0.33	0.474	0.264	0.139	0.8	0.14
0.34	0.7	0.342	0.604	0.034	0.014	0.1	0.01
0.36	0.7	0	0	0	0	0	0.00
0.38	0.7	0	0	0	0	0	0.00
0.4	0.7	0	0	0	0	0	0.00



APPENDIX II : RCI PRESSURE SURVEY REPORT AND DATA

Santos

RCI PRESSURE SURVEY

WELL: Martha 1 RT: 21.5 metres Gauge Type : CQG Page : 1 OF 3

WITNESS: M. Lahiff Time since last circ : 6:30 hrs, 31-10-04 Probe/Packer Type : Standard Date : 31/10/2004

TEST NO	FORMATION	DEPTH RT MD m	DEPTH SUBSEA m	FILE NO	TEST RESULTS					INTERPRETATION		COMMENTS
					HYDRO BEFORE PSIA	FORM PRESS PSIA	HYDRO AFTER PSIA	TEMP deg Far	D/D MOB MD/CP	BU Description	Super-charged yes/no	
												Correlation Run
1	Paaratte Fm.	1258.7	1237.2	3	2272.70	1803.60	2272.70	58.4	38.7	Good		
1	Paaratte Fm.	1258.7	1237.2	3	2272.70	1804.10	2272.70	58.4	45.7	Good		Repeat
2	Paaratte Fm.	1260.6	1239.1	4	2276.30	1804.50	2276.50	59.0	18.7	Good		
2	Paaratte Fm.	1260.6	1239.1	4	2276.30	1804.50	2276.50	59.0	22.9	Good		Repeat
3	Paaratte Fm.	1276.0	1254.5	5	2304.40	1832.40	2304.40	59.5	119.5	Good		
3	Paaratte Fm.	1276.0	1254.5	5	2304.40	1832.60	2304.40	59.5	283.8	Good		Repeat
4	Paaratte Fm.	1276.8	1255.3	6	2305.70		2306.00	60.1	57.60	Slow		Did not stabilise
4	Paaratte Fm.	1276.8	1255.3	6	2305.70	1833.10	2306.00	60.1	37.00	Good		Repeat
4	Paaratte Fm.	1276.8	1255.3	6	2305.70	1833.10	2306.00	60.1	37.00	Good		Repeat.
5	Paaratte Fm.	1281.3	1259.8	7	2314.10		2314.20	61.1	165.40	Slow		Not stable
5	Paaratte Fm.	1281.3	1259.8	7	2314.10	1833.14	2314.30	61.1	286.60	Good		Repeat
5	Paaratte Fm.	1281.3	1259.8	7	2314.10	1833.23	2314.30	61.1	286.60	Good		Repeat
6	Paaratte Fm.	1284.5	1263.0	8	2320.10		2320.50	61.7	92.40	Slow		Not stable
6	Paaratte Fm.	1284.5	1263.0	8	2320.10	1835.90	2320.50	61.7	163.70	Good		Repeat
6	Paaratte Fm.	1284.5	1263.0	8	2320.10	1836.00	2320.50	61.7	167.00	Good		Repeat
7	Paaratte Fm.	1289.4	1267.9	9	2328.90	1843.29	2329.20	62.1	35.90	Good		
7	Paaratte Fm.	1289.4	1267.9	9	2328.90	1843.40	2329.20	62.1	32.50	Good		Repeat
8	Paaratte Fm.	1300.5	1279.0	10	2349.30		2349.50	62.2	54.00	Slow		Not stable
8	Paaratte Fm.	1300.5	1279.0	10	2349.30	1860.00	2349.50	62.2	48.00	Slow		stable
8	Paaratte Fm.	1300.5	1279.0	10	2349.30	1859.90	2349.50	62.2	53.10	Slow		stable
9	Thylacine Mbr	1366.2	1344.7	11	2466.70	1997.35	2467.00	62.3	5.40	V. Slow	Possibly sc	stable.
10	Thylacine Mbr	1367.6	1346.1	12	2469.50	1993.20	2469.50	62.8	11.70	Good		stable
10	Thylacine Mbr	1367.6	1346.1	12	2469.50	1993.00	2469.50	62.8	10.70	Good		Repeat
11	Thylacine Mbr	1383.7	1362.2	13						n/a		failure
12	Thylacine Mbr	1383.7	1362.2	14	2498.40		2498.70	64.2		tight		tight
13	Thylacine Mbr	1385.6	1364.1	15	2501.80	2049.90	2502.00	64.2	3.80	V. Slow		stable
14	Thylacine Mbr	1386.8	1365.3	16								Lost seat.
15	Thylacine Mbr	1386.8	1365.3	17								Tool plug
16	Thylacine Mbr	1383.0	1361.5	18								Tool plug
16	Thylacine Mbr	1383.0	1361.5	18	2497.40		2497.60					Tight
17	Thylacine Mbr	1386.8	1365.3	19	2503.60	2045.10	2504.10	65.5	4.60	Slow		Stable
17	Thylacine Mbr	1386.8	1365.3	19	2503.60	2045.10	2504.10	65.5	4.60	Slow		repeat
				20								**Correlation Run**
18	Waarre	1484.5	1463.0	21	2679.30	2203.15	2677.70	66.4	3.00	Good		Stable
18	Waarre	1484.5	1463.0	21	2679.30	2203.30	2677.70	66.4	3.90	Good		Repeat
19	Waarre	1487.5	1466.0	22	2683.20		2683.60	66.5	44.20	Slow		Not stable
19	Waarre	1487.5	1466.0	22	2683.20	2204.30	2683.60	66.5	103.50	Good		Repeat.Stable
20	Waarre	1491.8	1470.3	23	2691.00		2691.00	66.6	117.50	Good		Not stable
20	Waarre	1491.8	1470.3	23	2691.00	2204.70	2691.20	66.6	117.50	Good		Repeat.
21	Waarre	1495.5	1474.0	24	2697.60		2697.60	66.7	82.70	Good	Possibly sc	Not stable
21	Waarre	1495.5	1474.0	24	2697.60	2205.20	2697.60	66.7	182.40	Good		Repeat. Stable
22	Waarre	1496.8	1475.3	25	2699.90		2699.80	67.5	7.50			Not stable

Santos

RCI PRESSURE SURVEY

WELL: Martha 1 RT: 21.5 metres Gauge Type : CQG Page : 2 OF 3
WITNESS: M. Lahiff Time since last circ : 6:30 hrs, 31-10-04 Probe/Packer Type : Standard Date : 31/10/2004

	FORMATION	DEPTH RT MD m	DEPTH SUBSEA m	FILE NO	TEST RESULTS					INTERPRETATION		COMMENTS
					HYDRO BEFORE PSIA	FORM PRESS PSIA	HYDRO AFTER PSIA	TEMP deg Far	D/D MOB MD/CP	BU Description	Super-charged yes/no	
22	Waarre	1496.8	1475.3	25	2699.90	2205.37	2699.80	67.5	7.00			Repeat.
23	Waarre	1507.5	1486.0	26	2719.10		2719.20	67.5				Tight
24	Waarre	1517.6	1496.1	27	2737.10		2737.40	68.0				Tight
25	Waarre	1520.0	1498.5	28	2741.50		2741.50					Tight
				29								**Correlation Run**
26	Waarre	1579.8	1558.3	30	2848.10		2848.20			V.Slow		Tight. Unstable BU
27	Waarre	1585.5	1564.0	31	2858.50	2717.60	2858.30	69.5	4.30	V.Slow		Stable
28	Waarre	1602.3	1580.8	32								No Seal
28	Waarre	1602.2	1580.7	33								No Seal
29	Waarre	1608.0	1586.5	34								No Seal
30	Waarre	1613.0	1591.5	35								No Seal
31	Waarre	1613.0	1591.5	35								No Seal
				36								**Correlation Run**
32	Waarre	1488.6	1467.1	37								
32	Waarre	1488.6	1467.1	38		2204.40			54.90			Repeat & Sample (4 x 850cc)
				39								**Correlation Run**
33	Paaratte Fm.	1258.6	1237.1	40								Possible lost seal
33	Paaratte Fm.	1258.6	1237.1	41								Repeat. Possible lost seal
34	Paaratte Fm.	1258.7	1237.2	42								Possible lost seal
35	Paaratte Fm.	1258.7	1237.2	43								Unstable
35	Paaratte Fm.	1258.7	1237.2	44		1804.00			52.90			Repeat. Stable. Sample (2 x 850cc)

35 PRE-TESTS: 17 Normal, 9 Lost Seals, 2 Tool Plugged, 6 Curtailed/Tight, 1 Failure
SAMPLES: 1488.6mRT; 4 X 850cc bottles
1258.7m; 2 X 850 cc bottle

Expected Water Gradient: 0.423 psi/ft
Mud Weight : 10.5ppg

SAMPLE CHAMBER 189733 (850cc)
DEPTH: 1488.6m
WAARRE FM.
AMBIENT TEMPERATURE: 17degC
SURFACE PRESSURE 4500 PSI

Sample chamber bled down 1.5 cuft to purge lines.
After taking samples a total of 2.7 cuft had been bled down
FINAL CHAMBER PRESSURE: 3000 PSI
The sample chamber was not fully bled down and was transported to Petrolab for further analysis.

	PPM	%
C1	742661	93.651
C2	32869	4.145
C3	11409	1.439
IC4	2444	0.308
NC4	2368	0.299
IC5	765	0.096
NC5	489	0.062
	793005	
		94/4/1.4/0.6/TR

SAMPLE CHAMBER 369205 (850cc)
DEPTH: 1258.7m
PAARATTE FM
AMBIENT TEMPERATURE: 17degC
SURFACE PRESSURE 4500 PSI

Sample chamber bled down 1.6 cuft to purge lines.
After taking samples a total of 2.1 cuft had been bled down
FINAL CHAMBER PRESSURE: 3000 PSI
The sample chamber was not fully bled down and was transported to Petrolab for further analysis.

	PPM	%
C1	941628	96.058
C2	29271	2.986
C3	5742	0.586
IC4	1894	0.193
NC4	948	0.097
IC5	590	0.060
NC5	198	0.020
	980271	
		96/3/1/TR/TR

APPENDIX III: HYDROCARBON SHOW REPORT

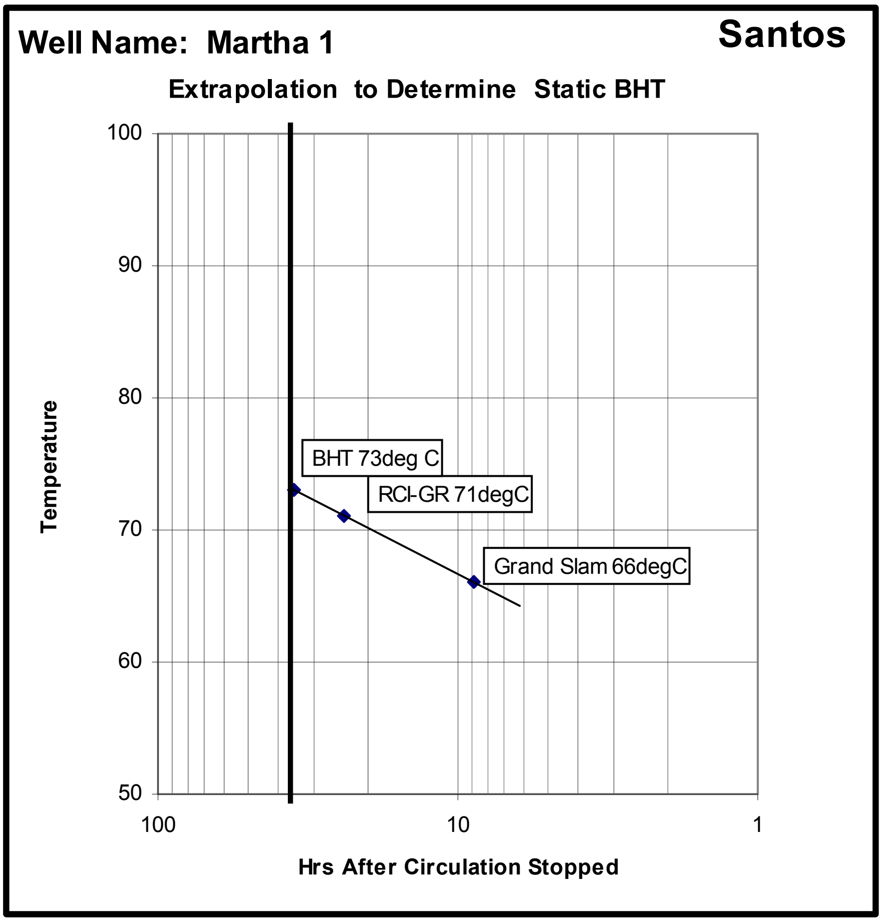
No Fluorescence was observed in Martha 1.

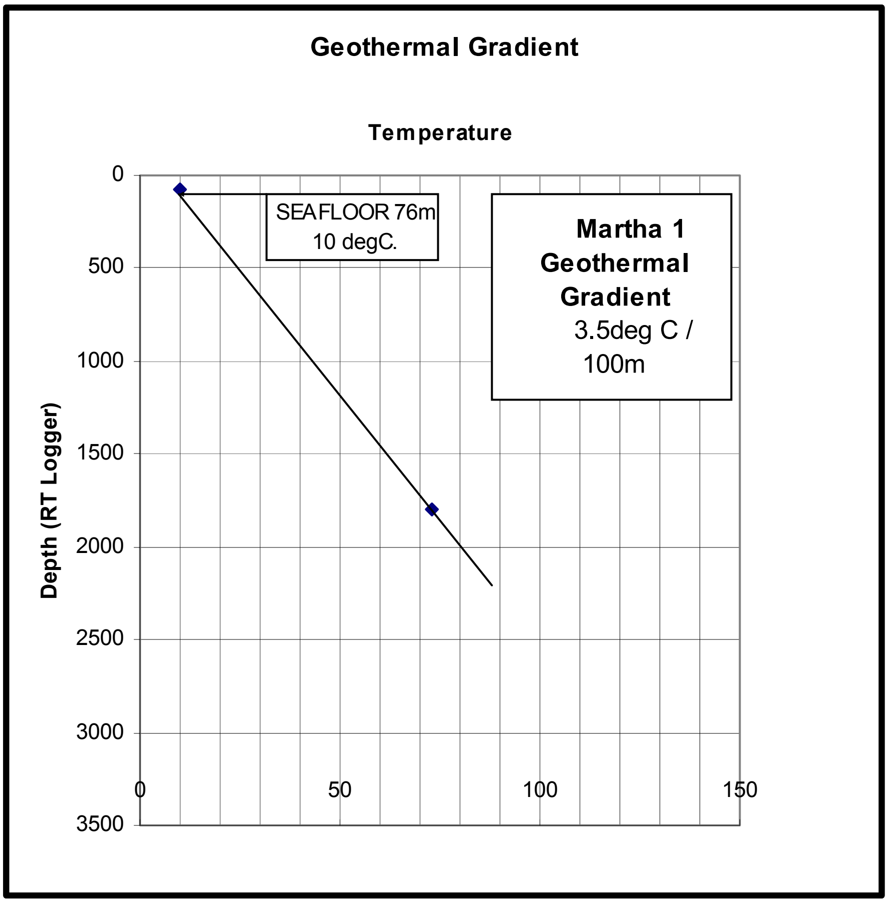
APPENDIX IV : GEOTHERMAL GRADIENT

Data from Wireline Logs were used to estimate a Geothermal Gradient. An extrapolated static bottom hole temperature of 73°C at 1800m and a geothermal gradient of 3.5°C/100m were calculated from downhole temperatures recorded during logging operations.

LOG	TEMP	DEPTH	TIME SINCE LAST CIRCULATION
Run 1 Grand Slam	66ºC	1790m	8 hours 30 minutes
RCI-GR	71.1ºC	1613	24 hours

The results are depicted graphically overleaf.


Well Name: Martha 1
Santos
Extrapolation to Determine Static BHT
Temperature
100
90
80
70
60
50
BHT 73deg C
RCI-GR 71degC
Grand Slam 66degC
100
10
1
Hrs After Circulation Stopped


Geothermal Gradient
Temperature
Depth (RT Logger)
0
500
1000
1500
2000
2500
3000
3500
SEAFLOOR 76m
10 degC.
Martha 1
Geothermal
Gradient
3.5deg C /
100m
0
50
100
150

APPENDIX V : PETROLOGY REPORT

Report prepared for:

SANTOS LTD
91 King William St
Adelaide SA 5000

PETROLOGY REPORT

MARTHA-1

OTWAY BASIN

Report prepared by:

Dr S E PHILLIPS
PGPC
1c Short Crescent
Beaumont SA 5066

March 2005

Mobile: 0414 712 728 Fax/phone: (61) 08 8379 8281 Email:pgpc@bigpond.com.au

CONTENTS

Front cover:
Thin section photomicrograph, Martha-1, swc 6, depth 1598.4m. Plane light. Horizontal field of view 1.30mm.

1. SUMMARY

Santos Ltd submitted seven sidewall cores to PGPC from the well Martha-1 in the Otway Basin (VIC/P44). Samples were selected from the Late Cretaceous Waarre Formation, Belfast Mudstone and Paaratte Formation for detailed petrological description. The aim of the study was to determine the lithology, mineralogy, sediment provenance, depositional environments, diagenetic alteration and factors controlling reservoir quality. Two samples were selected for X-ray diffraction analysis and grain size analysis was possible on three samples. Typically the sidewall cores are very crushed and the textural relationships in sidewall cores 13 and 23 were very difficult to identify.

The lithology, texture and mineralogy of all samples is summarised in Table 1. Values given in this table are based on visual estimates, not point counts. Fine to medium grained, poor to moderately well sorted litharenites from the base of the Waarre Formation at Martha-1 are lithologically similar to sediments from Unit A at Pecten-1A and the Casino Field. These sandstones are overlain at Martha-1 by a sandy to silty mudstone with minor fine grained moderately well sorted sublitharenite which could represent Unit B. Glauconitic mudstone from the Belfast Mudstone also contains very fine grained, poorly sorted sublitharenite. The Paaratte Formation sample is a fine grained, well sorted subarkose.

Sediment in the Waarre Formation litharenites was derived directly from an igneous-metamorphic terrane as indicated by the abundance and nature of lithics, feldspars and accessory minerals. The igneous source included basic/mafic volcanics and plutonics and was dominant at Martha-1. This resulted in high percentages of basalt lithics and plagioclase. In contrast at the Casino Field the igneous source included acid/felsic volcanics and plutonics which shed K-feldspars, but the metamorphic source was dominant. There are also differences in the nature of sedimentary lithics with a noticeable absence of chalcedony from Martha-1. Smectite and chlorite in the basal Waarre Formation sandstone and the mudstone from the top of the sequence could represent alteration products of the volcanic lithics (glass). A mixed igneous-metamorphic terrane was also the source for the Paaratte Formation sandstone but there might have been significant reworking to produce this mineralogically more mature sediment.

Chlorite rims suggest the Waarre Formation litharenites were deposited in a near shore marine facies close to a river mouth, similar to the sequence at Pecten-1A. However, differences in sediment provenance may indicate it was not the same river mouth. Glauconite and forams in the overlying mudstone reflect a deeper water, open marine depositional environment, possibly influenced by turbidity currents. The Belfast Mudstone sample could represent a delta front/ prodelta mud where there was sediment instability. A shallow near shore marine setting is possible for the Paaratte Formation due to the presence of chloritic pseudo-ooids similar to those found in the Nullawarre Greensand in the Port Campbell Embayment.

Diagenetic alteration in the Waarre Formation litharenites was dominated by the precipitation of chlorite rims on intergranular pores and partial replacement of lithics by chlorite. Authigenic ?feldspar/zeolite that postdates the chlorite and mechanical compaction further reduced pore size. There is no evidence of significant quartz overgrowths, kaolin and carbonate cements as seen elsewhere in Waarre Unit A. In both the Belfast Mudstone and Paaratte Formation diagenetic alteration was related to the depositional environments. Glauconite and framboidal pyrite are abundant in the mudstone, and chloritic pseudo ooids in the subarkose.

Reservoir quality is probably poor in the Waarre Formation due to the deformation of ductile lithics during mechanical compaction and precipitation of chlorite rims. Seal capacity in the mudstone at the top of the Waarre Formation and the Belfast Mudstone should be good if the

associated fine grained sandstones are not interconnected. The mineralogically more mature Paaratte Formation has retained the best reservoir quality. Primary intergranular pores may be dominant which would favour preservation of permeability. Secondary pores associated with corroded feldspars are present in all lithologies but these would not improve effective porosity. Micropores could be a significant component of total porosity where there is abundant glauconite and chlorite.

TABLE 1 LITHOLOGY, TEXTURE & MINERALOGY – MARTHA-1

Swc	3	4	5	6	13			23		24
Depth(m)	1659.5	1630.2	1612.9	1598.4	1489.2			1338.0		1309.3
Strat Unit	Waarre	Waarre	Waarre	Waarre	Waarre			Belfast		Paaratte
Lithology	litharenite	f litharenite	litharenite	litharenite	sdyM	sltyM	Sst	Sst	Mudst	subarkose
Avg Grain size	medium (0.33mm)	medium	v f/ medium	fine (0.22mm)	clay	clay	f-m	very fine	clay	fine (0.24mm)
Sorting	mod well (0.52phi)	mod well	poor/m w	mod well (0.57phi)	very poor	very poor	m w	poor	very poor	well (0.44phi)
Grain shape	A-SA	A-SR	A-SR	A-SA	A-SA	A-SA	A-SR	A-SR	A-SR	A-SA
Structures	bed	-	bed	bed	bed	?	?	lamin	?	?lamin
Framework grains										
Quartz - mono	15	18	12	10	20	30	87	66	10	65
- poly	tr	3	1	tr	tr	-	tr	1	1	tr
Feldspar - Kspar	2	3	-	1	-	tr m	-	tr	tr	2
- plag	11 a	14	7	8	1 a	1 a	1 a	1	tr	2
Lithics - sedimentary	4	3	tr	tr	tr	-	tr	tr	tr	tr
- metamorphic	17 i	20	20	25	1	1	5 i	2	1	tr
- igneous	25 s	24	28	30	1	1	3	-	-	tr
Mica - muscovite	tr	-	tr	tr	tr	tr	-	1	tr	tr
- biotite	1	tr	tr	1	tr	1	tr	3	tr	-
Fossils	-	-	-	-	tr	tr	-	-	1	tr
Accessory	tr	-	tr	tr	tr	tr	tr	1	tr	1
Matrix										
Clay	-	-	10	?2	74csi	65csi	-	3	62	5
Organic matter	6	-	tr	tr	-	-	1	4	5	1
Authigenic										
Glaucony - glauconite	-	-	-	-	tr	tr	-	4	12	-
- chlorite replace	4 c	3	4	6	-	-	2	3	-	7
- chlorite rim	10 c	8	8	10	-	-	-	-	-	?
Quartz	-	-	-	-	-	-	-	-	-	-
?Feldspar – fill pores	-	-	3	4	-	-	-	-	-	-
Carbonate	-	tr	-	tr	2 d	-	-	-	-	-
Pyrite - replace	-	-	-	-	tr	tr	-	5	7	4
- fill	1	-	-	-	-	-	-	-	-	-
Kaolin - replace	-	tr	-	-	-	-	-	-	-	-
Porosity										
Intergranular	-	-	2	?tr	-	-	?	?2	-	?10
Dissolution	3	3	4	2	-	-	-	3	-	2
Micropores	tr	tr	tr	tr	-	-	-	tr	tr	-

f = feldspathic, sdyM = sandy mudstone, sltyM = silty mudstone, Sst = sandstone (sublitharenite), f-m = fine to medium, mod = moderately, m w = moderately well, A = angular, SA = subangular, SR = subrounded, bed = bedding, lamin = laminae
XRD results, a = albite, c = chlorite, d = dolomite, i = illite, m = microcline, s = smectite

2. INTRODUCTION

Santos Ltd submitted seven sidewall cores to PGPC from the wildcat exploration well Martha-1 in the Otway Basin (VIC/P44). Samples were selected from the Late Cretaceous Campanian Paaratte Formation, Coniacian-Santonian Belfast Mudstone and Turonian Waarre Formation for detailed petrological description. The study was designed to ascertain the lithology, mineralogy, sediment provenance, depositional environments, diagenetic alteration and factors controlling reservoir quality.

The client supplied a wireline log and lithological descriptions over the relevant depth interval. After initial inspection of the thin sections, services listed below (Table 1) were provided by PGPC.

TABLE 1 SUMMARY OF SAMPLES & SERVICES

Sidewall core	Depth (m)	Unit	TS description	Grain size analysis	XRD (Bulk/clay)
3	1659.5	Waarre	*	*	*
4	1630.2	Waarre	*	-	-
5	1612.9	Waarre	*	-	-
6	1598.4	Waarre	*	*	-
13	1489.2	Waarre	*	-	*
23	1338.0	Belfast	*	-	-
24	1309.3	Paaratte	*	*	-

3. METHODS

Thin section

Sidewall cores were impregnated with araldite prior to thin section preparation by Petrographic Technical Services Pty Ltd. Blue dye was used in the araldite to facilitate description of porosity and permeability. Thin sections were prepared using standard techniques to produce a thickness of 30 microns (Adams *et al*, 1984). Thin sections were systematically scanned to determine lithology, composition, porosity and textural relationships. Siliciclastics have been classified according to guidelines by Folk (1974) and carbonates using the nomenclature of Tucker (2001). Grain morphology (both sphericity and roundness) was estimated by comparison with charts in Pettijohn *et al* (1987), grain fabric (packing and texture) from the diagram in Tucker (2001) and sorting from diagrams by Harrell (1984). All percentages of composition given in the thin section descriptions are visual estimates (Terry & Chilingar, 1955) not point counts. The basic data for grain size analyses was collected by measuring the long axis of 100 representative grains in thin section. The graphic mean, mode and inclusive graphic standard deviation (Folk, 1974) were then calculated.

X-ray diffraction (XRD)

To determine bulk mineralogy samples were ground in a Siebtechnick mill and back mounted into aluminium holders by Amdel Mineral Services. Continuous scans were run of these powder pressings from 3^o to 75^o 2θ , at 1^o/minute, using Co Kα radiation, 50kV and 35mA, on a Philips PW1050 diffractometer. For detailed clay mineralogy a less than 5 micron size fraction was separated. This was obtained by hand crushing, addition of dispersion solution, mechanical shaking for 10 minutes and settling of the dispersed material in a water column according to Stokes' Law. The less than 5 micron fraction was pipetted off and prepared as an oriented sample on ceramic plates held under vacuum. Samples were saturated with Mg solution and treated with glycerol. Continuous scans of oriented clay samples were run from 3^o to 45^o 2θ at 1^o/minute. Peaks were identified by comparison with JCPDS files stored in a computer program called XPLOT.

4. PETROLOGY

4.1 Martha-1, swc 3, depth 1659.5m, Waarre Formation

Rock classification: **Litharenite**

Texture:

Sedimentary structures: bands & stringers of blocky reddish to opaque organic matter outline the orientation of bedding (Fig. 1)
Average grain size: medium sand (0.33mm)
Range in grain size: fine to coarse sand
Roundness / sphericity: angular to subangular with low sphericity
Sorting: moderately well sorted (0.52 φ)
Texture: grain supported
Packing / grain contacts: ?close / tangential & concavo-convex where ductile grains deformed
Pore types: texture is too disrupted to be certain if intergranular pores have survived, honeycomb pores within feldspars & possible intragranular pores within lithics, rare grain size dissolution pores, micropores could be associated with authigenic chlorite

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with sutured crystal boundaries, fresh & rarely corroded plagioclase with albite twinning, rare examples of feldspars with simple twinning & remnants of zoning, dusty K-feldspars with tartan twinning or that lack twinning, intergrowths of feldspar & quartz (?myrmekite), lithics of chert, volcanics with trachytic texture, dusty volcanic glass with feldspar laths, illitic shale, micaceous schist, quartzite, other unidentified metamorphic lithics & granule size mudstone with organic stringers, highly deformed flakes of biotite & muscovite up to 0.45mm in length, accessory very fine sand size zircon
Matrix: thick bands (up to 2mm) of organic matter are fractured, stringers of reddish organic matter have cellular structure
Authigenic minerals: pores are rimmed by chlorite & both lithics & feldspars partially replaced by chlorite, typically rims are comprised of platelets oriented at right angles to the grain surface & are up to 15 microns in thickness, pyrite framboids up to 15 microns diameter associated with the organic matter

Visual Estimate of Composition			Volume %
Framework grains	Quartz	monocrystalline	15
		polycrystalline	tr
	Feldspar	K-spar	2
		plagioclase	11
	Lithics	sedimentary	4
		metamorphic	17
		igneous	25
	Mica	muscovite	tr
		biotite	1
	Accessory minerals		tr
Matrix	Organic matter		6
Authigenic minerals and cements	Chlorite	replace	4
		rim	10
	Pyrite	fill pores	1
Porosity	Dissolution		3
	Micropores		tr

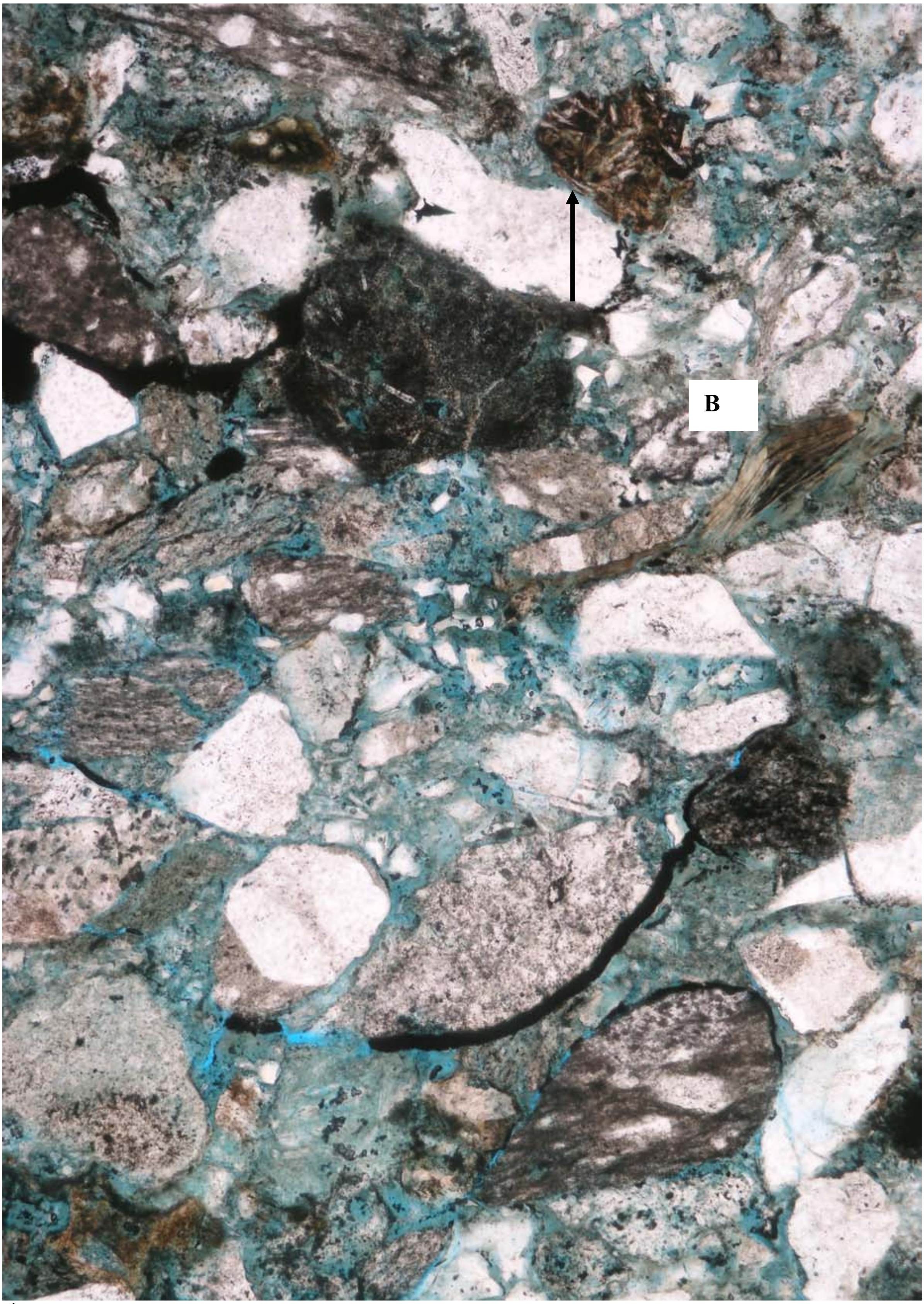


Figure 1
Textural integrity has been disrupted during sampling of this litharenite. Volcanic lithics (arrow) are abundant, there is extensive replacement of framework grains by chlorite, and organic matter (opaque) and biotite (B) are evident. Chlorite (pale green) has filled intergranular pores. Martha-1, swc 3, depth 1659.5m. Plane light. Horizontal field of view 1.30mm.

4.2 Martha-1, swc 4, depth 1630.2m, Waarre Formation

Rock classification: **Feldspathic litharenite**

Texture:

Sedimentary structures: none apparent, extensive textural disruption during sampling
Average grain size: medium sand
Range in grain size: fine to coarse sand
Roundness / sphericity: angular to subrounded with low sphericity
Sorting: moderately well
Texture: grain supported
Packing / grain contacts: ?close / tangential & concavo-convex
Pore types: honeycomb dissolution pores within feldspars, intragranular pores within lithics, micropores associated with chlorite

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with either straight or sutured crystal boundaries, feldspars include examples that are fresh or sericitised, have albite, simple & tartan twinning, zoning & mrymekite texture, lithics include chert, volcanics with trachytic texture, ?olivine rich basalt (Fig. 2a), illitic shale, quartzite, micaceous schist, other metamorphic fragments of unknown origin, dark brown mudstone & siltstone, biotite flakes are crushed & splayed

Authigenic minerals: intergranular pores are rimmed and filled by chlorite platelets oriented at right angles to the detrital grain surface (Fig. 2b), these rims are up to 15 microns thick, chlorite has replaced phenocrysts within volcanic lithics & completely replaced grains of unknown origin, coarse sand size grains are replaced by anhedral kaolin booklets that are up to 20 microns in diameter, dusty anhedral carbonate has partially replaced selected lithics

Visual Estimate of Composition			Volume %
Framework grains	Quartz	monocrystalline	18
		polycrystalline	3
	Feldspar	K-spar	3
		plagioclase	14
	Lithics	sedimentary	3
		metamorphic	20
		igneous	24
	Mica	muscovite	-
		biotite	tr
	Accessory minerals		-
Authigenic minerals and cements	Chlorite	replace	3
		rim	8
	Carbonate		tr
	Kaolin	replace	tr
Porosity	Dissolution		3
	Micropores		tr

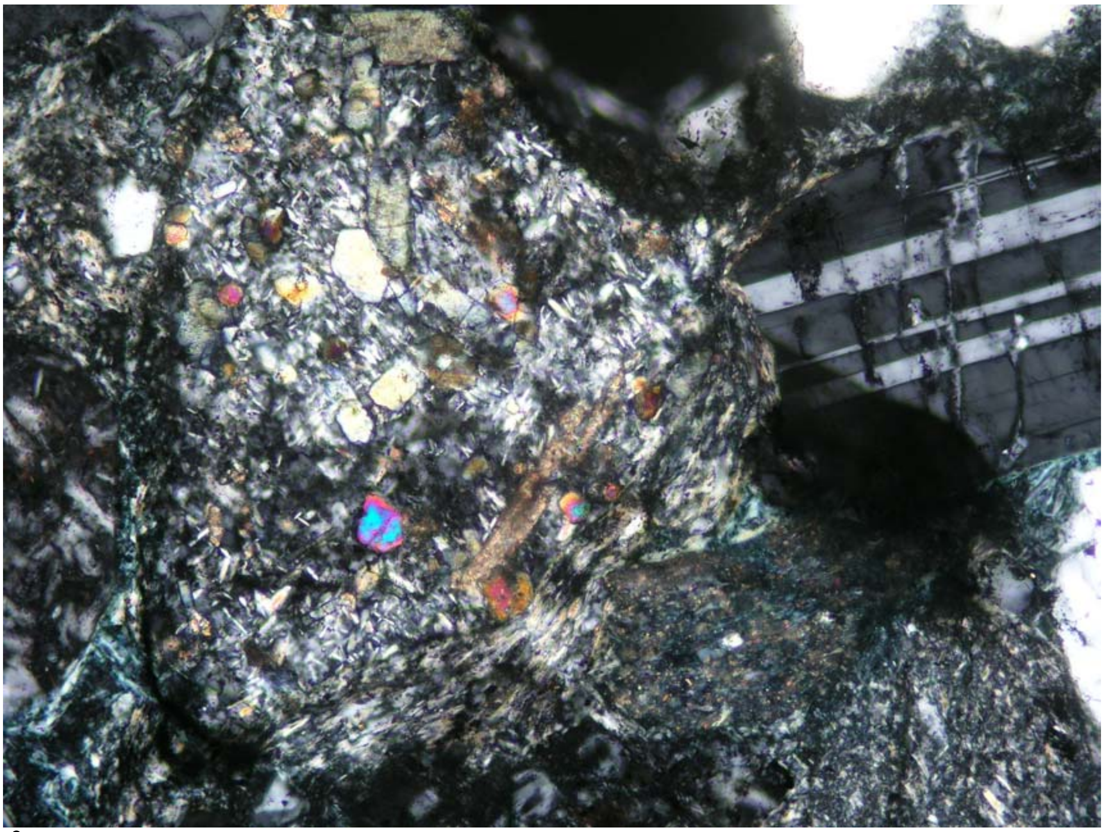


Figure 2a

The central lithic is composed of ?olivine basalt. Note the twinning in a relatively fresh feldspar adjacent to the lithic. Martha-1, swc 4, depth 1630.2m. Crossed nicols. Horizontal field of view 0.65mm.

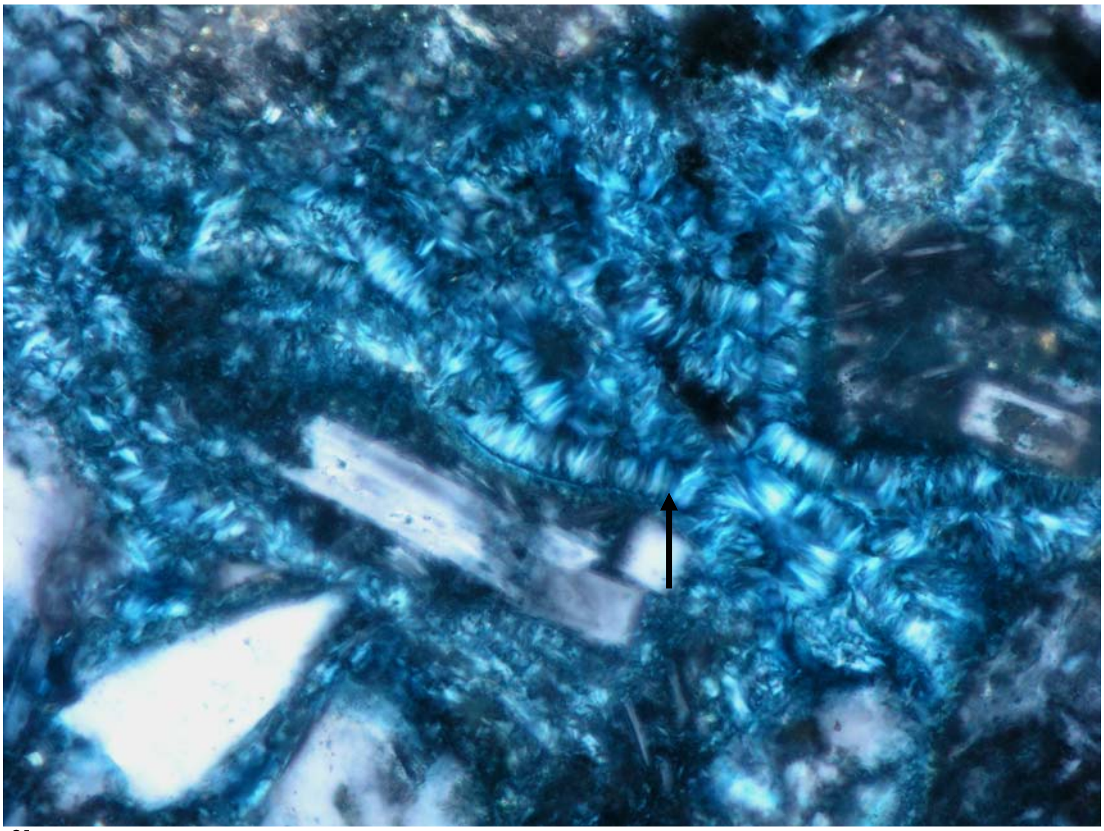


Figure 2b

Chlorite platelets (arrow) are aligned in rims of uniform thickness on intergranular pores & also replace grains. Martha-1, swc 4, depth 1630.2m. Crossed nicols. Horizontal field of view 0.33 mm.

4.3 Martha-1, swc 5, depth 1612.9m, Waarre Formation

Rock classification: **Litharenite**

Texture:

Sedimentary structures: bed approximately 1cm thick of fine grained material & minor organic matter separating medium grained sands, disrupted texture due to sampling

Average grain size: very fine to fine sand, medium sand

Range in grain size: clay to coarse sand

Roundness / sphericity: angular to subrounded with low to moderate sphericity, finer sand is more angular

Sorting: in the fine bed poor sorting, the medium grained beds are moderately well sorted

Texture: fine bed is matrix supported, medium beds are grain supported

Packing / grain contacts: medium grained beds have moderately close packing with tangential & concavo-convex contacts

Pore types: remnants of primary intergranular pores in the medium grained beds, micropores associated with chlorite, dissolution honeycomb pores, no pores in the fine bed

Composition:

Framework grains: fine grained bed contains monocrystalline quartz, polycrystalline quartz with straight or sutured crystal boundaries, plagioclase feldspars, lithics of shale, volcanics & quartzite, minute biotite & muscovite flakes up to 0.05mm in length, accessory very fine sand size zircon

medium grained beds contain monocrystalline quartz, corroded & fresh feldspars with albite twinning, myrmekite texture & zoning, lithics of volcanic origin including those with trachytic texture, quartzite, chert, shale, & unidentified very fine grained metasediments, bent biotite flakes up to 0.30mm in length

Matrix: anhedral pale brown to greenish clay with randomly oriented illite laths & silt size grains in the fine grained bed, fragments of cellular opaque material float in the matrix

Authigenic minerals: intergranular pores are rimmed by chlorite platelets, rims are typically 15 microns thick, chlorite has partially replaced volcanic lithics & completely replaced grains of unknown origin, blocky ?feldspar (?albite twinning) postdates the chlorite & has further reduced the size of intergranular pores, commonly these rims are up to 30 microns thick & have been extensively disrupted during sampling

Visual Estimate of Composition			Volume %
Framework grains	Quartz	monocrystalline	12
		polycrystalline	1
	Feldspar	plagioclase	7
	Lithics	sedimentary	tr
		metamorphic	20
		igneous	28
	Mica	muscovite	tr
		biotite	tr
	Accessory minerals		tr
Matrix	Clay		10
	Organic matter		tr
Authigenic minerals and cements	Chlorite	replace	4
		rim	8
	?Feldspar	fill pores	3
Porosity	Intergranular		2
	Dissolution		4
	Micropores		tr

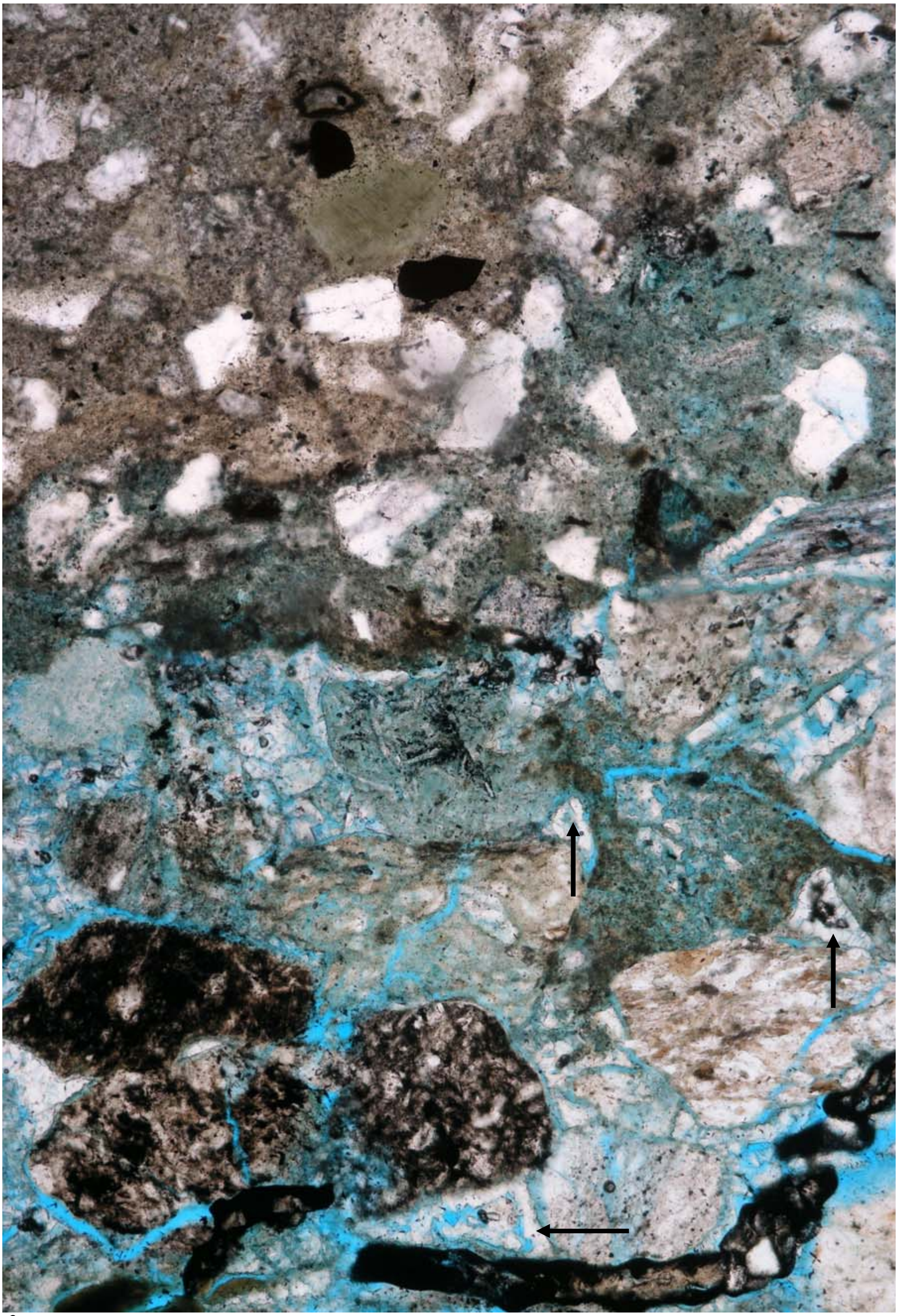


Figure 3
Contact between the fine and medium grained beds. Note the triangular shaped intergranular pores in the medium grained bed that are filled with authigenic ?feldspar (arrows). Rare intergranular spaces such as those below the dark brown lithics have retained porosity (blue). Stringers of dark brown/black material represent either invasion by drilling mud or grinding paste from section preparation. Martha-1, swc 5, depth 1612.9m. Plane light. Horizontal field of view 1.30mm.

4.4 Martha-1, swc 6, depth 1598.4m, Waarre Formation

Rock classification: **Litharenite**

Texture:

Sedimentary structures: possible graded bedding from medium to fine grained, stringers of organic matter
Average grain size: fine sand (0.22mm)
Range in grain size: very fine to coarse sand
Roundness / sphericity: angular to subangular with low sphericity
Sorting: moderately well (0.57 φ)
Texture: grain supported
Packing / grain contacts: close packing / tangential & concavo-convex grain contacts
Pore types: possible remnants of intergranular pores, rare honeycomb dissolution pores, micropores associated with chlorite

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with either straight or sutured crystal boundaries, fresh & corroded feldspars with albite twinning & zoning, mrymekite texture, dusty K-feldspars with simple twinning, lithics include volcanics with trachytic texture, devitrified glass, shale, chert, quartzite, unidentified very fine grained metasediments, bent & straight biotite & muscovite flakes up to 0.50mm in length, accessory very fine sand size colourless garnet, opaques & zircon

Matrix: rare crenulated stringers of opaque organic matter, traces of dark brown clay rimming grains in irregular patches could be either drilling mud or detrital clay which inhibited chlorite rims

Authigenic minerals: chlorite rims intergranular pores but is absent at grain contacts, rims are typically 10 microns thick, chlorite has partially to completely replaced grains, final pore filling phase of anhedral blocky ?feldspar with weak evidence of twinning, irregular replacement of grains within lithics by anhedral spar

Visual Estimate of Composition			Volume %
Framework grains	Quartz	monocrystalline	10
		polycrystalline	tr
	Feldspar	K-spar	1
		plagioclase	8
	Lithics	sedimentary	tr
		metamorphic	25
		igneous	30
	Mica	muscovite	tr
		biotite	1
	Accessory minerals		tr
Matrix	Clay		?2
	Organic matter		tr
Authigenic minerals and cements	Chlorite	replace	6
		rim	10
	?Feldspar	fill pores	4
	Carbonate		tr
Porosity	Intergranular		tr
	Dissolution		2
	Micropores		tr

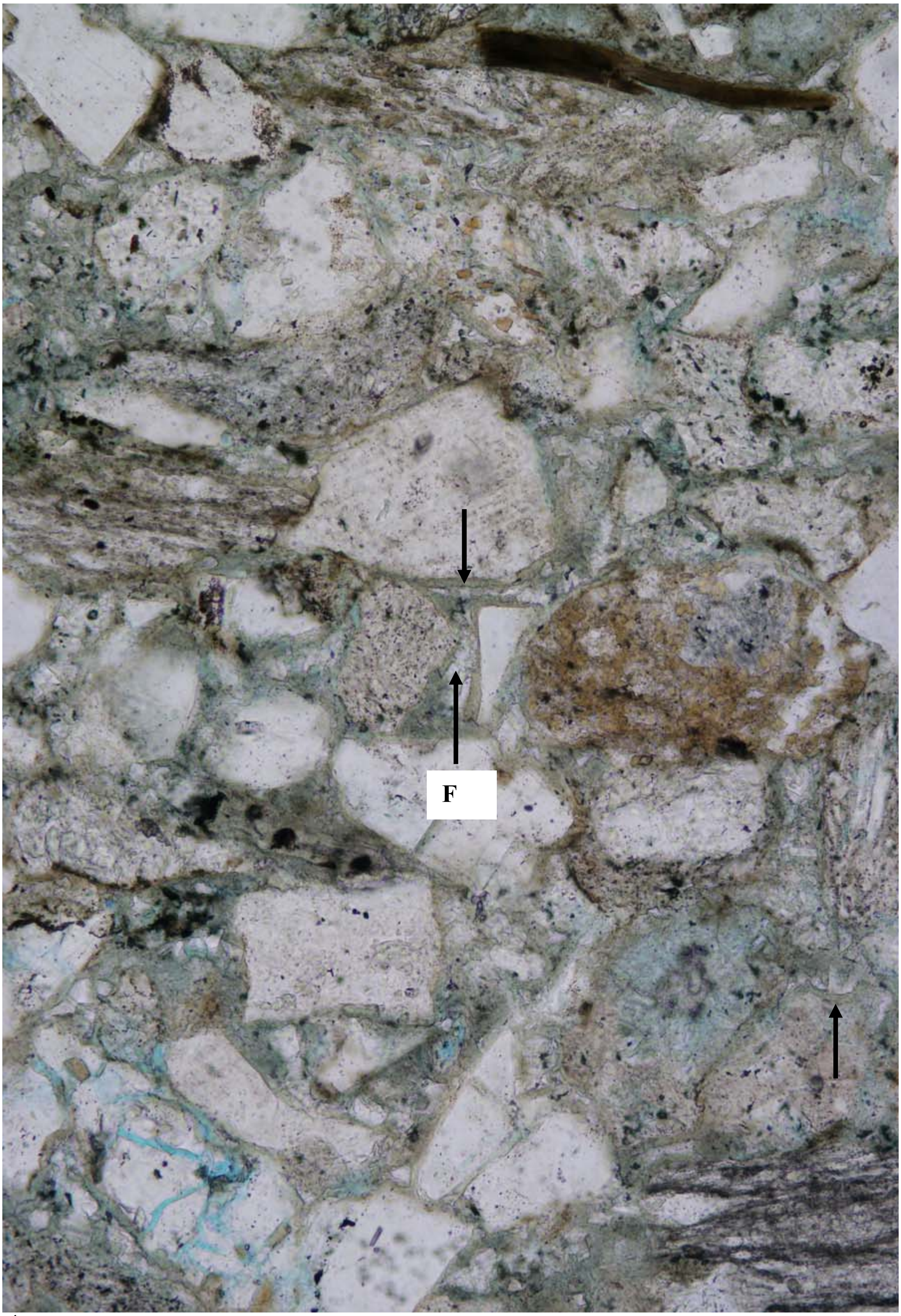


Figure 4
Chlorite rims (arrows) have reduced the size of intergranular pores & in places filled the pores. Blocky remnants of authigenic ?feldspar (arrow F) postdate the chlorite rims. Grain fracturing is probably an artifact of sampling. Martha-1, swc 6, depth 1598.4m. Plane light. Horizontal field of view 0.65mm.

4.5 Martha-1, swc 13, depth 1489.2m, Waarre Formation

General Texture:

Extensive disruption during sampling (fragmentation) & section preparation has made this description very difficult & possibly unreliable. There appear to be three lithologies present but the nature of contacts and extent of contamination from drilling mud is unknown. The dominant lithology is sandy mudstone with minor silty mudstone & a very small area of sandstone (Fig. 5a). These minor lithologies appear to be ?chips within the sandy mudstone & the silty mudstone could be drilling mud.

Rock classification: **Sandy mudstone**

Texture:

Sedimentary structures: weak alignment of grains may indicate the orientation of bedding in the sandy mudstone but there may also be contacts with beds/laminae of silty mudstone and sandstone
Average grain size: clay
Range in grain size: clay to medium sand
Roundness / sphericity: angular to subangular with low sphericity
Sorting: very poor
Texture: matrix supported
Packing / grain contacts: open/ grains float in the matrix
Pore types: none apparent

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with straight crystal boundaries, angular fresh & sericitised plagioclase with pericline & albite twinning & mrymekite texture, lithics of quartzite, chert, volcanics & shale, calcareous fragments of forams, dusty calcite spines, straight & bent muscovite & biotite flakes up to 0.20mm in length, accessory rutile, tourmaline, opaques & ?zircon
Matrix: anhedral greenish to dark brown clay
Authigenic minerals: fine to medium sand size rounded bright green grains of glaucony with a wormy texture typical of glauconite, isolated grains replaced by carbonate spar, minute pyrite crystals scattered throughout the matrix

Rock classification: **Silty mudstone**

Texture:

Sedimentary structures: none apparent within mudstone but irregular contact with sandy mudstone
Average grain size: clay
Range in grain size: clay to fine sand
Roundness / sphericity: angular to subangular with low sphericity
Sorting: very poor
Texture: matrix supported
Packing / grain contacts: open / rare point & tangential contacts, typically grains float in the matrix
Pore types: none apparent

Composition:

Framework grains: monocrystalline quartz, fresh plagioclase with albite twinning & other feldspars with simple twinning, lithics include volcanics, quartzite, micaceous schist & shale, calcareous fragments of forams, straight & bent muscovite & biotite flakes up to 0.10mm in length, accessory tourmaline, opaques & zircon
Matrix: very pale brown to greenish illitic clay
Authigenic minerals: fragmented very fine sand size bright green grains of glaucony with wormy texture typical of glauconite, blocky ?pyrite replacing grains

4.5 continued Martha-1, swc 13, depth 1489.2m, Waarre Formation

Rock classification: **Sublitharenite**

Texture:

Sedimentary structures: a wedge of crushed sandstone on the edge of the section has one contact with the illitic silty mudstone & the other with the dark brown sandy mudstone, texture in the sandstone has not been retained
Average grain size: fine to medium grained sand
Range in grain size: silt to medium sand
Roundness / sphericity: angular to subrounded with low sphericity
Sorting: moderately well
Texture: probably grain supported
Packing / grain contacts: texture not preserved
Pore types: none apparent

Composition:

Framework grains: monocrystalline quartz, rare polycrystalline quartz with sutured crystal boundaries, feldspar with mrymekite texture, other dusty feldspars have albite twinning, lithics of chert, quartzite, shale & volcanics with trachytic texture, straight biotite flake, accessory tourmaline
Matrix: blocky opaque organic matter
Authigenic minerals: crushed grains replaced by chlorite

Visual Estimate of Composition			SandyM	Volume % SiltyM	Sandst
Framework grains	Quartz	monocrystalline	20	30	87
		polycrystalline	tr	-	tr
	Feldspar	K-spar	-	tr	-
		Plagioclase	1	1	1
	Lithics	Sedimentary	tr	-	tr
		Metamorphic	1	1	5
		Igneous	1	1	3
	Mica	Muscovite	tr	tr	-
		Biotite	tr	1	tr
	Fossils		tr	tr	-
	Accessory minerals		tr	tr	tr
Matrix	Clay		74	65	-
	Organic matter		-	-	1
Authigenic minerals and cements	Glaucony		tr	tr	-
	Pyrite		tr	tr	-
	Carbonate		2	-	-
	Chlorite		-	-	2
Porosity			-	-	?

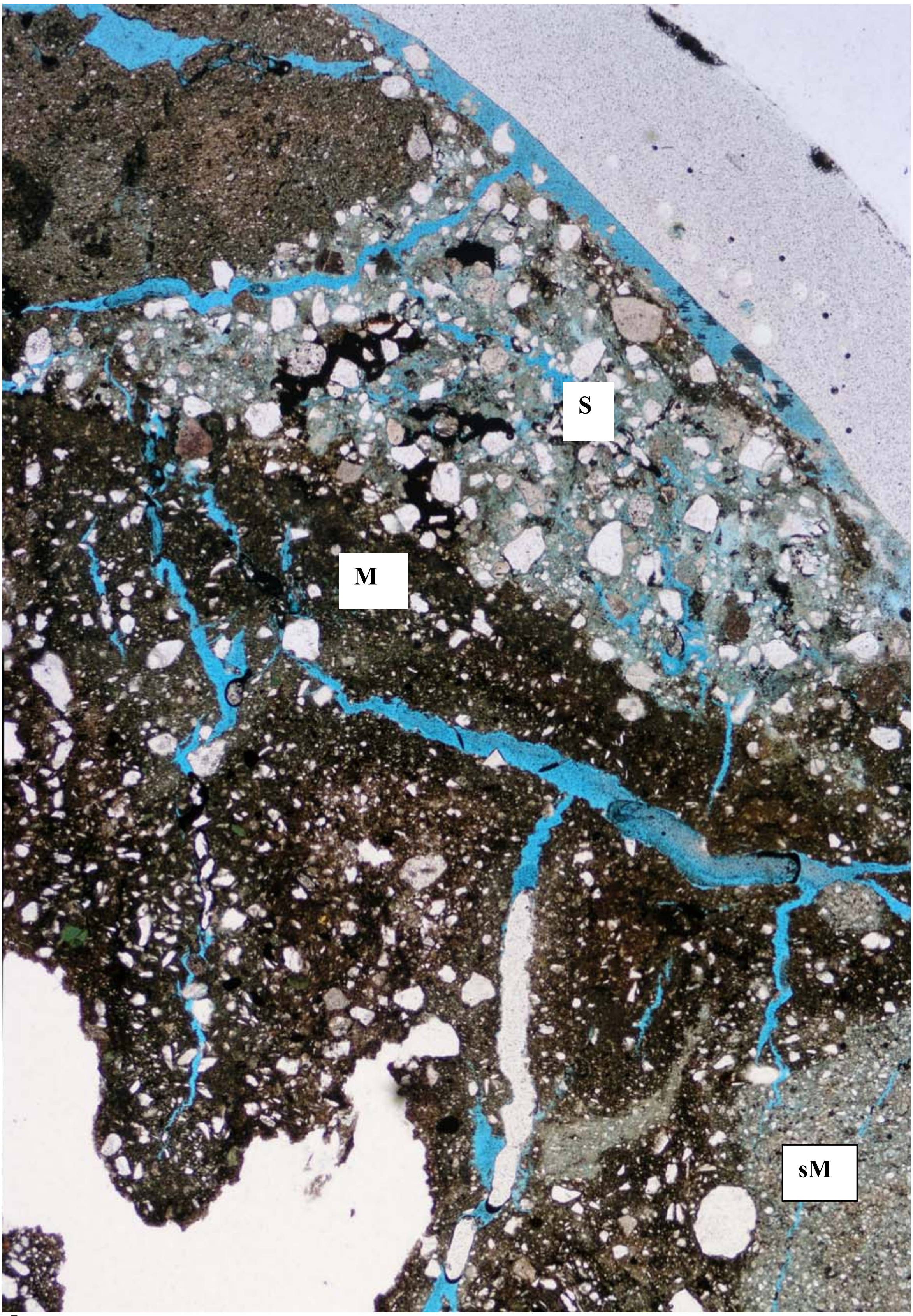


Figure 5a

General view of crushed sandstone (S) on the edge of the sample which contrasts with the dark brown sandy mudstone (M) & lighter silty mudstone (sM). Cracking (blue) and plucking during sample preparation (white areas) are also apparent. Martha-1, swc 13, depth 1489.2m. Plane light. Horizontal field of view 6.5mm.

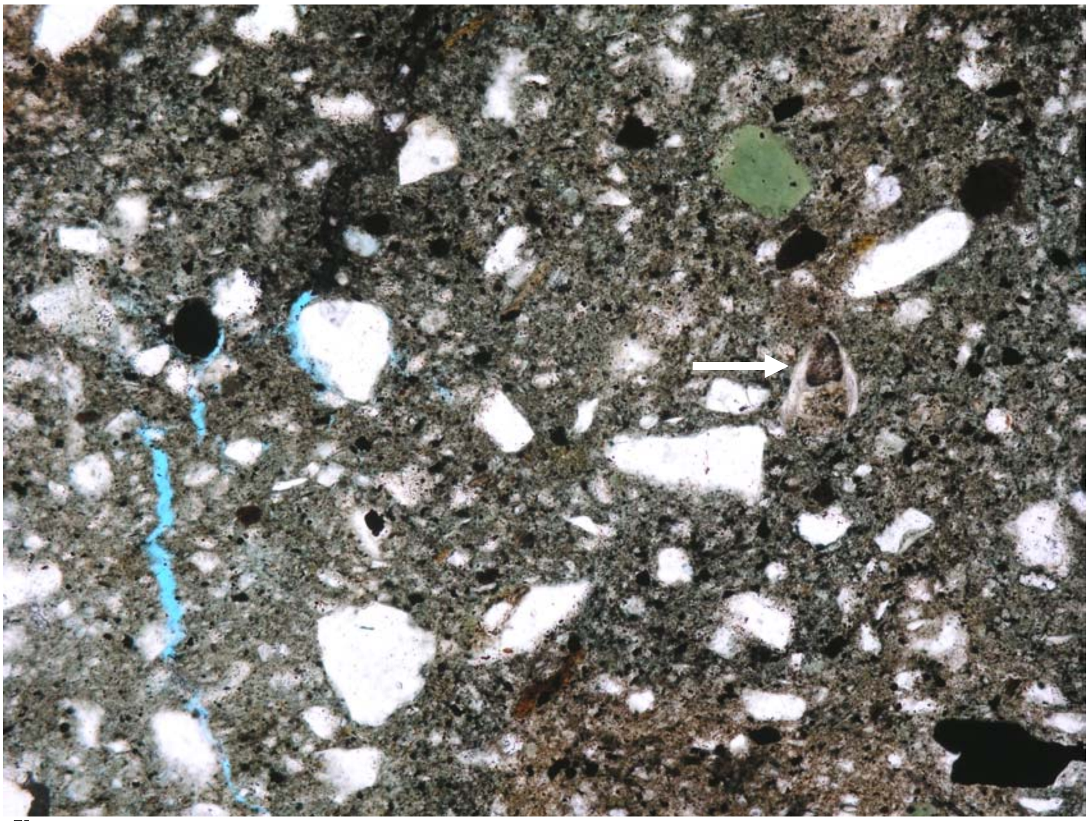


Figure 5b

Foram fragment (arrow) and bright green glaucony in the dark brown sandy mudstone. Martha-1, swc 13, depth 1489.2m. Plane light. Horizontal field of view 1.30mm.

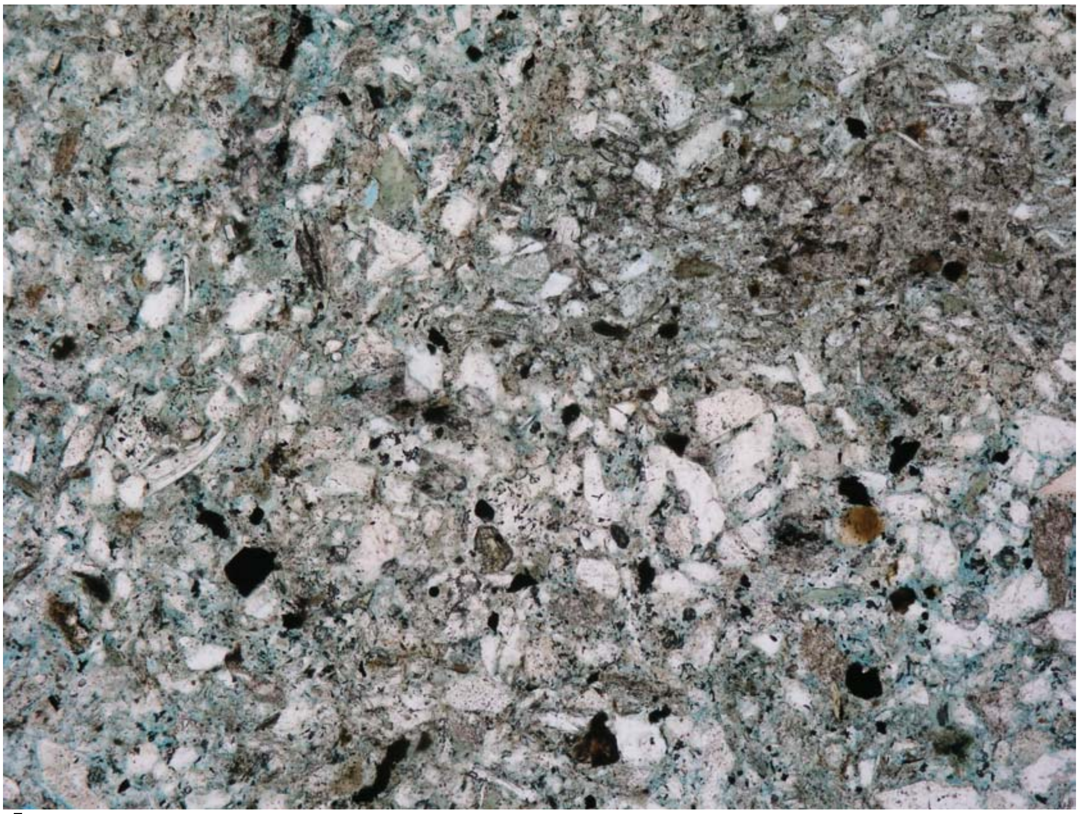


Figure 5c

General view of silt size grains in the illitic mudstone. Martha-1, swc 13, depth 1489.2m. Plane light. Horizontal field of view 1.30mm.

4.6 Martha-1, swc 23, depth 1338.0m, Belfast Mudstone

Rock classification: **Interbedded sandstone & mudstone**

Texture:

Sedimentary structures: planar contact between glauconitic mudstone & sandstone but laminae in the sandstone are at right angles to the mudstone contact (Fig. 6a), areas of drilling mud & sandstone forced into the mudstone

Average grain size: clay in the mudstone & very fine sand in the sandstone

Range in grain size: clay to coarse sand

Roundness / sphericity: angular to subrounded with low sphericity

Sorting: poor to very poor

Texture: matrix supported mudstone, grain supported sandstone

Packing / grain contacts: sandstone has moderately close packing / point, tangential & concavo-convex (where ductile grains deformed) grain contacts

Pore types: micropores associated with glaucony in both sandstone & mudstone, grain size dissolution pores & possible intergranular pores in the sandstone

Sandstone (Sublitharenite) (Fig. 6b)

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with sutured crystal boundaries, partially altered K-feldspars lack twinning or have tartan twinning, plagioclase with albite twinning, feldspar with micrographic texture, lithics of chert & micaceous schist, bent biotite & muscovite flakes concentrate in the finer grained beds, accessory very fine sand size zircon, tourmaline & rutile

Matrix: discontinuous stringers of dark brown clay & blocky opaque organic matter

Authigenic minerals: bright green rounded fine sand size grains of glaucony with a wormy texture, similar green material concentrates along the cleavage traces of feldspars, grains are replaced by fibrous olive green chlorite, pyrite framboids clustered along grain margins & partially replacing glaucony

Glauconitic Mudstone (Fig. 6c)

Composition:

Framework grains: monocrystalline quartz, polycrystalline quartz with either straight or sutured crystal boundaries, relatively fresh twinned feldspars include plagioclase with albite twinning & K-feldspar with tartan twinning, lithics of micaceous schist & chert, globular foram tests filled with pyrite & fragments of calcareous tests, large (3mm) recrystallised shell fragment (?bivalve), straight muscovite flakes up to 0.26mm in length & rare biotite flakes, accessory very fine sand size zircon, rutile & tourmaline

Matrix: dark brown anhedral clay & angular opaque organic matter & crenulated stringers of organic matter

Authigenic minerals: bright green very fine to coarse sand size (average medium sand) glaucony grains with wormy texture typical of glauconite, blocky & framboidal pyrite scattered throughout the matrix & partially replacing glaucony

Visual Estimate of Composition			Volume % Sandstone	Mudstone
Framework grains	Quartz	monocrystalline	66	10
		polycrystalline	1	1
	Feldspar	K-spar	tr	tr
		Plagioclase	1	tr
	Lithics	Sedimentary	tr	tr
		Metamorphic	2	1
	Mica	Muscovite	1	tr
		Biotite	3	tr
	Fossils		-	1
	Accessory minerals		1	tr
Matrix	Clay		3	62
	Organic matter		4	5
Authigenic minerals and cements	Glaucony		4	12
	Chlorite		3	-
	Pyrite		5	7
Porosity	Intergranular		2	-
	Dissolution		3	-
	Micropores		tr	tr

Figure 6a

Planar contact between very fine grained sandstone (white) and mudstone (brown). At this contact the mudstone is silty/sandy rather than glauconitic and detrital grains are very angular. Note the orientation of laminae in the sandstone (arrows) at right angles to the mudstone contact. There has been grain plucking (blue) in the sandstone during section preparation. Martha-1, swc 23, depth 1338.0m. Plane light. Horizontal field of view 3.25mm.

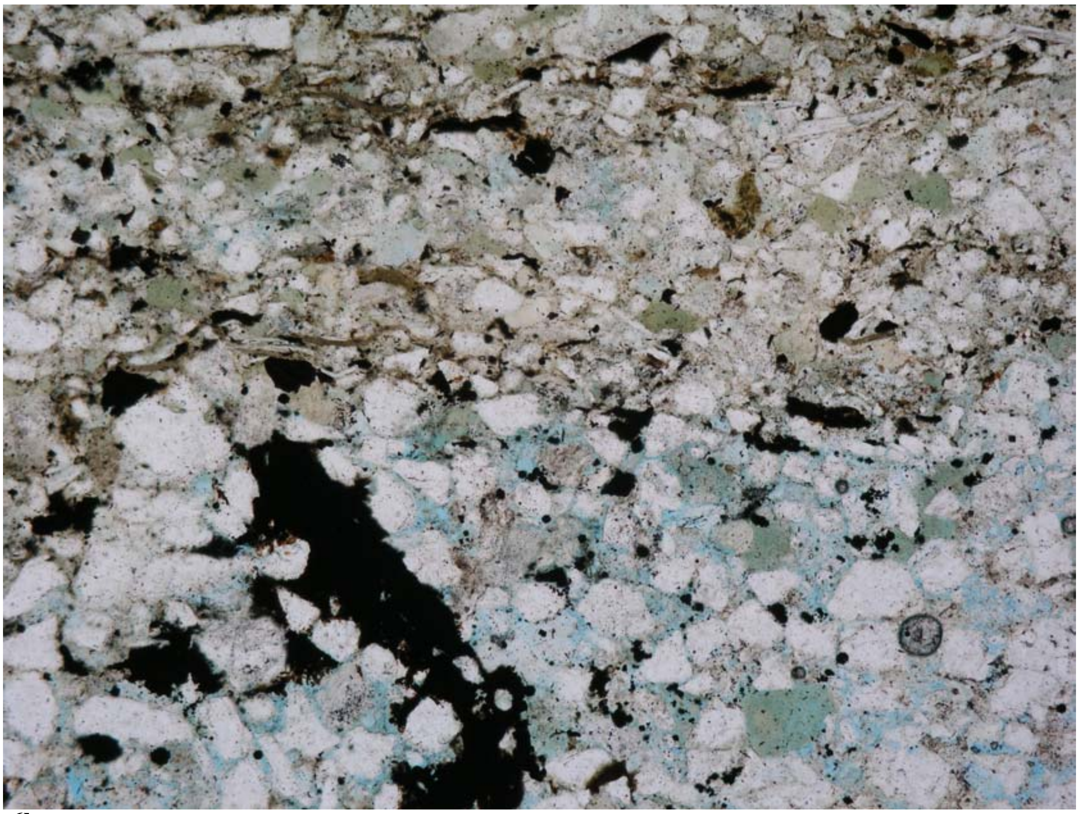


Figure 6b

Intergranular pores (blue) could be preserved in the coarser grained beds of the sandstone. Note the alignment & concentration of mica flakes in the finer sandstone. The large opaque material is organic matter. Martha-1, swc 23, depth 1338.0m. Plane light. Horizontal field of view 1.30mm.

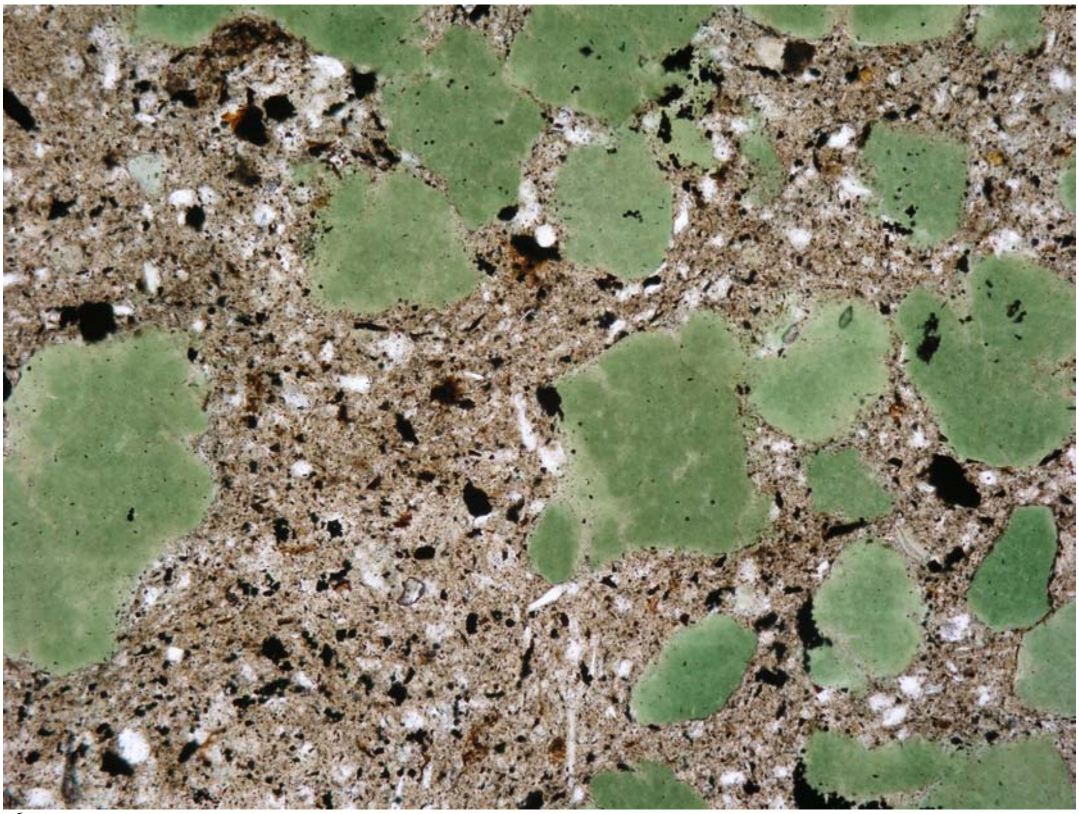


Figure 6c

General view of mudstone showing the bright green fresh nature of glaucony grains that appear to float in the matrix. Pyrite (opaque) is associated with both the glaucony & brown anhedral clay matrix. Martha-1, swc 23, depth 1338.0m. Plane light. Horizontal field of view 1.30mm.

4.7 Martha-1, swc 24, depth 1309.3m, Paaratte Formation

Rock classification: **Subarkose**

Texture:

- Sedimentary structures: none apparent, minor invasion by drilling mud or possible sedimentary laminae/burrow, texture disrupted
- Average grain size: fine sand (0.24mm)
- Range in grain size: very fine to coarse sand
- Roundness / sphericity: angular to subangular with low to moderate sphericity
- Sorting: well sorted (0.44 φ)
- Texture: grain supported
- Packing / grain contacts: ?open packing / point & tangential contacts dominant with minor concavo-convex between ductile grains
- Pore types: highly angular fines partially fill intergranular pores, rare honeycomb pores where feldspars are corroded

Composition:

- Framework grains: monocrystalline quartz, polycrystalline quartz with either straight or sutured crystal boundaries, dusty & corroded K-feldspars, rare examples have tartan twinning, silt to fine sand size fresh plagioclase with albite twinning, lithics of possible granitic origin (quartz + feldspar intergrowth), chert & quartzite, fresh & bent muscovite flakes up to 0.85 mm in length, one crushed calcareous shell fragment, accessory very fine to fine sand size opaques, zircon, tourmaline, rutile & ?epidote
- Matrix: dark brown illitic clay & fragmented opaque organic matter has a patchy distribution
- Authigenic minerals: highly deformed grains replaced by dark green fibrous chlorite form a localised pseudo-matrix, rare blocky & framboidal pyrite associated with the chlorite & matrix, it is uncertain whether chlorite forms partial rims on intergranular pores

Visual Estimate of Composition			Volume %
Framework grains	Quartz	monocrystalline	65
		polycrystalline	tr
	Feldspar	K-spar	2
		plagioclase	2
	Lithics	sedimentary	tr
		metamorphic	tr
		igneous	tr
	Mica	muscovite	tr
	Fossils		tr
	Accessory minerals		1
Matrix	Clay		5
	Organic matter		1
Authigenic minerals and cements	Chlorite		7
	Pyrite		4
Porosity	Intergranular		?10
	Dissolution		2

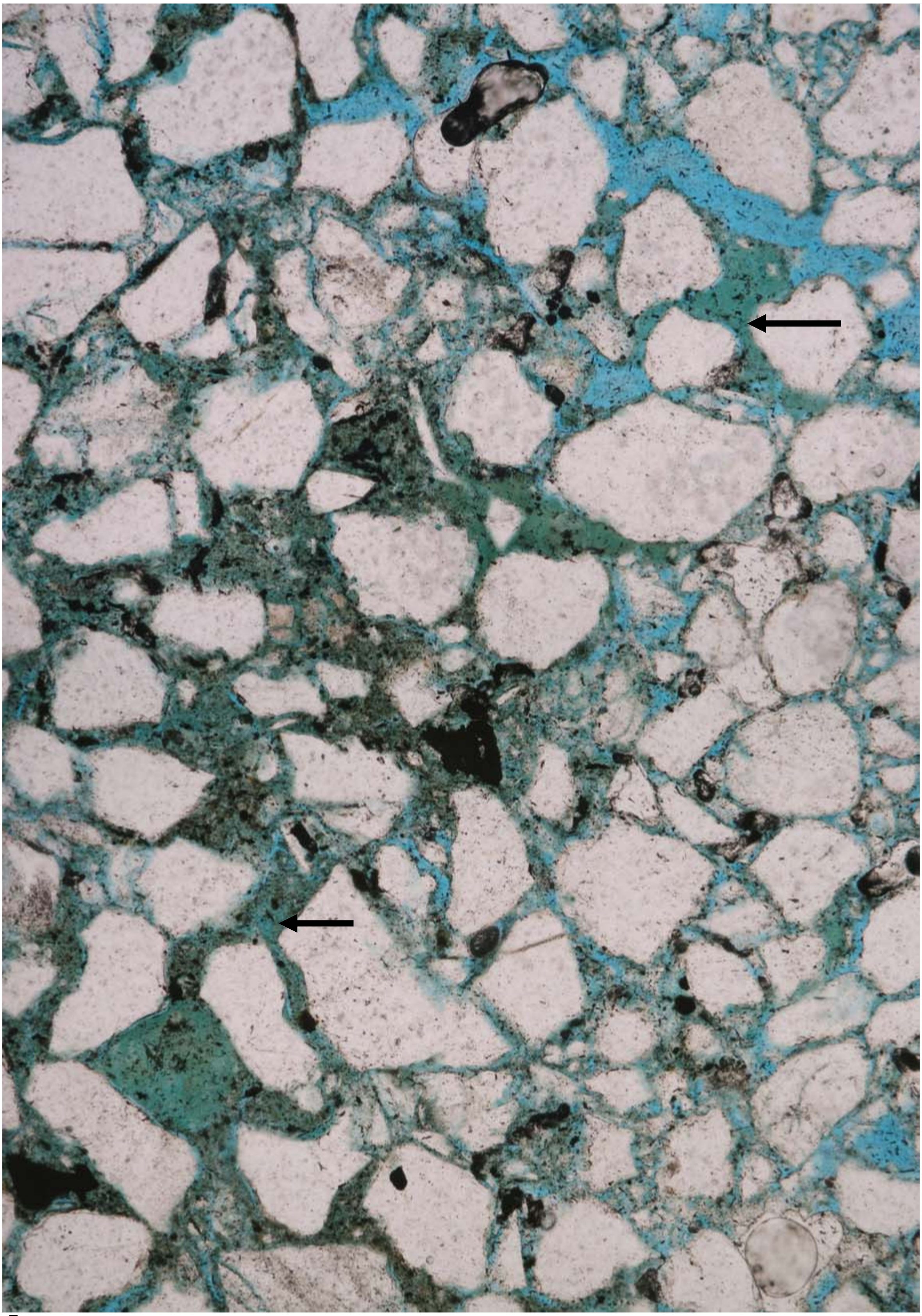


Figure 7

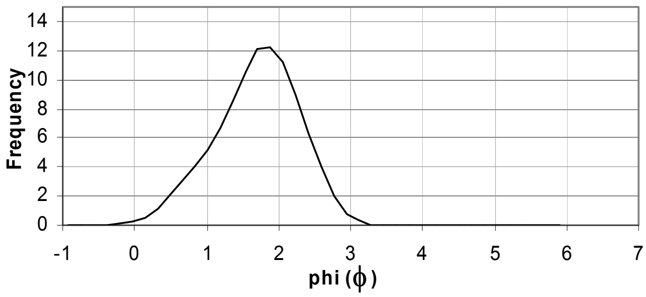
General field of view illustrating the textural disruption in this subarkose. Note framework grains appear to float in the green chlorite (arrows) which is comprised of highly deformed grains that make a pseudo-matrix. Martha-1, swc 24, depth 1309.3m. Plane light. Horizontal field of view 1.30mm.

5. GRAIN SIZE ANALYSIS

Thin Section Statistics | **Frequency Distribution**

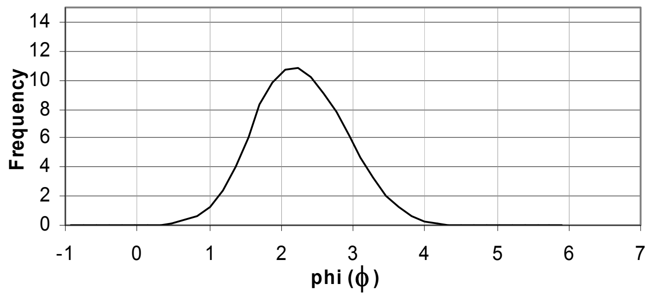
Swc: **3**
Depth (m) **1659.50**

Parameter		mm	φ
Mean		0.33	1.69
		medium sand	
Mode		0.28	1.81
		medium sand	
Range:	min	0.14	2.84
	max	0.90	0.15
Standard Deviation		0.13	0.52
		moderately well sorted	



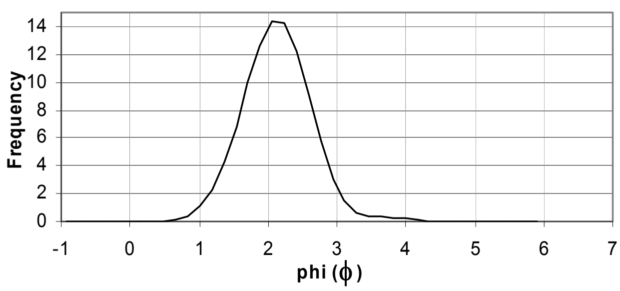
Swc: **6**
Depth (m) **1598.40**

Parameter		mm	φ
Mean		0.22	2.29
		fine sand	
Mode		0.22	2.17
		fine sand	
Range:	min	0.07	3.84
	max	0.55	0.86
Standard Deviation		0.09	0.57
		moderately well sorted	



Swc: **24**
Depth (m) **1309.30**

Parameter		mm	φ
Mean		0.24	2.14
		fine sand	
Mode		0.23	2.14
		fine sand	
Range:	min	0.07	3.84
	max	0.50	1.00
Standard Deviation		0.07	0.44
		well sorted	



6. X-RAY DIFFRACTION

All the XRD results are summarised in the tables below and the traces from which this data was obtained are presented in Figures 8 and 9. Quartz and feldspars are the dominant minerals in the bulk traces. Albite is present in both samples but microcline is restricted to sidewall core 13. Trace amounts of dolomite and pyrite were also detected in sidewall core 13. The clay fraction in both samples includes smectite, chlorite and illite. Smectite is more abundant in the basal sample and does not appear to be converting to illite with depth. At least some of the smectite in the basal sample is regularly interstratified with the chlorite as indicated by the broad base of the peak near 7.2 Angstroms (Fig. 8b). However, this same interstratification is not apparent in sidewall core 13.

TABLE 3. BULK XRD MINERALOGY MARTHA-1

Swc No	Depth (m)	Chlorite	I/M	Quartz	Microcline	Albite	Dolomite	Pyrite
				Strongest peak height in counts				
3	1659.5	315	247	2389	-	1317	-	-
13	1489.2	290	180	4870	392	451	126	60

I/M = illite/muscovite

TABLE 4. CLAY XRD MINERALOGY MARTHA-1

Swc No	Depth (m)	Smectite	Chlorite	Illite	Quartz	Albite
			Strongest peak height in counts			
3	1659.5	1663	900	345	1377	392
13	1489.2	1046	1435	586	1895	313

To facilitate between-sample comparisons of relative abundance for the same mineral, the results in each table are given in counts of peak height. These figures are based on the strongest line for each mineral detected. Caution should be used in assessing relative abundance from these figures since peak height is also significantly affected by factors such as crystal size and crystallinity. For these reasons the figures are even more unreliable when comparing different minerals in the same sample. For example, based on peak height alone carbonate minerals will always appear less abundant than similar proportions of quartz because of differences in crystallinity. Clay minerals will also appear to be less abundant than quartz in a bulk XRD trace because of differences in crystal size. Furthermore, comparison should not be made between peak heights given for bulk samples and those for the clay fractions because results have been influenced by the sampling and preparation methods. XRD will not detect minerals that represent less than approximately 5% of the total rock composition.

Only the strongest peaks for each mineral identified have been labeled on the XRD traces. The horizontal axis on each trace is in degrees two theta and the vertical axis is in counts of peak height. For the clay fraction both Mg saturated and glycerol traces have been included to demonstrate movements in the peaks that aided identification of clay minerals. The following abbreviations have been used on the XRD traces:

A = albite
C = chlorite
D = dolomite
I/M = illite or muscovite
M = microcline
N = machine noise
P = pyrite
Q = quartz
S = smectite

Martha-1, swc 3, depth 1659.5m

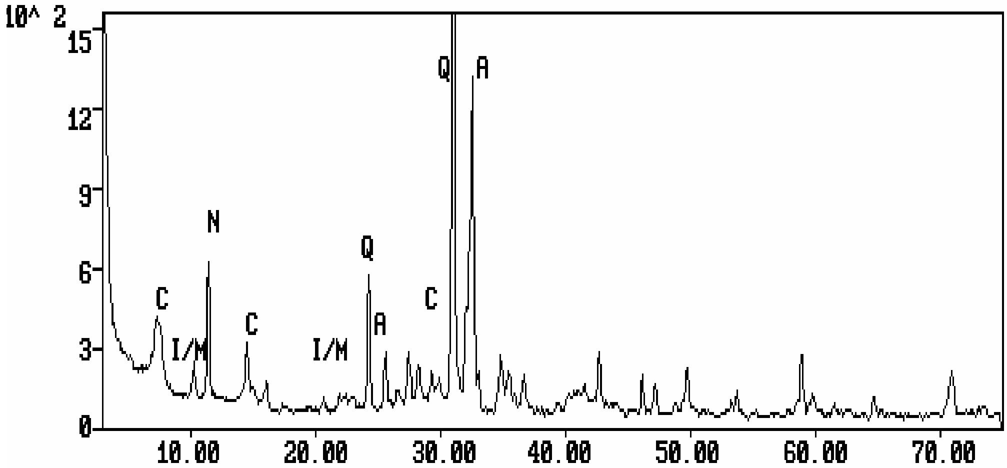


Figure 8a
Bulk XRD trace

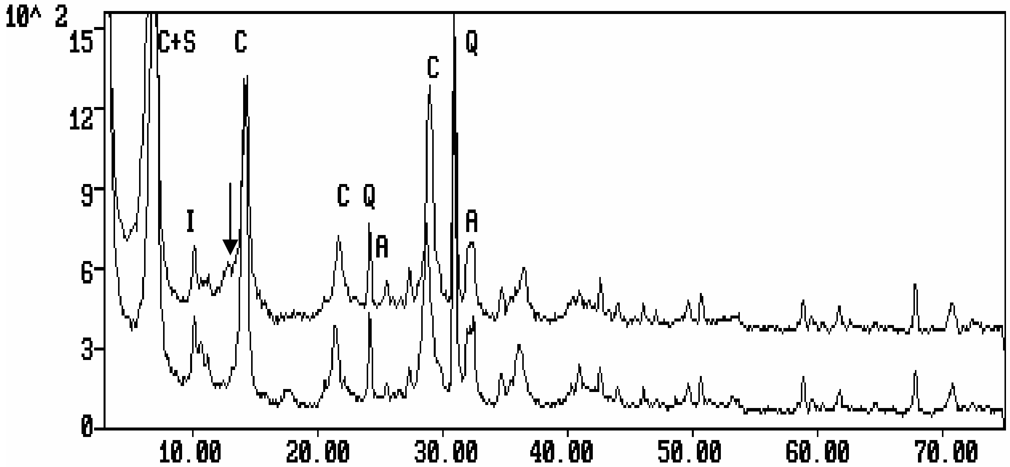


Figure 8b
Clay XRD traces. Note the broad base of the chlorite peak at a d-spacing of 7.2 Angstroms (arrow) on the upper trace. (Lower trace is Mg saturated & air dried. Upper trace is Mg & glycerol saturated & air dried).

Martha-1, swc 13, depth 1489.2m

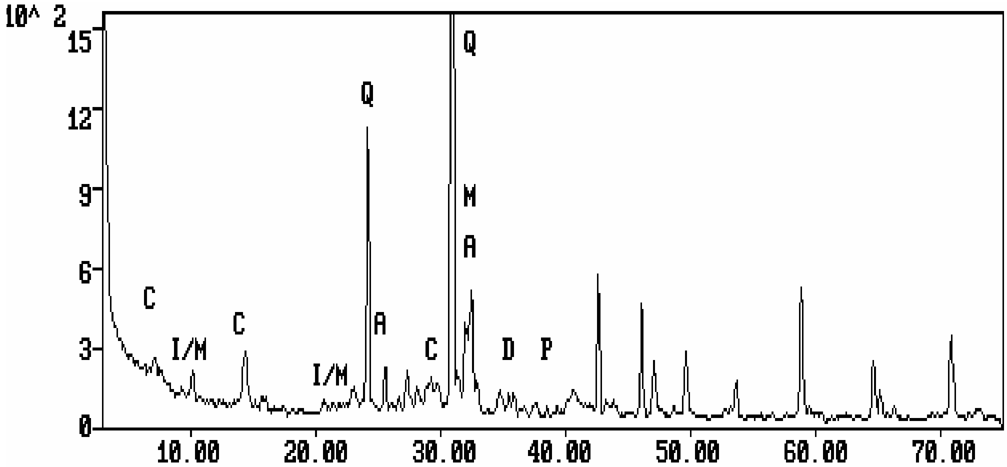


Figure 9a
Bulk XRD trace

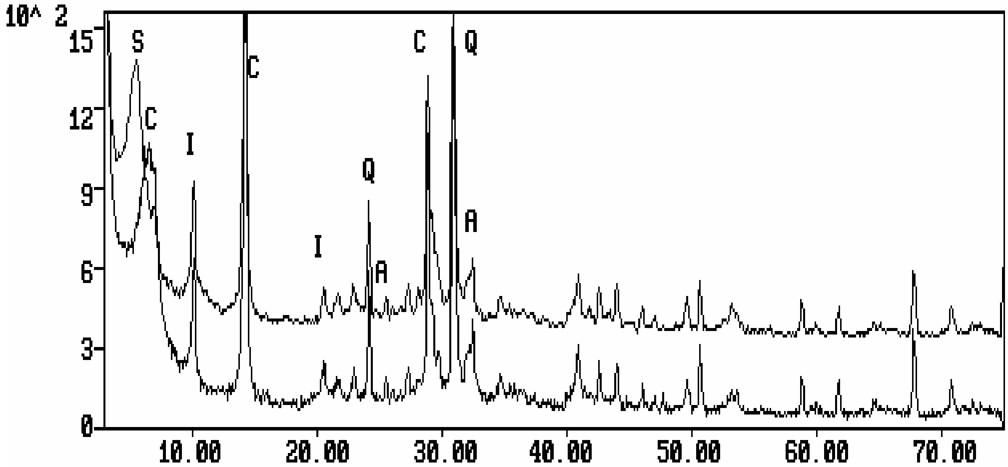


Figure 9b
Clay XRD traces. (Lower trace is Mg saturated & air dried. Upper trace is Mg & glycerol saturated & air dried).

7. DISCUSSION

Significant textural disruption in the sidewall cores from Martha-1 has made thin section descriptions difficult. As a result visual estimates of composition and reservoir quality are likely to be inaccurate. These problems were most pronounced for sidewall cores 13 and 23 (depths 1489.2m & 13338.0m) where there are several lithologies present and the extent of invasion by drilling mud is unknown.

7.1 Lithology & texture

a. <u>Waarre Formation</u>
Lithologically the four basal sidewall cores (3, 4, 5 & 6) are very similar in Martha-1. These sandstones are fine to medium grained, poor to moderately well sorted, mineralogically immature litharenites. Slightly higher feldspar contents in sidewall core 4 result in a classification of this sandstone as a feldspathic litharenite. Grain size ranges from clay to coarse sand and grain shape from angular to subrounded with low sphericity. There is evidence of bedding in three of these sidewall cores as indicated by changes in grain size, clay content and abundance of organic matter.

Sidewall core 13 (depth 1489.2m) is dominated by sandy mudstone but also contains minor patches of silty mudstone and fine to medium grained, moderately well sorted sublitharenite. Sorting in the mudstones is very poor with grain size ranging from clay to medium sand that is angular to subangular in shape. In the sublitharenite grain shape varies from angular to subrounded. There is evidence of grain alignment in the sandy mudstone which might be the result of bedding. Fragments of calcareous forams and possible spines were also noted.

Comparison of these sidewall cores from Martha-1 with other samples in the Waarre Formation suggest the basal four samples are lithologically most similar to the deepest rock types recognised from Unit A at Casino-2 (Phillips, 2003) and to a lesser extent Casino-3 (Phillips, 2004a) and Pecten-1A (Phillips, 2004c). However, the percentage of both lithics and feldspars is greater at Martha-1 than either of the Casino wells or Pecten-1A. Grain size at Casino-3 is slightly coarser than samples from Martha-1, Pecten-1A or Casino-2, and Casino-3 has the highest percentage of K-feldspars and polycrystalline quartz.

Although Unit A does include muddy intervals, it is also possible that sidewall core 13 from Martha-1 is equivalent to Waarre Unit B. At Casino-2 Unit B includes interbedded mudstone and greywacke which has less lithics than samples from Unit A. The sublitharenite in sidewall core 13 has significantly less lithics than the underlying four samples.

b. <u>Belfast Mudstone</u>
There are two lithologies present in sidewall core 23 (1338.0m) from the Belfast Mudstone in Martha-1. Very fine grained, poorly sorted sublitharenite has grains which are angular to subrounded in shape and there are planar laminae present outlined by changes in grain size and abundance of micas. The other lithology is glauconitic mudstone which is very poorly sorted, contains globular forams, recrystallised shell fragments and minor detrital grains that float in the matrix. These detrital grains are angular to subrounded in shape. Juxtaposition between the two lithologies is not consistent with typical sedimentary bedding in the sidewall core.

Previous lithological descriptions of the Belfast Mudstone (eg. Partridge, 2001; Boyd & Gallagher, 2001) are similar to the glauconitic mudstone in Martha-1 and include rare interbeds of siltstone and fine to coarse grained sandstones. No siderite was identified in the mudstone or sandstone at Martha-1 and this might indicate it is equivalent to the Upper Belfast Mudstone of Boyd & Gallagher (2001).

c. Paaratte Formation
A fine grained, well sorted, mineralogically submature subarkose (swc 24, depth 1309.3m) represents the Paaratte Formation at Martha-1. Grain size ranges from very fine to coarse sand and typically grains are angular to subangular. Minor amounts of illitic clay could be either drilling mud, or a disrupted lamina in the subarkose.

Elsewhere the Paaratte Formation has been described as fine to very coarse grained sandstone interbedded with minor mudstones (Boyd & Gallagher, 2001). At Hill-1 the Paaratte Formation is comprised of fine to medium grained, poor to moderately well sorted, subarkoses and sublitharenites interbedded with fine to medium grained, very poorly sorted greywackes (Phillips, 2004b). Lithologically the sample from Martha-1 is similar to previous descriptions but appears to be better sorted.

7.2 Detrital mineralogy & sediment provenance

a. Waarre Formation
High percentages of metamorphic (17-25%) and igneous (24-30%) lithics in the basal four sidewall cores of the Waarre Formation at Martha-1 are indicative of the dominant sediment sources. Furthermore, they indicate rapid rates of erosion in the source area(s). Metamorphic lithics are comprised of shale, quartzite, micaceous schist and other metasediments which could not be identified. Igneous lithics are dominated by volcanics with trachytic textures, devitrified glass and possibly olivine basalt. However, the relative abundance of plagioclase (7-14%) may also indicate the source included plutonic igneous rocks, not just volcanics. Because of their coarsely crystalline nature plutonic rocks were probably disaggregated during transport. Trace amounts of muscovite and biotite, and accessory minerals of zircon, opaques and garnet could all have been derived from an igneous/metamorphic terrane.

Rapid uplift and erosion of the Otway Ranges during the Turonian was thought by Palmowski *et al* (2004) to be the most likely source of sediment filling the Shipwreck Trough. If rifting initiated both depocentres and areas of uplift at the same time as suggested by Palmowski *et al* (2004) then sediment could not have been transported across the trough onto the Mussel Platform from the Otway Ranges. On the Mussel Platform it is more likely that Early Palaeozoic basement rocks of the Lachlan and Delamerian Fold Belts provided the sediment source for the Waarre Formation. Geary *et al* (2001) noted that the Lachlan Fold Belt was uplifted and eroded in the mid-Cretaceous at the same time as the Otway Ranges. Basement east of the Moyston Fault (Delamerian Fold Belt) includes the Kanmantoo Group equivalents of low grade metasediments, metavolcanics and granite intrusives, and the turbidites, limestones, volcaniclastics, granitic plutons, metagabbro sills and dykes of the Glenelg Metamorphic Complex (Morton *et al*, 1995). Following the Delamerian Orogeny the Glenelg River Complex was intruded by granite plutons and gabbroic bodies. Elsewhere there were granite intrusions and rhyolitic volcanism associated with mafic magmatism. These Palaeozoic metamorphic and igneous rocks could be the source of all the lithics identified in the Waarre at Martha-1 and elsewhere at Casino and Pecten-1A

X-ray diffraction results from sidewall core 3 (depth 1659.5m) in Martha-1 noted the presence of smectite and interstratified chlorite-smectite. It is highly possible that these clays reflect the alteration of volcanic glass in the lithic fraction.

The total number of lithics and plagioclase at Martha-1 is significantly higher than identified for Waarre Unit A in the Casino Field, or at Pecten-1A (Table 5). Furthermore, at these other locations metamorphic lithics are more abundant than igneous lithics. These observations might suggest that Martha-1 was located closer to the sediment source and in particular to an igneous provenance. If lithics of olivine basalt have been correctly identified then the volcanic source at Martha-1 included basic or mafic rocks. This is consistent with the higher percentage of plagioclase at Martha-1 which could have been eroded from a coarse grained equivalent mafic rock ie gabbro. It is also consistent with the identification of myrmekitic textures in the feldspars which result from the intergrowth of plagioclase and vermicular quartz. In contrast, at Casino-3 the volcanics are thought to include rhyolite and glass (Phillips, 2004a) which could be from an acid or felsic igneous source. Rhyolite can have a high proportion of glass therefore these may not be different types of volcanics. The coarse grained equivalent of rhyolite is granite which could explain the dominance of K-feldspars in the Casino Field. It would also explain why feldspars have granophyric textures due to intergrowth of quartz and alkali feldspar. Monazite and tourmaline were detected in the Casino Field and Pecten-1A and these minerals are commonly derived from granites. Rutile in these same wells might reflect the stronger metamorphic sediment provenance. Based on these observations it would appear that at least the igneous source was different at Martha-1 (mafic) compared to the Casino Field (acid).

TABLE 5. COMPARISON OF DETRITAL MINERALOGY IN WAARRE UNIT A

Well	**Martha-1**	**Casino-2**	**Casino-3**	**Pecten-1A**
Number of samples	4	6	5	1
Average grain size	fine-medium	fine-medium	medium-coarse	very fine
Source of Data	this report	Phillips (2003)	Phillips (2004a)	Phillips (2004c)
	Average %			***Total %***
Quartz - monocrystalline	14	41	36	59
- polycrystalline	1	3	9	2
Feldspar - Kspar	2	2	6	2
- plagioclase	10	1	0.5	3
Lithics - sedimentary	2	2	3	0.5
- metamorphic	21	8	7	8
- igneous	27	7	2	2
Mica - muscovite	0.2	0.6	0.3	tr
- biotite	0.4	tr	tr	tr
Accessory	tr (Z,O,G)	tr (Z,T,R,O,G,M)	tr (Z,T,R,M)	tr (Z,T,R,M)

Z = zircon, O = opaque, G = garnet, T = tourmaline, R = rutile, M = monazite

Sedimentary lithics in the basal samples from Martha-1 include chert, mudstone and siltstone. No chalcedony was identified and this might reflect another difference in sediment provenance when compared with the Casino Field. Chalcedony is a fibrous variety of quartz which forms in association with chert and is common in the sediments of Waarre Unit A from the Casino Field. It is difficult to identify the significance of this difference because chert/chalcedony can form in a number of different environments. Bedded cherts are typically associated with volcanic rocks, there are similar cherts derived from radiolarian and diatom oozes, and nodular cherts are diagenetic features within limestones. At least one of these possible sources had a stronger influence on sediment provenance at the Casino Field.

The sublitharenite of sidewall core 13 (depth 1489.2m) at Martha-1 which may represent Waarre Unit B has more metamorphic lithics (5%) of quartzite and shale than volcanic lithics (3%) with trachytic texture. Associated mudstones appear to have equal proportions of metamorphic and volcanic lithics. In both lithologies there are feldspars with myrmekitic texture which might suggest either reworking or derivation from the same mafic source as the underlying Unit A samples. Detrital clays in the mudstones are comprised dominantly of chlorite with lesser amounts of smectite and possibly illite. These XRD results may be consistent with a decline in volcanic influence which would have resulted in higher percentages of smectite.

b. <u>Belfast Mudstone</u>

Detrital grains in the sublitharenite and mudstone from sidewall core 23 (depth 1338.0m) are very similar in composition. Monocrystalline quartz is more abundant in the sandstone but all other grains (feldspars, lithics, micas and accessory minerals) are present in approximately equal amounts. Of most significance is the apparent absence of igneous lithics from the

Belfast Mudstone. Lithics of chert and micaceous schist were identified and these might reflect reworking of other sedimentary sequences and/or a metamorphic influence. Slightly higher percentages of mica in the fine grained laminae of the sublitharenite would also be consistent with a metamorphic source.

c. Paaratte Formation
Sediment in the subarkose (sidewall core 24, depth 1309.3m) from the Paaratte Formation had a mixed igneous and metamorphic provenance. This hypothesis is suggested by polycrystalline quartz with both straight and sutured boundaries, K-feldspars and plagioclase, lithics of quartzite and ?granite and accessory minerals of zircon, tourmaline, rutile, opaques and possibly epidote. The fact that chert is also present is not indicative of any particular source and it might have been recycled many times.

A similar sediment provenance was identified for the Paaratte Formation at Hill-1 (Phillips, 2004b). However, the igneous source was not just plutonic, it also included volcanics at Hill-1. Furthermore, there were lithics of micaceous schist which indicates a more complex metamorphic source.

7.3 Depositional environments

a. Waarre Formation
Sharp and Wood (2004) recognised that Waarre Unit A sedimentation occurred in fluvial to shallow marine settings and that there were several regressive-transgressive cycles during deposition. In the Casino Field the depositional environment was brackish to very shallow marine within the upper part of Unit A. This interpretation was partly based on the presence of glaucony and framboidal pyrite as indicators of marginal marine conditions.

At Martha-1 there is no glauconite in the basal four samples which might indicate either conditions were not open marine, or sedimentation rates were too high to enable glauconite to form. Rare framboidal pyrite does occur in the deepest sample at 1659.5m where it is associated with organic matter. It is possible that conditions were brackish at this depth since pyrite can form where conditions are reducing and there is a supply of sulphate typically from sea water. Further evidence of the depositional environment is apparent from the presence of authigenic chlorite rims in the basal four samples. Chlorite rims commonly develop near river mouths in near-shore marine facies. Fe transported from terrestrial environments as hydroxyls on clays is flocculated when the river water enters the sea (Ehrenberg, 1993). This amorphous Fe is in a highly reactive state and is thought to reprecipitate as chlorite after infiltrating into the sediment. Similar chlorite rims were observed at Pecten-1A (Phillips, 2004c). Therefore it would appear that both these wells could have been located close to a river mouth during deposition of Waarre Unit A. Differences in sediment provenance suggest this was not the same river mouth.

Bright green fine to medium grained glauconite does occur in the mudstone portion of sidewall core 13 at Martha-1. Either sedimentation rates were lower or this was deeper water on the continental shelf when this sediment was deposited. The associated fine to medium grained sublitharenite might suggest that there was still current activity, perhaps as storm deposits or turbidity on the shelf. The latter could explain the chaotic texture identified from thin section. Fragments of globular calcareous forams and possible spines noted in the mudstones are consistent with open marine conditions and probably deeper water than Unit A.

b. Belfast Mudstone
Glauconite and framboidal pyrite occur in both the mudstone and sublitharenite from sidewall core 23 (depth 1338.0m). In addition, there are fragments of globular forams and calcareous shell fragments, possibly of recrystallised bivalves, in the mudstone. These characteristics combined with the very fine grain size indicate deposition occurred in a low energy open marine setting. Coarse grains of glauconite in the mudstone would have taken a long time to

form and are consistent with very low rates of sedimentation on a continental shelf in water depths of 50 to 200m. Glauconite precipitates at the sediment-water interface when pH is near 8 and Eh is slightly reducing. The bright green colour indicates this is mature or highly evolved glauconite which has been in constant contact with sea water.

Elsewhere the depositional environment of the Belfast Mudstone has been described as open marine inner to outer shelf with progradation of delta front facies (Boyd & Gallagher, 2001). If the mudstone at Martha-1 does represent prodelta muds, then it is possible that the textural disruption and confusion in this sample is the result of sediment instability on the delta front. Typically in delta front/prodelta facies there can be evidence of debris flows, turbidity currents, growth faults, slide blocks and slumps (Tucker, 2001) any of which could have produced the disrupted texture noted from thin section.

c. <u>Paaratte Formation</u>

The fine sand size, well sorted and symmetrical nature of the grain size distribution in the subarkose from sidewall core 24 (1309.3m) at Martha-1 indicates a moderate energy depositional environment. Framboidal pyrite and crushed shell fragments suggest this was a marine setting. In addition, the presence of deformed grains of fibrous chlorite may be significant in the interpretation of the depositional environment. These chloritised grains do not contain remnants of any precursor mineral or lithic, therefore it is possible that they represent the initial stages of a chloritic ooid or pseudo ooid. For the grains to be so deformed they were probably ductile at the time of deposition and this is a characteristic of spastoliths. Spastoliths are deformed ooids of berthierine or chamosite both of which look like chlorite in thin section. There are berthierine/chamosite ooids in the Nullawarre Greensand in the Port Campbell Embayment (Boyd *et al*, 2004) and it is possible that these chloritised grains at Martha-1 have either been reworked from the Nullawarre or have formed in a similar depositional environment. Since there is no evidence of oxidation it is less likely that the pseudo ooids have been reworked from the Nullawarre. The actual mechanism by which these chloritic pseudo ooids have formed is poorly understood. It is possible that the depositional setting was similar to that which favoured chlorite rims to develop in the Waarre Formation. However, the water was probably more agitated (?shallower) which prevented the infiltration of amorphous Fe to rim pores and resulted in its concentration into structureless pseudo ooids. Later compaction associated with sediment burial caused the deformation of the pseudo ooids and may have initiated alteration to berthierine and later possibly chamosite.

Some previous workers have interpreted the Paaratte Formation as a lower delta plain (Morton, *et al* 1995; Cliff *et al*, 2004) but others have recognised a component that included near shore marine environments (Moore *et al*, 2000; Partridge, 2001; Boyd & Gallagher, 2001). It would appear that the sample from Martha-1 was deposited in a near shore marine environment.

7.4 Authigenic mineralogy & diagenetic alteration

a. <u>Waarre Formation</u>

Diagenetic alteration involved phases of dissolution, mechanical compaction due to burial, and precipitation of glauconite, pyrite, kaolin, chlorite, ?feldspar and carbonate. Glauconite is restricted to sidewall core 13 (depth 1489.2m) where it reflects a difference in the depositional environment compared to the basal samples. Similarly the presence or absence of pyrite may also be the result of variations in the salinity of depositional environments. Kaolin is restricted to sidewall core 4 (depth 1630.2m) where one coarse grain has been replaced. This could be the result of minor meteoric flushing soon after burial which resulted in acidic pore fluids (pH 4-7) altering feldspar. Partial corrosion of other feldspars to form honeycomb pores in the basal four samples probably occurred at this time.

Diagenetic alteration in the basal four samples was dominated by the development of chlorite rims (8-10% total rock volume) and complete to partial replacement of grains by chlorite (3-6% total rock volume. Chlorite rims are typically 10 to 15 microns in diameter, comprised of platelets oriented perpendicular to grain surfaces and concentrated in coarser grained beds. These rims surround primary intergranular pores and are absent at grain contacts which indicates the rims formed after initial burial and development of grain contacts. The mechanism by which rims are thought to have developed was described in section 7.3. Infiltration of amorphous Fe would be easiest in those beds with good reservoir quality hence the concentration of chlorite in cleaner beds. Chlorite precipitated from alkaline pore fluids (pH 7-9) when there was sufficient Mg^{2+}, but minimal K^{+}. Where detrital grains are partially replaced by chlorite it is apparent that many of these grains were volcanic lithics. In these instances the components of the lithics were the source of Fe and Mg for chlorite precipitation.

Blocky twinned ?feldspar laths (3-4% total rock composition) postdate the chlorite rims in sidewall cores 5 and 6 (depths 1612.9m & 1598.4m). Identification of these laths as feldspar is very tentative, an alternative interpretation might be that of a zeolite. The exact chemical and mineralogical composition needs to be checked by electron microprobe analysis on a polished thin section. For authigenic feldspars to form pore waters were alkaline and rich in Na or K, Si and Al. These elements were probably derived from the alteration of detrital feldspars. Zeolites are common in rocks containing abundant volcanic lithics.

Trace amounts of dusty carbonate spar have selectively replaced lithics in the basal four samples. This spar could have been an alteration product at the sediment source. Alternatively the spar might have formed at the same time as minor amounts noted in sidewall core 13. XRD results indicated that this spar is dolomite. There is no cement stratigraphy to indicate the timing of carbonate precipitation in these samples from the Waarre Formation. Ca and Mg necessary for dolomite to form would have been locally available from altered feldspars and lithics. It is possible that the source of CO_2 was associated with hydrocarbon migration.

This diagenetic sequence is similar to that recognised at Pecten-1A where chlorite was the dominant authigenic mineral. In contrast, the Waarre Unit A sandstones from the Casino Field contain significantly more carbonate cement (siderite, calcite & ankerite/dolomite), kaolin and quartz overgrowths. The latter may be inhibited at Martha-1 by both the chlorite rims which are probably related to the depositional environments and the abundance of lithics which would inhibit sites for quartz precipitation.

b. Belfast Mudstone

Diagenetic alteration in the Belfast Mudstone at Martha-1 was related to the depositional environment. Glauconite (4-12% total rock volume) would have precipitated at the sediment-water interface and the framboidal pyrite (5-7% total rock volume) soon afterwards as conditions became more reducing with burial. Typically the framboids are associated with grains of glaucony and the clay matrix, both of which could have provided localised sources of Fe necessary for pyrite precipitation. Grains replaced by fibrous chlorite (3% total rock volume) in the sublitharenite could either have been reworked from older sedimentary sequences, or formed via a mechanism similar to that described for the Paaratte Formation. Reworking might be the most plausible explanation given that deposition of the Belfast Mudstone was probably in deeper less agitated water than the Paaratte Formation. However, there is no evidence of oxidation to support this hypothesis.

Elsewhere siderite concretions and cements are common in the Belfast Mudstone (Boyd & Gallagher, 2001) but siderite was not apparent in the sample from Martha-1.

c. Paaratte Formation

There is minimal diagenetic alteration evident in the sample from the Paaratte Formation at Martha-1. A possible mechanism for the development of chloritised pseudo-ooids has already been described in section 7.3. Following this early diagenetic event, blocky and framboidal pyrite (4% total rock volume) partially replaced the chloritised grains and clay matrix. Fe was probably derived from these sources and the sulphate from marine pore waters to enable pyrite to form. Mechanical compaction after burial caused the deformation of the chloritised grains and there was minor dissolution of feldspars to form honeycomb pores.

It is interesting to note the lack of obvious quartz overgrowths in the Paaratte Formation. This was not due to chlorite rims or abundant lithics as for the Waarre Formation but might be attributed to the shallower depths of burial if the source of silica was chemical compaction at quartz-mica/clay contacts. Minimal development of quartz overgrowths was also noted at Hill-1 (Phillips, 2004b) but there was carbonate cement and grain replacing kaolin which are not recorded from the sample at Martha-1.

7.5 Reservoir quality

Assessment of reservoir quality from crushed sidewall cores is very unreliable. For more accurate estimates of porosity the wireline logs should be used. However, remnants of different pore types can be recognised in thin section and these can help to understand permeability.

a. Waarre Formation

There was very limited evidence that primary intergranular pores were preserved in the sandstones from the Waarre Formation. This probably suggests that permeability is likely to be poor. It would appear that the combination of abundant lithics, some of which were ductile, and chlorite rims has occluded intergranular pores. Compaction of the sediment would have deformed ductile lithics (especially those containing abundant smectite) into intergranular pores. Authigenic chlorite rimming the remaining pore space would have further reduced the porosity and interconnection between pores. In those samples (sidewall cores 5 & 6, depths 1612.9m & 1598.4m) which have a diagenetic phase of ?feldspar that postdates the chlorite, pore size has been further reduced.

Secondary pores (2-4% total rock volume) in the Waarre Formation have resulted from the partial corrosion of feldspars (honeycomb pores) and lithics (intragranular pores), and rarely the complete dissolution of labile grains (grain size pores). These pore types do contribute to total porosity but are unlikely to significantly improve permeability and effective porosity.

The final pore type recognised in the sediments was microporosity associated with chlorite rims in the sandstones. Authigenic platelets oriented perpendicular to the grain surface would have spaces between the platelets. The abundance of these micropores is difficult to assess but they could be linked to intergranular pores. Micropores are unlikely to be effective for oil migration but they might be large enough to allow gas migration.

Mudstone in sidewall core 13 could represent an effective seal due to the presence of smectite, chlorite and illite in the detrital clays. However, the nature and frequency of sandstones within the mudstone are uncertain and these might reduce the seal potential if interconnected.

b. Belfast Mudstone

Similar comments would apply to the Belfast Mudstone as the mudstone at the top of the Waarre Formation. It might be an effective seal depending on the nature and abundance of interbedded sandstones. Micropores associated with glauconite are unlikely to influence seal potential.

c. Paaratte Formation

Lack of mechanical compaction and authigenic cement in the subarkose might indicate that reservoir quality is moderately good in this interval of the Paaratte Formation. Primary intergranular pores could be preserved (?10%) and there is only minor detrital clay (or drilling mud) that would limit vertical permeability. The dominance of intergranular pores should mean that permeability is moderate. However, the deformation of chloritised grains would reduce the size of juxtaposed intergranular pores and thus slightly limit permeability.

Secondary honeycomb pores (2% total rock volume) are unlikely to significantly improve reservoir quality because there are not enough feldspars in the rock to corrode.

8. CONCLUSIONS

1. Fine to medium grained, poor to moderately well sorted litharenites from the base of the Waarre Formation at Martha-1 are lithologically similar to sediments from Unit A. These sandstones are overlain by a sandy to silty mudstone with minor fine grained moderately well sorted sublitharenite which could represent Unit B. Glauconitic mudstone from the Belfast Mudstone also contains very fine grained, poorly sorted sublitharenite. The Paaratte Formation sample is a fine grained, well sorted subarkose.

2. Sediment in the Waarre Formation litharenites was derived from an igneous-metamorphic terrane. The igneous source was more important at Martha-1 and included basic/mafic volcanics and plutonics. This resulted in high percentages of basalt lithics and plagioclase. In the Casino Field the igneous source included acid/felsic volcanics and plutonics, as a result feldspars are typically K-feldspars but the abundance of metamorphic lithics indicates this was a more important source of sediment.

3. Chlorite rims suggest the Waarre Formation litharenites were deposited in a near shore marine facies close to a river mouth, similar to the sequence at Pecten-1A. Glauconite and forams in the overlying mudstone indicate a deeper water, open marine depositional environment, possibly influenced by turbidity currents. The Belfast Mudstone sample could represent a delta front/ prodelta mud where there was sediment instability. A shallow near shore marine setting is possible for the Paaratte Formation due to the presence of chloritic pseudo-ooids.

4. Diagenetic alteration in the Waarre Formation litharenites was dominated by the precipitation of chlorite rims on intergranular pores and partial replacement of lithics by chlorite. Authigenic ?feldspar/zeolite that postdates the chlorite and mechanical compaction further reduced pore size. There is no evidence of significant quartz overgrowths, kaolin and carbonate cements as seen elsewhere in Waarre Unit A. In both the Belfast Mudstone and Paaratte Formation diagenetic alteration was related to the depositional environments. Glauconite and framboidal pyrite are abundant in the mudstone, and chloritic pseudo ooids in the subarkose.

5. Reservoir quality is probably poor in the Waarre Formation due to the deformation of ductile lithics during mechanical compaction and precipitation of chlorite rims. Seal capacity in the mudstone at the top of the Waarre Formation and the Belfast Mudstone should be good if the associated fine grained sandstones are not interconnected. The mineralogically more mature Paaratte Formation has retained the best reservoir quality. Primary intergranular pores may be dominant which would favour preservation of permeability. Secondary pores associated with corroded feldspars are present in all lithologies but these would not improve effective porosity. Micropores could be a significant component of total porosity where there is abundant glauconite and chlorite.

9. GLOSSARY OF TERMS

Framboid
A cluster of pyrite crystals with a spheroidal outline.

Glaucony
A term used to describe green minerals without any genetic connotations. If the green minerals can be identified, a specific mineral name is given.

Glauconite
An Fe-rich dioctahedral illite. The term is also used to refer to a family of Fe-rich dioctahedral clays with varying ratios of expanded (smectite) and non-expanded layers.

Granophyric Texture
A variety of micrographic intergrowth of quartz and alkali feldspar that is either crudely radiate or is less regular than micrographic texture.

Honeycomb Porosity
Secondary porosity produced by the corrosion (etching) of detrital grains.

Micrographic Intergrowth
A regular intergrowth of two minerals.

Microporosity
Porosity directly associated with clay minerals.

Myrmekite
Intergrowth of plagioclase and quartz with a vermicular texture.

Trachytic
A textural term applied to the groundmasses of volcanic rocks in which there is a subparallel arrangement of microcrystalline, lath shaped feldspars. The term is not restricted in use to rocks of trachyte composition.

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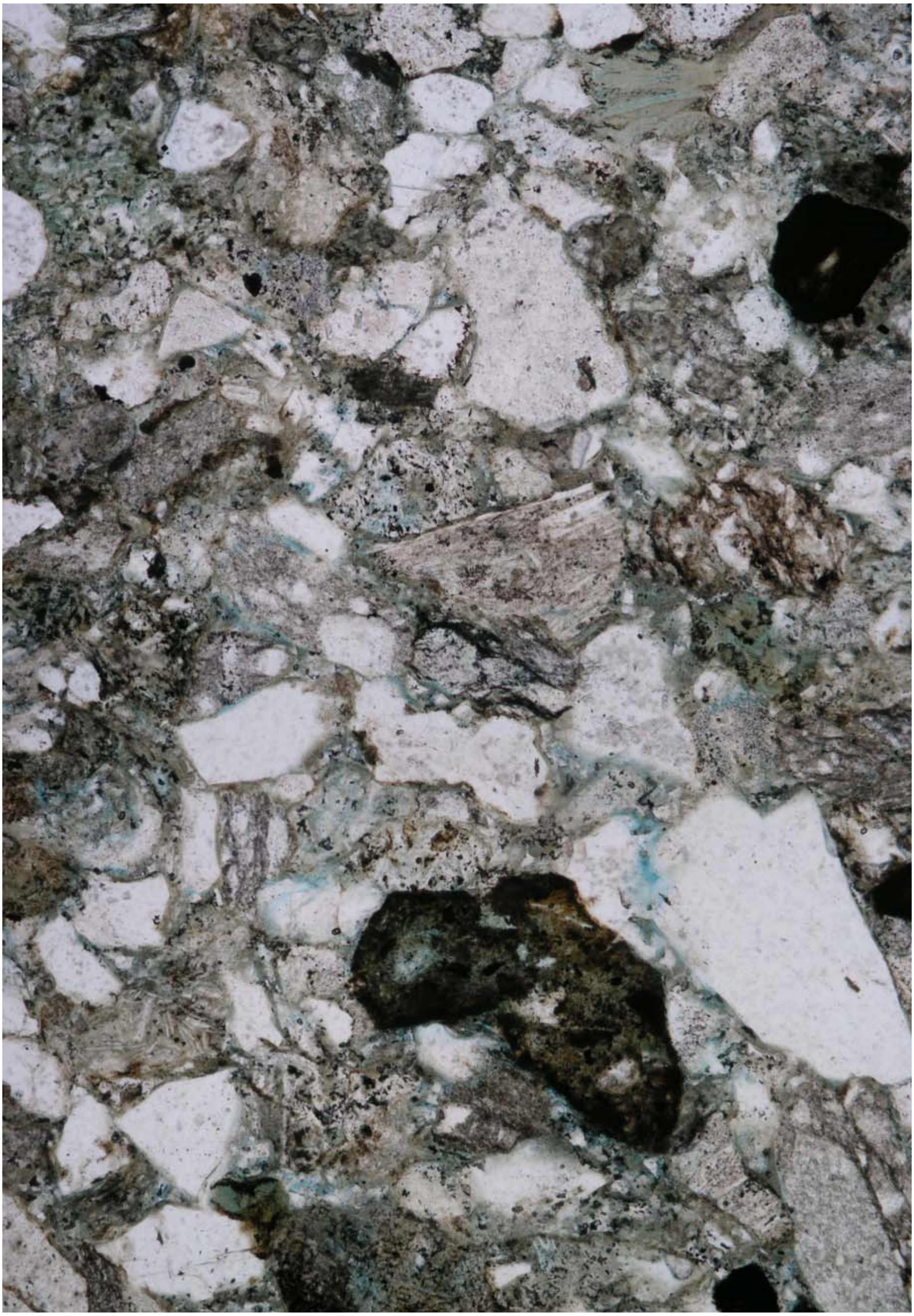

APPENDIX VI : PALYNOLOGY REPORT

The Palynology Report is presented overleaf.

SANTOS STRATIGRAPHIC SERVICES
GEOSCIENCE & NEW VENTURES

Palynology Report No. 2004/31

Author: R.HELBY

PALYNOLOGICAL REPORT NO. 2004/31
PALYNOSTRATIGRAPHICAL ANALYSIS

MARTHA -1 WELL

Santos Ltd
A.C.N. 007 550 923

Introduction

Twenty one sidewall core samples from Santos Martha-1, drilled VIC-P44, were examined palynologically. An additional 13 cuttings samples were examined on board the Jack Bates during drilling of Santos Callister-1. The Santos laboratory technicians noted that the sidewall cores were "soft and fragile" indicating that pre-processing cleaning of the cores was very difficult. Mud contamination, largely represented by dinocysts from higher levels, is evident in most of the preparations. This was a particular problem in the recognition of the Eumeralla Formation. One of the definitive features of the Eumeralla Formation, hitherto, has been the apparent absence of dinocysts. In most instances the contaminants clearly originated from the interval of the Paaratte Formation to the Belfast Mudstone "C" unit.

The palynostratigraphic results are summarised on Chart 1 and presented in detail presented in on Table 1. The palynostratigraphic scheme utilised (Figure 1) is based on Partridge (1999, 2001) and the relationships of the biostratigraphic zones to the lithostratigraphy and sequence nomenclature follows Sharp & Wood (2004). A range chart of palynomorphs recorded in this study is appended.

R. Helby

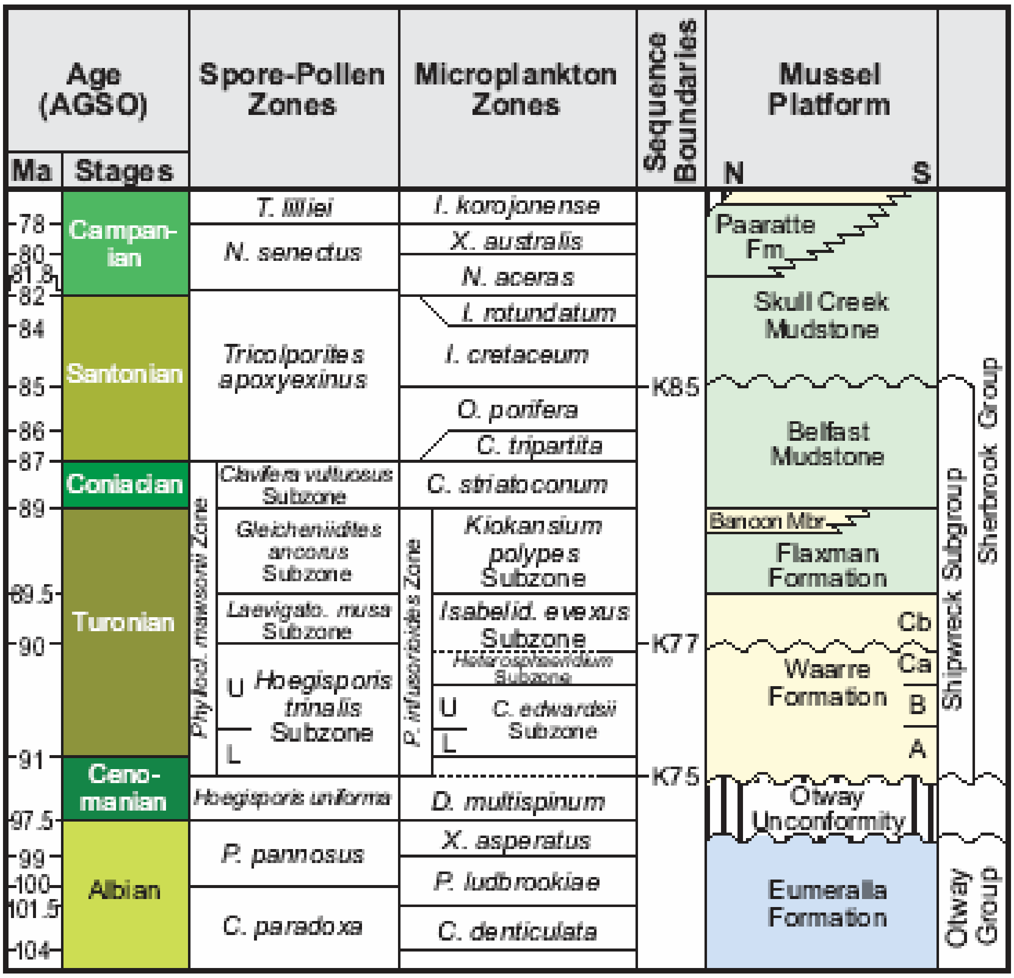

Figure 1 Palynostratigraphic Scheme utilised (after Partridge 1999, 2001 & Sharp & Wood, 2004)

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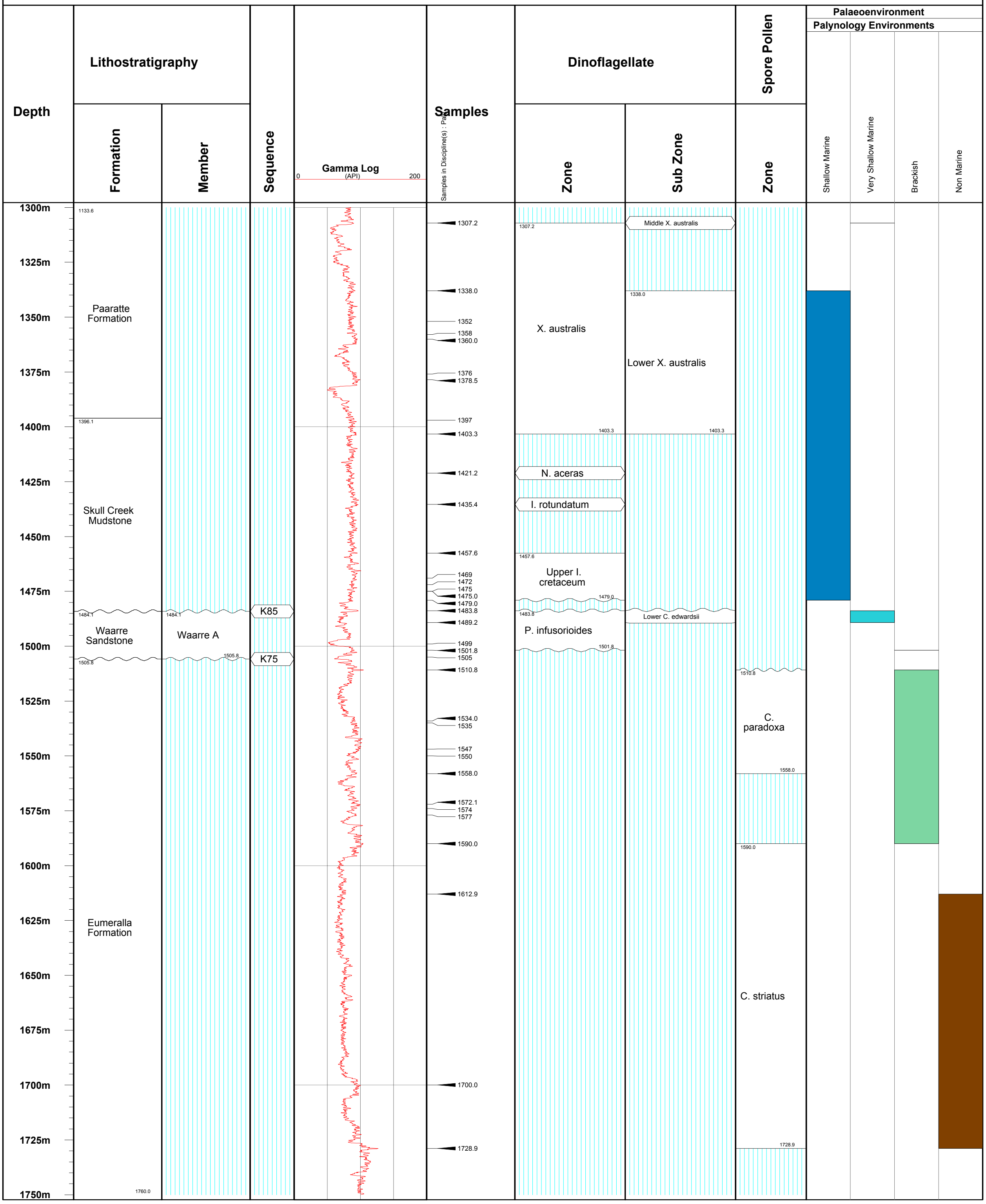
Well Name : Martha-1

Santos Ltd
Adelaide

Operator	:
Well Code	: MARTHA-1
Lat/Long	: 0° 0' 0.00"N 0° 0' 0.00"
Interval	: 1300m - 1750m
Scale	: 1:1500
Chart date	: 15 March 2005
Spudded	: 16 November 2004
Completed	: 16 November 2004

Project : OTWAY
Chart : Martha-1 Summary Chart

IGD Boundary Key
Possible
Probable
Confident
Unconformable
?Unconformable
Fault
?Fault
Sampling
Cutting
Core
Sidewall core



Santos PALYNOLOGY REPORT

Study: **Martha No. 1**

Author: R. Helby

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1307.2	*Xenikoon australis* (Early Campanian)	Paaratte Formation	X	Perm.	P-F	Mod	High	Moderately rich (21% of total palynomorphs), low diversity dinocyst suite with frequent *Xenikoon australis, Nelsoniella aceras* and frequent *Heterosphaeridium* spp. The high diversity spore pollen suite is not particularly diagnostic, lacking *Nothofagidites* spp. and *Tricolporites apoxyexinus.* Near-shore marine.
SWC	1338.0	*Xenikoon australis* (Early Campanian)	Paaratte Formation	2	Perm.	P-F	Mod	High	Rich (50% of total palynomorphs), high diversity dinocyst suite with frequent *Xenikoon australis, Nelsoniella aceras, N. tuberculata, Odontochitina porifera* and common *Heterosphaeridium* spp. The moderate diversity spore-pollen suite is not particularly diagnostic. Shallow marine.
SWC	1360	*Xenikoon australis* (Early Campanian)	Paaratte Formation	-	-	P-F	Mod	High	Rich (39% of total palynomorphs), high diversity microplankton suite with *Nelsoniella aceras,* questionable *N. tuberculata, Odontochitina porifera* with common *Heterosphaeridium* spp. but lacking Xenikoon *australis.* The moderate diversity spore-pollen suite is not particularly diagnostic. Shallow marine. The moderate diversity spore-pollen suite is not particularly diagnostic. Shallow marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1378.5	*Xenikoon australis* (Early Campanian)	Paaratte Formation	2	Perm.	P-F	Mod	High	Rich (38% of total palynomorphs), moderate diversity microplankton suite with *Xenikoon australis,* frequent *Nelsoniella aceras, N. tuberculata* and *Odontochitina porifera* with common *Heterosphaeridium* spp. Shallow marine.
SWC	1403.3	*Xenikoon australis* (Early Campanian)	Paaratte Formation	>1	Perm.	P-F	Mod	Mod.	Rich (46% of total palynomorphs), moderate diversity microplankton suite with *Xenikoon australis,* frequent *Nelsoniella aceras* and *Odontochitina porifera* with abundant *Heterosphaeridium* spp. Shallow marine.
SWC	1421.2	*Nelsoniella aceras* (Early Campanian)	Skull Ck Mudstone	>2	Perm.	P-F	Mod	Mod.	Rich (47% of total palynomorphs), low diversity dinocyst suite with *Nelsoniella aceras,* common *Odontochitina* spp. (including *O. magna and O. porifera*) and abundant *Heterosphaeridium* spp. Shallow marine.
SWC	1435.4	*Isabelidinium rotundatum* (Early Campanian)	Skull Ck Mudstone	2	Perm.	P-F	Mod	Mod.	Rich (65% of total palynomorphs), moderate diversity dinocyst suite with common *Isabelidinium rotundatum,* common *Heterosphaeridium* spp. and frequent *Trithyrodinium vermiculatum. Nelsoniella aceras* not observed. Shallow marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1457.6	Upper *Isabelidinium cretaceum* (Early Campanian)	Skull Ck Mudstone	X	Perm.	P-F	Mod	Mod.	Super-abundant (97% of total palynomorphs), moderate diversity, dinocyst suite dominated by *Odontochitina lepros* (*O.* 'stubby' of MPA), common Heterosphaeridium spp. and *Trithyrodinium glabrum*, with *Amphidiadema denticulata*, *Isabelidinium elongatum*, *Odontochitina magna, O. porifera, O. wannabe* and *Trithyrodinium vermiculatum*. Spore-pollen diversity is extremely restricted and the assemblage is not diagnostic. Shallow marine.
SWC	1475.0	Upper *Isabelidinium cretaceum* (Early Campanian)	Skull Ck Mudstone	1	Perm.	P-F	Mod	Mod.	Moderately rich (31% of total palynomorphs), moderate diversity, dinocyst suite with common *Isabelidinium* spp. (including *I. elongatum* and *I. rectangulare*), *Odontochitina porifera* and frequent *Heterosphaeridium* spp. Shallow marine.
SWC	1479.0	Upper *Isabelidinium cretaceum* (Early Campanian)	Skull Ck Mudstone	X	Perm.	VP-F	Mod	Mod.	Moderately rich (26% of total palynomorphs), moderate diversity, dinocyst suite with common *Isabelidinium* spp. (including *I. cretaceum* and *I. elongatum*), *Amphidiadema denticulata Odontochitina porifera, Trithyrodinium glabrum, T. vermiculatum* and common *Heterosphaeridium* spp. Shallow marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1483.8	*P. infusorioides – C. edwardsii Subzone* (Turonian)	Waarre Sandstone "A"	X 1	Perm. Trias.	P-F	Mod	Mod.	Moderately rich (36% of total palynomorphs), moderate diversity, dinocyst suite with common *Circulodinium* cf. *C. deflandrei* and frequent *Cyclonephelium compactum*, *Heterosphaeridium* spp., *Kiokansium polypes* with *Cribroperidinium* spp (including fragments of *C. edwardsii*). A fairly diverse caved assemblage from the Skull Creek Mudstone was recorded. The spore-pollen suite includes *Appendicisporites distocarinatus* and *Hoegisporis trinalis*. Near-shore marine.
SWC	1489.2	*P. infusorioides – C. edwardsii Subzone* (Turonian)	Waarre Sandstone "A"	1	Perm.	P-F	Mod	Mod.	Relatively lean (13% of total palynomorphs), low diversity, dinocyst suite with frequent *Circulodinium* cf. *C. deflandrei, Heterosphaeridium* spp. and *Palaeoperidinium cretaceum*. The spore-pollen suite lacks diagnostic elements. Near-shore marine.
SWC	1501.8	*P. infusorioides* (undiff. - ?) (Turonian)	Waarre Sandstone "A" (?)	-	-	P-F	Mod	Mod.	This zone pick is tentatively based on a single specimen of *Heterosphaeridium*. No other dinocysts were recorded. The spore-pollen suite appears to lack *Appendicisporites* spp., *Hoegisporis trinalis* or *Phyllocladidites* spp. - species that would support Waarre Sandstone "A" assignment. Possible marine influence.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1510.8	*Coptospora paradoxa* (Albian)	Eumeralla Formation	X X	Perm. Trias.	P-F	High	High	Rich, diverse spore-pollen suite, dominated by smooth fern spores (58%) with frequent *Cicatricosisporites* spp. The zone pick is based on the occurrence of the eponymous species and the apparent absence of younger indices. None of the marker taxa from the *Phyllocladidites mawsonii* Zone were observed. No unequivocal dinocysts were recorded. The occurrence of the fresh-water to brackish algal species *Sigmopollis carbonis* is recorded
SWC	1534.0	*Coptospora paradoxa* (Albian)	Eumeralla Formation	X	Perm.	P-F	Mod.	High	Moderately rich, diverse spore-pollen suite dominated by saccate pollen and fern spores. The zone pick is based on the occurrence of *Coptospora paradoxa* and the absence of younger indices. None of the marker taxa from the *Phyllocladidites mawsonii* Zone were observed. Dinocysts not recorded, however, the occurrence of *Micrhystridium* spp. and unidentified diaphanous cysts may indicate minor salinity suggesting a possible brackish environment of deposition.
SWC	1558.0	*Coptospora paradoxa* (Albian)	Eumeralla Formation	X	Perm.	P-F	Mod.	High	As above
SWC	1572.1	Indeterminate	Indeterminate	-	-	P-F	X. low	V. low	Almost barren – lacking diagnostic taxa.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1590.0	*Crybelosporites striatus* (Late Aptian to early Albian)	Eumeralla Formation	1	Perm.	P-F	Mod.	High	Moderately rich, diverse spore-pollen suite dominated by saccate pollen. The zone pick is based on the occurrence of *Crybelosporites striatus* and the apparent absence of *Coptospora paradoxa* and other younger markers. No dinocysts were recorded, however, the occurrence of *Micrhystridium* spp. with other algal cysts may indicate minor salinity suggesting a possible brackish environment of deposition.
SWC	1612.9	*Crybelosporites striatus* (Late Aptian to early Albian)	Eumeralla Formation	1	Perm.	P-F	Mod.	Mod.	An extremely lean, but moderately diverse, spore-pollen assemblage lacking diagnostic species is recorded. The zone pick is based on the samples position between unequivocal *C. striatus* zone samples. Three specimens of *Xenikoon australis*, three specimens of *Heterosphaeridium* spp. and a single *Odontochitina specimen* were recorded. These are clearly contaminants from higher levels (Waarre Ss-Paaratte).
SWC	1700.0	*Crybelosporites striatus* (Late Aptian to early Albian)	Eumeralla Formation	1	Perm.	P-F	Mod.	Mod.	This very lean, low diversity, spore-pollen assemblage lacks diagnostic species. The zone pick is based on the samples' stratigraphic position Specimens of *Heterosphaeridium* spp., Isabelidinium spp. and *Odontochitina* were recorded. These are clearly contaminants from above. No spinose acritarchs observed. Non-marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
SWC	1728.9	*Crybelosporites striatus* (Late Aptian to early Albian)	Eumeralla Formation	1	Perm.	P-F	Mod.	High	Saccate pollen and fern spores dominate this moderately rich, diverse spore-pollen suite. The zone pick is based on the occurrence of *C. striatus* and the apparent absence of *Coptospora paradoxa* and other younger markers. The moderately diverse dinocyst suite including *Isabelidinium rotundatum, Nelsoniella aceras, Odontochitina magna* and *Xenikoon australis* originates from higher levels in the well (probably Skull Ck Mdst-Paaratte Mdst). No spinose acritarchs observed. Non-marine.

ON-RIG SAMPLES - PALYNOLOGY REPORT - REINTERPRETED

Study: **Martha No. 1**
Author: R. Helby

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS %	REWORKED ELEMENTS AGE	PRESER VATION	YIELD	DIVER SITY	REMARKS
CUTT	1352	*Xenikoon australis* (Early Campanian)	Paaratte Formation	1	Perm	P-F	Mod	Mod	Low diversity dinocyst suite with prominent *Heterosphaeridium* spp. (>15%), *Nelsoniella* sp. and *Xenikoon australis* (tentative). Spore-pollen suite includes *Nothofagidites senectus*. Near-shore marine.
CUTT	1358	*Xenikoon australis* (Early Campanian)	Paaratte Formation	1	Perm	P-F	Mod	Mod	Very low diversity dinocyst suite with prominent *Heterosphaeridium* spp. (≈15%) and a single, specimen of *Isabelidinium* sp. Spore-pollen suite not particularly diagnostic. Near-shore marine.
CUTT	1376	*Xenikoon australis* (Early Campanian)	Paaratte Formation	-	-	P-F	Mod	Mod	Low diversity dinocyst suite with abundant *Heterosphaeridium* spp. (≈30%), *Nelsoniella aceras, Odontochitina porifera* and *Xenikoon australis* (tentative). Spore-pollen suite not particularly diagnostic. Near-shore marine.
CUTT	1397	*Nelsoniella aceras* (?) (Early Campanian)	Skull Ck Mdst (caved ?)	X	Perm	P-F	Mod	Mod	Low diversity dinocyst suite with prominent *Heterosphaeridium* spp. (26%) and *Nelsoniella* sp. Spore-pollen suite not particularly diagnostic. Near-shore marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS %	REWORKED ELEMENTS AGE	PRESER VATION	YIELD	DIVER SITY	REMARKS
CUTT	1469	Upr *Isabelidinium cretaceum* to *Isabelidinium rotundatum* (Early Campanian)	Skull Creek Mudstone	1	Perm	P-F	Mod	High	Moderate diversity dinocyst suite with abundant *Heterosphaeridium* spp. (≈40%), with *Isabelidinium elongatum, I rotundatum*, *Nelsoniella* aceras, common *Odontochitina* spp. (including *O. magna, O. porifera* and O. sp. (stubby), frequent *Trithyrodinium glabrum* and *T. vermiculatum*. Near-shore marine.
CUTT	1475	Upr *Isabelidinium cretaceum* to *Isabelidinium rotundatum* (Early Campanian)	Skull Creek Mudstone	3	Perm	P-F	Mod	High	Moderate diversity dinocyst suite with abundant *Heterosphaeridium* spp. (≈30%), with *Isabelidinium* spp. (including *I. elongatum, I. nuculum* and *I. rotundatum)*, *Nelsoniella* aceras, prominent *Odontochitina* spp. (including *O. cribropoda, O. porifera, O. wannabe* and O. sp. - stubby) and frequent *Trithyrodinium glabrum*. Near-shore marine.
CUTT	1499	Upr *Isabelidinium cretaceum* to *Isabelidinium rotundatum* (Early Campanian)	Skull Creek Mudstone (caved)	X	Perm	P-F	Mod	High	Moderate diversity dinocyst suite with frequent *Heterosphaeridium* spp., with *Isabelidinium* spp. (including *I. cretaceum, I. elongatum, I. nuculum* and *I. rectangulare* and *I. rotundatum)*, *Nelsoniella* aceras, prominent *Odontochitina* spp. (including *O. cribropoda, O. porifera* and O. sp. - stubby) and frequent *Trithyrodinium glabrum* and *T. vermiculatum*. Near-shore marine.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
CUTT	1505	Upr *Isabelidinium cretaceum* to *Isabelidinium rotundatum* (Early Campanian)	Skull Creek Mudstone (caved)	1	Perm	P-F	Mod	High	Moderate diversity dinocyst suite with frequent *Heterosphaeridium* spp., with *Isabelidinium* spp. (including *I. belfastense, I. cretaceum* and *I. rotundatum)*, *Nelsoniella* aceras, prominent *Odontochitina* spp. (including *O. porifera, O. wannabe* and O. sp. - stubby) and frequent *Trithyrodinium glabrum*. Near-shore marine.
CUTT	1547	*Coptospora paradoxa to Crybelosporites striatus* (Late Aptian to Albian)	Eumeralla Fm (or younger)	1	Perm	P-F	Mod	Mod	Moderately diverse spore-pollen suite with *Crybelosporites striatus*, apparently lacking markers from the *P. mawsonii* Zone. The low diversity dinocyst suite wit*h Isabelidinium rotundatum, Odontochitina* porifera, *Trithyrodinium glabrum, T. vermiculatum* and *Xenikoon australis* is considered to be caved. A fragment of *Cribroperidinium edwardsii* was also recorded. No evidence of in-situ marine influence.
CUTT	1550	*Coptospora paradoxa to Crybelosporites striatus* (Late Aptian to Albian)	Eumeralla Fm (or younger)	1	Perm	P-F	Mod	Mod	The moderately diverse spore-pollen suite apparently lacks markers from the *P. mawsonii* Zone is marked by prominent *Cicatricosisporites* spp. (15%). The very low diversity dinocyst suite includes *Odontochitina* porifera and *Trithyrodinium glabrum* and is considered to be caved. No evidence of in-situ marine influence.

SAMPLE	DEPTH (metres)	PALYNOSTRATIGRAPHICAL UNIT (Age)	INFERRED STRATIGRAPHICAL UNIT	REWORKED ELEMENTS		PRESER VATION	YIELD	DIVER SITY	REMARKS
				%	AGE				
CUTT	1574	*Coptospora paradoxa to Crybelosporites striatus* (Late Aptian to Albian)	Eumeralla Fm (or younger)	1	Perm	P-F	Mod	Mod	The moderately diverse spore-pollen suite apparently lacks markers from the *P. mawsonii* Zone. The very low diversity dinocyst suite includes *Isabelidinium rotundatum, Nelsoniella* aceras and *Xenikoon australis* is considered to be caved. No evidence of in-situ marine influence.
CUTT	1577	*Coptospora paradoxa to Crybelosporites striatus* (Late Aptian to Albian)	Eumeralla Fm (or younger)	2	Perm	P-F	Mod	Mod	The moderately diverse spore-pollen suite apparently lacks markers from the *P. mawsonii* Zone. The lean, very low diversity dinocyst suite, which includes *Nelsoniella* aceras and *Odontochitina wannabe,* is considered to be caved. No evidence of in-situ marine influence.

APPENDIX VII : DRILL STEM TEST ANALYSIS REPORT

No production tests were conducted at the Martha 1 location.

ENCLOSURE I : COMPOSITE LOG (1:500 SCALE)

ENCLOSURE II : DEPTH STRUCTURE MAP

ENCLOSURE III : STRATIGRAPHIC CROSS SECTION

ENCLOSURE IV : LOG INTERPRETATION ANALOGUE PLOT