

WELL COMPLETION REPORT

SCALLOP -1

**VOLUME 2
INTERPRETIVE DATA**

**GIPPSLAND BASIN
VICTORIA**

ESSO AUSTRALIA PTY LTD

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WELL COMPLETION RPEORT SCALLOP- 1
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VOLUME 2:

INTERPRETIVE DATA

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1. INTRODUCTION

The Scallop-1 well was drilled as a wildcat exploration well, approximately 3 km south-east of East Pilchard-1 (Figure 1). The well was located in 110 metres of water, within the VIC/RL2 licence area of the Gippsland Basin, and was drilled to a TD of 3174m MD (3148.1m TVDSS).

The well spudded on 2nd February 2003, and TD was reached on the 22nd February 2003. The well was plugged and abandoned and the rig was released on the 4th March 2003.

The Scallop-1 well targeted hydrocarbons in the fluvial reservoirs of the sub-volcanic Golden Beach Group (*T. lilliei* – *N. senectus* age). A lowside fault dependent closure was mapped on the Scallop fault block, straddling the VIC/RL2 - VIC/L9 permit boundary. Two possible DHIs (flatspots) had also been identified. The primary risks for the Scallop-1 well were fault seal and that the flatspots observed were related to residual gas, or lithological complications within the reservoir section.

A secondary objective for the well was a possible fault dependent closure in the fluvial-coastal plain reservoir facies in the shallower upper *T. lilliei* Latrobe Group section (above the volcanics).

2. SUMMARY OF WELL RESULTS

A comparison of prognosed versus actual formation tops penetrated in Scallop-1 is summarised in Table 1, and the relevant stratigraphy is summarised in Figure 2. The prognosed stratigraphy was based on adjacent well data and regional seismic correlations.

The primary objectives of the well were the *T. lilliei* and *N. senectus* sub-volcanic reservoirs below three separate volcanic intervals, First Volc (deepest), Intra-Volc and Top Volc (shallowest). These reservoirs were intersected some 11-57m deep to prognosis, which is attributed to faster velocities than expected in the Intra-Latrobe and stratigraphic complexities associated with the intercalation of the volcanic packages with the sedimentary sequence. The net to gross of the reservoir section was relatively low, as expected, resulting in multiple sealing units and reservoir systems.

The well intersected a total of 6.3 net metres of oil and 23.3 net metres of gas in the sub-volcanic reservoir section. Two oil-bearing reservoirs were encountered from 2628.7m-2841.4m MD, in thin sands embedded within and immediately below Top Volc. A series of thin gas-bearing sands were found within the interval 2888.3mMD - TD (three main gas sands below Intra-Volc and another three gas sands below First Volc) interbedded with water-bearing sands.

Lab-derived compositional analyses on the Scallop-1 oil samples indicate a GOR of 1375 scf/stb and 41.3° API gravity; gas sample analyses resulted in a CGR (condensate/gas ratio) of 33 stb/mscf and CO₂ concentrations of 17.6%.

Hydrocarbon column heights are generally well constrained, based on the interpretation of pressure data, log data and current maps, although some range exists depending on water gradients used (see Figure 3 and further discussions below).

The secondary target, a fault-dependant closure in the upper *T. lilliei* of the Latrobe Group, was intersected 4m shallow to prediction and was found to be water-bearing without hydrocarbon shows. Fault-dependent closure is therefore interpreted as being absent at this stratigraphic level and location.

Although Scallop-1 intersected oil and gas, the discovery was assessed as sub-economic and the well was plugged and abandoned.

3. GEOLOGICAL DISCUSSION

OVERVIEW

Exploration in the Gippsland basin has historically focussed on upper Latrobe structural and stratigraphic traps. Tests of deeper hydrocarbon potential (in the Golden Beach Group, Emperor Subgroup) have generally been confined to wells targeting Top of Latrobe closures but which were subsequently deepened to explore secondary objectives. The Kipper-1 well (1986) drilled into the Late Cretaceous sub-volcanic reservoir section and encountered the largest hydrocarbon column in the Gippsland Basin (~320m gross gas column). The East Pilchard-1 well (2001) was drilled to further test this sub-volcanic play in the greater Kipper area, successfully discovering economic hydrocarbons.

The G99A Kipper 3D seismic survey was acquired in 1999 to progress delineation of the Kipper gas field. The area of the survey was designed to be large enough to extend over several adjacent fault blocks, and the high quality of the data enabled mapping of the Golden Beach Group over much of the survey area. Initial interpretation of the G99A data resulted in recognition of DHIs and lowside fault-dependent closures on several fault ramps, including the Scallop prospect, which straddles the boundary between VIC/RL2 and VIC/L9 (Figure 1).

REGIONAL SETTING

The initial formation of the Gippsland Basin was associated with rifting and subsidence that extended along the southern margins of Australia during the Jurassic to Early Cretaceous. During this period, deposition of predominantly volcanoclastic successions occurred in alluvial and fluvial environments, in NE trending en-echelon graben systems (Otway and Strzelecki Groups). A phase of structuring and localised uplift of the Strzelecki Group occurred around 100-95Ma.

A renewed phase of Late Cretaceous (approximately 90 Ma) rifting coincided with the onset of Tasman seafloor spreading to the east of Tasmania. This resulted in the rapid development of extensional basins in the Gippsland area, with active extensional faults oriented WNW/ESE (oblique to the earlier extensional event). A thick (overall coarsening-up) succession was deposited in these tectonically active depocentres (Golden Beach Group and Emperor Subgroup). Initial rift deposition included marine and lacustrine shales in distal parts of the basin, while deltaic successions and alluvial fans developed along basin margins. The rift fill succession gradually evolved into a fluvial-dominated system. The upper parts of the Golden Beach Group (eg. Kipper

3. GEOLOGICAL DISCUSSION (CONT'D)

sub-volcanic reservoir section) were predominantly braided fluvial to delta plain in character. As the northward migrating Tasman spreading centre passed by the Gippsland Basin around 85-80Ma, the eruption of mafic volcanics and emplacement of related intrusions occurred across the Gippsland basin. These volcanics form the topseal for several hydrocarbon accumulations (eg. the Kipper volcanics).

The active rift phase in the Gippsland Basin ceased at approximately 80 Ma, as the Tasman Rift proceeded to migrate further northwards towards Queensland. From this time onwards, the Gippsland Basin essentially evolved into a failed arm of the Tasman rift system. The Latrobe Group was deposited in this sag phase basin setting, with fault controlled subsidence continuing until the Late Palaeocene. Most of the Latrobe Group was deposited in a non-marine setting behind a NE-SW trending beach-barrier complex. During the Early Eocene, the Tuna/Flounder Channel eroded down into the underlying Latrobe Group sediments and filled with predominantly marine to marginal marine sediments of the Flounder Formation. As sedimentation rates declined across the basin, the strandline moved to the northwest, depositing a thin, time-transgressive unit of glauconitic green sands (Gurnard Formation) over a wide area including the Tuna/Flounder Channel. The top of the Gurnard Formation forms the Top of Latrobe Group. In the Middle Eocene, another major channelling event, the Marlin Channel, occurred to the west of the Kipper area and partially filled with distal marine sediment of the Turrum Formation. Erosion associated with these channelling events and the top of Latrobe unconformity resulted in the formation of many of the hydrocarbon traps in the basin.

The end of the Latrobe Group is marked by deposition of marl and calcareous siltstone of the Lakes Entrance Formation in response to continued marine transgression in the Oligocene. Prograding limestone and calcareous siltstone wedges of the Gippsland Limestone resulted in the formation of the present day shelf.

Compressional events in the late Eocene to mid Miocene caused selective inversion of faults around the basin and the establishment of the major ENE-WSW anticlinal trends in the basin.

3. GEOLOGICAL DISCUSSION (CONT'D)

STRATIGRAPHY

The prognosed stratigraphy of the Scallop-1 well was based on adjacent well data (Kipper-1 and -2, East Pilchard-1, Tuna-1, Chimaera-1 and Manta-1) and regional seismic correlations.

The actual stratigraphic section intersected is shown in Figure 2. The well penetrated the expected thick sequence of limestones and marls of the Gippsland Limestone and the Lakes Entrance Formation. The Top Latrobe marker came in 14m deep to prognosis. The 4m thick Gurnard Formation overlies the Flounder Formation (*P. asperopolus* age), which was recognised with the aid of the large, regional Northern Fields 3D seismic survey extending over the western half of the Kipper area. At Scallop, the Flounder Formation is characterised by a 43m thick sequence of thinly interbedded marginal marine sands and shales. The remaining upper Latrobe Group (lower *M. diversus* - lower *L. balmei*, or K/T boundary) varies from thick shoreface sands to coastal plain shales, channel sands and coals. The lower Latrobe Group interval (upper *T. longus* (aka *F. longus*) - upper *T. lillie*) is comprised of meandering fluvial channel sands, coastal plain shales and coals and marginal marine estuarine and bayhead delta deposits.

The primary objective of the Scallop-1 well was to test the sub-volcanic hydrocarbon potential of the Golden Beach Group, the S1 reservoir. Three volcanic packages were intersected, as expected - Top Volc (shallowest), Intra Volc and First Volc (deepest) -which were expected to act as topseals for separate S1 hydrocarbon reservoirs. The top of the Top Volc volcanics was intersected 52m deep to prognosis (2613m MD), primarily due to faster velocities than expected in the Intra-Latrobe. The total thickness of Top Volc intersected was 225m thick. Volcanic lithologies encountered include volcanic flows and weathered equivalents, similar to those intersected at East Pilchard-1. Intrusive bodies feeding the flow units are also identifiable from seismic data. A series of intra-volcanic sand intervals were also intersected within this Top Volc section, one of which is oil-bearing, the other water-bearing. The top of the sub-volcanic reservoir interval came in 57m deep to prognosis. The primary S reservoir was expected to consist of sediments ranging from good quality braided fluvial to upper delta plain sands and gravels, as seen in the Kipper wells, to the lower net to gross fluvial reservoirs seen in the East Pilchard-1 well. However, the Scallop-1 well intersected poorer quality S reservoir sands, similar to those seen at East Pilchard-1, leading to the development of multiple top and base sealed reservoir systems.

The top of the second volcanic package, Intra Volc, was intersected 25m deep to prediction (2846m MD) and was 36m thick at the well (compared to the predicted 50m). The top of the sub-Intra Volc reservoir was intersected

3. GEOLOGICAL DISCUSSION (CONT'D)

11m deep to prediction (2882.5m MD). The top of the third volcanic package, First Volc, came in 57m deep to prognosis (3067m MD) and was 26m thick compared to 50m predicted. The sub-First Volc reservoir was intersected 33m deep to prediction (3093m MD). The sub-First Volc reservoir sands are the thickest hydrocarbon-bearing sands (7-11m thick) encountered by Scallop-1, although the porosity and net to gross remain low (10-13% porosity, 22% NTG).

STRUCTURE

Like the Kipper structure, the Scallop trap is a lowside fault-dependent closure (Enclosures 1, 2). The northern-bounding Scallop Fault is a long-lived major normal fault, displaying growth across it from at least *P. mawsonii* time (ie. Emperor Subgroup) through to the upper Latrobe Group. The structuring on the lowside of the fault was predominantly due to pulses of compressional deformation during the Eocene. However, there is also evidence for periods of structuring against the fault going back to at least Golden Beach Group time (as indicated by subtle isopach thinning along the fault). This may be a result of changes in the principle direction of extension from the late Cretaceous through to the Tertiary, with extension slightly oblique to fault orientation resulting in transpressional structuring on the lowside of growth faults.

Since the Scallop trap is fault-dependent, fault seal was seen as a major risk. Sand-on-sand juxtapositional relationships occur at the S-1 reservoir level along the Scallop Fault. Similar sub-volcanic reservoir juxtapositional relationships occur at East Pilchard, Manta and Gummy fields, yet all four fault-dependent traps hold significant hydrocarbon columns. Fault seal in this area appears not to be controlled by juxtapositional relationships, but more by syn-volcanic processes and subsequent cementation along fault planes.

The Scallop Fault has variable fault throw: normal down-to-the-south throw in the east decreases towards the west and eventually becomes slightly reversed. The uncertainty of the presence and extent of the fault in the west added to the risk associated with trap adequacy for both the primary sub-volcanic reservoirs as well as the secondary *T. lilliei* objective. The discovery of hydrocarbons in the sub-volcanic objective indicates the presence and sealing capacity of the fault at this level, despite small throw. However, at the *T. lilliei* level no hydrocarbons or shows were found, suggesting the absence of closure at this level.

3. GEOLOGICAL DISCUSSION (CONT'D)

HYDROCARBON DISTRIBUTION

The Scallop-1 well intersected multiple top and base sealed reservoir systems (Figures 3a and b). Importantly, it discovered oil as well as gas, reinforcing the oil potential of this sub-volcanic play. Fluid contacts were determined from log analysis and MDT pressure data interpretation (refer to Appendices 1 and 2), although a range exists for some contacts depending on the water pressure gradients assumed. Since most of the net pay sands are thin and relatively poor quality, multiple valid points do not exist in many sands. Therefore a gas gradient of 0.42psi/m and an oil gradient of 0.83psi/m were assumed, as determined from PVT analyses. A water gradient of 1.42psi/m (average Gippsland Basin water gradient) was also used. All hydrocarbon column height calculations assume the fluid phase intersected at the well is the only one present in the reservoir - *ie* no updip gas caps or downdip oil legs.

The pressure gradient of Oil Sand 1 (located within Top Volc) falls below the water gradient trend (Figure 3a) and appears relatively isolated from nearby water sands. It is unlikely the sand is drawdown since production of these sub-volcanic sands has not yet commenced in the area. A water contact is interpreted in the wellbore (2609.8m TVDSS), resulting in a potential gross hydrocarbon column of 110m from mapped crest. Oil Sand 2 (below Top Volc) is interpreted to have a water contact between 2829.4m and 2870.3m TVDSS, depending on the aquifer gradient used, leading to a potential gross oil column of 120-160m.

Gas Sands 1, 2 and 3 lie below Intra Volc and are interpreted to have gross gas columns of around 90m. The upper two gas sands gave tight pressure readings, but were included to capture the maximum volumetric potential. The gas water contacts for Gas Sands 1 and 2 are 2880.7m and 2890.3m TVDSS respectively (Figure 3a). This depth range is close to the predicted depth of the upper DHI (2874m TVDSS), once depth adjustments are taken into account. (Table 1)

Gas Sands 4, 5 and 6 lie below First Volc and are volumetrically the most significant to the Scallop discovery. The gross gas column height for each of these sands is in the order of 110m, with a 16m variation depending on the aquifer gradient used (Figure 3b). The gas water contact of Gas Sand 4 ranges between 3090.0m and 3105.7m TVDSS. The deeper of these corresponds well with the predicted depth of the lower DHI (3070m TVDSS), once the 33m depth adjustment is taken into account. (Table 1)

3. GEOLOGICAL DISCUSSION (CONT'D)

Alternatively, the DHI may be responding to the gas-water interface of Gas Sand 5, which has a minimum water contact at 3104.2m TVDSS; the maximum gas-water contact is at 3120.0m TVDSS. The water contact for Gas Sand 6 is interpreted at 3133.6m TVDSS, where the gas gradient intersects the lower of two possible water gradients. A shallower interpretation (3121.2m TVDSS) is considered less likely, since two gas pressure points fall just below this upper aquifer gradient (see Appendix 1, 2).

MDT fluid samples were sent to the lab for further analysis. Oil sample analyses indicate a GOR of 1375 scf/stb and 41.3° API gravity. Lab derived compositional analyses of Scallop-1 gas samples indicate the gas is fairly liquids-rich (33 stb/mscf) and has CO₂ concentrations of around 18% (refer Scallop-1 Well Completion Report Volume 1 Basic Data, Appendix 8).

4. GEOPHYSICAL DISCUSSION

GEOPHYSICAL DATA

The Scallop-1 prospect was identified using seismic data from the Kipper G99A 3D survey. The data was acquired in January 1999. Seismic quality on the Kipper G99A proved to be good, with much improved multiple suppression and signal-to-noise ratio compared to previous 2D and 3D data.

Six wells in the survey area were tied to the seismic data using synthetic seismograms (Kipper-1, Kipper-2, East Pilchard-1, Stonefish-1, Admiral-1 and Judith-1). In addition, wells in adjacent 3D surveys were also used to control interpretation (Tuna-1, Tuna-A18, Chimaera-1, Manta-1, Gummy-1, Basker-1 and Basker South-1).

A synthetic seismogram was created in SEISMOD using good quality sonic and VSP/checkshot data, and is displayed along with a seismic tie line in Enclosure 3.

TIME INTERPRETATION

Time interpretations were completed on important horizons including top of the Latrobe Group (TOL), Cretaceous/Tertiary flooding surface (KTFS), a marker horizon in the upper *T.lilliei* section, top and base of Golden Beach Group volcanics, and two deeper intra-reservoir volcanic flows, Intra Volc and First Volc. In addition, DHIs and intrusions were interpreted locally over the Scallop trap area.

The character of the sub-volcanic reservoir section over the Kipper 3D survey area shows that sands have relatively low impedance and shales/volcanics have relatively high impedance. These relationships aided in the interpretation of reservoir and volcanic units over the Scallop Fault block. Stratigraphically concordant, high impedance features have been tied to basaltic extrusives in the Kipper-2, Chimaera-1, Manta-1, and Gummy-1 wells and two such flows have been mapped over the Scallop area (Intra Volc and First Volc). In addition, there are also irregular, high impedance reflections which cross cut stratigraphy, which have been identified as intrusives. They form cone-shaped and irregular dyke-like features that appear to be associated with some of the early faults; they are interpreted to have been emplaced at the same time as the volcanic extrusives.

4. GEOPHYSICAL DISCUSSION (CONT'D)

DEPTH CONVERSION

Time maps were depth converted using average velocity maps generated from seismic velocities. VRMS maps were initially smoothed using a Lowess filter and a conversion factor was applied to convert these to average velocity maps. The time horizons converted were Top of Latrobe, K/T Flooding Surface, Base Volcanics/Top S1, Intra-Volc and First Volc.

PREDICTED VS ACTUAL FORMATION TOPS

Formation/ Zone	mTVDSS			mMDRT
	Predicted	Actual	Difference	
Top Lakes Entrance Fm Top Latrobe Group	-1312	-1254.1	57.9 shallow	1280.0
KTFS	-1683	-1696.7	13.7 deep	1722.6
T.lilliei marker	-2208	-2178.4	29.6 shallow	2204.3
Top Volcanics Base Volcanics/ Top S1	-2511	-2507.2	3.8 shallow	2533.1
Top Intra-volc Base Intra-volc	-2535	-2586.9	51.9 deep	2612.8
Top 1st Volcanic	-2755	-2812.1	57.1 deep	2838.0
Base 1st Volcanic	-2796	-2820.5	24.5 deep	2846.4
	-2846	-2856.6	10.6 deep	2882.5
	-2984	-3041.0	57.0 deep	3066.9
	-3034	-3067.4	33.4 deep	3093.3
TD	-3100	-3148.1		3174.0

Table 1.

FIGURES

LOCALITY MAP

STRATIGRAPHIC TABLE

PRESSURE VS DEPTH PLOT

All Reservoirs

PRESSURE VS DEPTH PLOT

Sub-First Volc Reservoirs

ENCLOSURE 1

DEPTH STRUCTURAL MAPS

ENCLOSURE 2

STRUCTURAL CROSS SECTION

ENCLOSURE 3

SYNTHETIC SEISMOGRAM

ATTACHMENT 1

COMPOSITE WELL LOG

APPENDIX 1

MDT ANALYSIS

APPENDIX 2

QUANTITATIVE FORMATION EVALUATION

APPENDIX 3

PALYNOLOGICAL ANALYSIS

APPENDIX 4
GEOCHEMISTRY