Esso Australia Pty Ltd

WELL COMPLETION REPORT
EAST PILCHARD-1
VOLUME 2
INTERPRETIVE DATA

NOVEMBER 2001

WELL COMPLETION REPORT

EAST PILCHARD 1

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INTERPRETIVE DATA

GIPPSLAND BASIN
VICTORIA

ESSO AUSTRALIA PTY LTD

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November 2001

WELL COMPLETION RPEORT
EAST PILCHARD 1

VOLUME 2:

INTEPRETATIVE DATA

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1. INTRODUCTION

The East Pilchard-1 well was drilled as a wildcat exploration well, approximately 4 km south-west of Kipper-1 (Figure 1). The well was located in 91 metres of water, within the VIC/L9 licence area of the Gippsland Basin, and was drilled to a TD of 3113m TVDss.

The well spudded on 3rd July 2001, and TD was reached on the 1st August 2001. The well was cased and suspended as a future gas producer, and the rig was released on the 13th August 2001.

The East Pilchard-1 well targeted hyrdrocarbons in the fluvial-deltaic reservoirs of the sub-volcanic Golden Beach and Emperor Subgroups (*T.lilliei – N.Senectus - T.apoxyexinus* age). A lowside fault dependent closure was mapped on the Pilchard fault block and flatspots had been identified. The primary risk for the East Pilchard-1 well was that of fault seal, and that the "flatspots" observed were related to residual gas, or lithological complications within the reservoir section.

2. SUMMARY OF WELL RESULTS

A comparison of prognosed versus actual formation tops penetrated in East Pilchard 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, however the reservoir section at East Pilchard-1 had not been intersected in its entirety in any one well.

The well intersected the sub-volcanic reservoir section 3m high to prognosis, although the sealing volcanic interval itself was approximately 60m thicker than expected. A lower than expected net to gross reservoir section was encountered, and this has resulted in multiple top and base sealed reservoir systems (referred to here as the S100, S200, S300, S400, and S500 series systems).

The well found a total of 100.7 net metres of gas in the subvolcanic reservoir section. Gas bearing sands were seen from 2592.2m-2793.0 m MD (S100 to S320 reservoirs). No clear hydrocarbon contacts were seen on the log data, with all these upper intervals being gas on rock. A series of thinner gas bearing sands (intercalated with water-bearing sands) were then intersected down to 2966.2m MD (S400 reservoirs). A thick shaley interval was then drilled from the base of the S400 series to 3023.8m MD. From this depth to TD (3138m MD) a series of thinner, lower quality gas bearing sand intervals were encountered (S500 series).

Lab derived compositional analysis for East Pilchard 1 gas samples indicate that CO2 levels in the subvolcanic reservoirs range between 11.2-22.1%, with no clearly defined trend with increasing depth.

Column heights for the various reservoir systems remain unclear, and largely depend on water gradients assumed (see attached pressure profiles, and further discussions below).

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 and Emperor Subgroups) 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 recognition that such large columns of hydrocarbon can be trapped in fault dependent closures has led to renewed interest in the Golden Beach and Emperor Subgroups (the active rift-phase successions of the Gippsland Basin).

The G99A Kipper 3D seismic survey was aquired 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 and Emperor Subgroups over much of the survey area. Initial interpretation of the G99A data resulted in recognition of flatspots and lowside fault dependent closures on several fault ramps, including the East Pilchard area. The greater Pilchard closure is largely within the VIC/L9 licence area, but a small proportion of the East Pilchard trap area does straddle the boundary with VIC/RL2 (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 (Emperor-Golden Subgroups). 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 Subgroup (eg. Kipper 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 important 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 evolved into essentially 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 Paleocene. Most of the Latrobe Group was deposited in a non-marine setting behind a NE-SW tending beach-barrier complex. As sedimentation rates declined, the strandline moved to the northwest, depositing thin Eocene-aged glauconitic green sands over a wide area (Gurnard Formation).

Two major phases of canyon cutting occurred during the Tertiary. The Early Eocene Tuna/Flounder Channel was cut and then filled with predominantly marine sediments of the Flounder Formation. The Marlin Channel was cut during the Middle Eocene and partially filled with distal marine sediment of the Turrum Formation. Erosion associated with the top of Latrobe Group 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 result 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.

STRATIGRAPHY

The prognosed stratigraphy for the East Pilchard well was based on adjacent well data (Kipper 1 and 2 wells, and Tuna-1, Tuna-A18, Chimaera-1 and Manta-1).

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 4m low to prognosis. The upper Latrobe Group (lower *M. diversus* to the basal upper *L. balmei* age) section varies from thick upper shoreface sand packages with occasional lower shoreface sands and shales in the upper section to a lower succession dominated by shales and thin sheet sands deposited in a lower delta plain environment. Some thin coals, single channel sands generally less than 5m thick, minor point bars and some crevasse splay deposits also occur within this section.

The lower Latrobe Group interval (lower *T.longus*- upper *T.lilliei)* is comprised of braided to meandering fluvial non-marine deposits and marginal marine estuarine and bayhead delta deposits. Coals are more common than in the upper Latrobe section.

The primary objective of the East Pilchard-1 well was to test the sub-volcanic oil potential of the Golden Beach and Emperor Subgroups. The top of volcanics came in 65m high to prognosis (2430m MD), and in total the volcanic section intersected was more than 160m thick. Volcanic lithologies encountered include volcanic flows and weathered equivalents, as well as an intrusive body near the TD of the well. A series of intravolcanic sand intervals (water wet) was also intersected (2520.0-2557.8m MD). The top of the subvolcanic reservoir interval came in close to prognosis (3m high 2592.2m MD). The primary S reservoir was expected to comprise a succession of good quality, high net-to-gross braided fluvial to upper delta plain sands (as seen in the Kipper wells to the north). However, the actual reservoir section intersected proved to be a lower net-to-gross fluvial package than prognosed, which accounts for the development of multiple top and base sealed reservoir systems.

STRUCTURE

Like the Kipper structure, the Pilchard trap is a lowside fault dependent closure. A long-lived major normal fault (Pilchard Fault) displays growth across it from at least *P.mawsonni* 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 to at least Golden Beach Subgroup 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.

The East Pilchard trap is fault dependent, and thus fault seal was seen as a major predrill risk. Sand-on-sand juxtapositional relationships occur at the sub-volcanic reservoir level along the Pilchard Fault, and a similar situation occurs in the Manta and Gummy area, however all three fault dependent traps have proven to contain significant hydrocarbon columns.

A final possible influence on the East Pilchard trap geometry (at least in the upper S100 and S200 levels) may be the presence of an intrusive body about half way along the East Pilchard fault ramp, which has been reflected in the depth maps for the S100 and S200 levels (Enclosure 2). The depth structure maps for these upper levels show them closing off at a deeper level than structural closure alone would allow. Whether these intrusives turn out to be the lateral trapping mechanism for postulated large gas columns in the upper reservoirs remains to be tested by any future follow up Pilchard well(s). At the very least, the intrusive body on the Pilchard fault ramp might be regarded as a "plug" of non-net beneath the volcanic topseal.

HYDROCARBON DISTRIBUTION

The East Pilchard 1 well intersected multiple top and base sealed reservoir systems (S100 series through S500 series, Figures 3a-3e). No clearly identifiable contacts can be seen from the log data (much of the lower section of the well saw gas on rock interdispersed with water wet sands).

Gas column heights in the S100 system are largely dependent on what water/aquifer gradient is assumed. Figure 3a shows that an aquifer gradient at a slightly higher pressure than the regional Latrobe aquifer gradient will result in a contact for the S100A and S100B systems around 2710m TVDSS (close to the predrill interpretation of a flatspot), giving a column height in the order of 230m. A more pessimistic interpretation of the pressure data for the S100 series would assume an interpreted contact at the LKG found in the well. Similarly, column heights for the S200 reservoirs are dependent on aquifer gradients assumed (Figure 3b).

Better constrained water gradients in the S300 and S400 series result in lower most-likely column heights (generally < 30m, Figures 3c, 3d).

The deeper S500 series reservoir intervals again have the possibility for very large column heights (Figure 3e) albeit in lower reservoir quality. If an aquifer system for the S500 reservoirs is assumed to have a slightly higher pressure than the aquifer for the S460/470 reservoirs (the deepest identifiable water wet sand in the well), then significant column heights (>300m) are possible. However, a more pessimistic interpretation of possible aquifer pressures might suggest that typical column heights maybe more similar to those in the S400 reservoirs (ie. generally < 30m).

4. GEOPHYSICAL DISCUSSION

GEOPHYSICAL DATA

The East Pilchard-1 prospect was identified using seismic data from the Kipper G99A 3D survey. The data was acquired in January 1999, and first pass interpretation had been completed by December 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.

Five wells in the survey area were tied to the seismic data using synthetic seismograms (Kipper-1, Kipper-2, 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 (Tlill_tr3), top and base of Golden Beach Subgroup volcanics, and a deeper intra-reservoir volcanic flow. In addition, flatspots and intrusions were interpreted locally over the East Pilchard trap area. The primary pre-drill risk for these flatspots was that they may be related to a residual gas column, or to lithological complications in the reservoir.

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 Pilchard Fault block. Stratigraphically concordant, high impedence features have been tied to basaltic extrusives in the Kipper-2, Chimaera-1, Manta-1, and Gummy-1 wells. In addition, there are also irregular, high impedence reflections which cross cut stratigraphy, which have been identified as intrusives. The TD of the East Pilchard 1 well was just within one of these intrusive bodies.

DEPTH CONVERSION

Depth conversion of the seismic time data utilised both seismic stacking velocities and well-based velocity data. Seismic stacking velocities were used to produce a depth conversion to the top of the Latrobe Group. A combined seismic velocity and well based mid-point depth function method was used to provide an isopach from top Latrobe to the top of the volcanics seismic marker. Interval velocities defined using seismic velocities were then used to produce an isopach which was added to the above horizons to depth convert the base of volcanics/top of S1 reservoir. This is the top of the main Kipper Field gas and oil accumulation. Below this level average velocities defined by wells were used to depth convert the top of the *P.mawsonii* section. The intra-Latrobe horizons were depth converted using a velocity volume that was constructed from all of the velocity fields described above. A selection of depth maps from throughout the subvolcanic reservoir section has been included in Enclosure 2.

FIGURES

INSERT LOCALITY MAP –

INSERT STRATIGRAPHIC TABLE

INSERT PRESSURE VS DEPTH PLOT

ENCLOSURE 1

STRUCTURAL CROSS SECTION

ENCLOSURE 2

POST DRILL DEPTH STRUCTURE MAP

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