Chapter 7 Discussion and Conclusions

7.1 Discussion

By using well OP1 that penetrated to Jurassic dolerite basement, the Longford Sub-basin seismic 2001, was calibrated to allow depth conversion. The RMS velocity used for data processing at depth was higher than implied from the well tie, but reflectors at this depth appear continuous.

The stratigraphy of the Longford Sub-basin can be divided using sequence stratigraphy principles. This approach works well in the basin where the lack of deep drill holes restricts lateral correlation. Seven Tertiary sequences have been identified within the Longford Sub-basin (Table 5.1). The movement along major faults influences the geometry of these packages. The overall uniform thickness of Tertiary sediments indicates subsidence and depositional rates remained comparable throughout basin evolution. Wedge shape geometries with package thickening towards bounding faults are expected, if episodic growth faulting had occurred (Jenyon & Goudswaard 1989).

Sequence boundaries mark changing depositional environments, depositional hiatuses and periods of tectonic instability. Sequence boundaries in the Longford Sub-basin are largely identified on the basis of onlap, and erosional truncation.

Gamma-ray logs also define sequence boundaries or break in the rock record as abrupt changes in response. Marked boundaries in OP1 correspond with sequence boundaries identified from the seismic data (figure 5.4). Logs however, allow a higher resolution breakdown of boundaries and suggest the addition of three more minor sequence boundaries within S4. Seismic character does not change dramatically on these surfaces.
Initial deposition in the basin has been dated as Palaeocene (Matthews 1983). This was restricted to the north of the western sub-basin, as indicated by the seismic and by the limited number of data holes.

The interpreted depositional environments during basin initiation are lacustrine. The interpretation is based on very high amplitude reflectors of S5 and S6, caused by rapid change in density between coal-rich layers to detrital beds.
Lake sediments are deposited through fine-grained suspended particles filtering through the water column and settling as laterally extensive layers. This is reflected in the Longford Sub-basin through extremely continuous reflections.
Lacustrine environments are calm, deep or shallow water environments. The presence of coal suggests phases of intermittent sub-aerial environments, such as peat bog, quagmires, marshland and wetlands. Direen (1995) thought it unlikely that a large standing body of water could ever exist during the basins history, due to high evaporation rates, low rainfall and prevailing weather patterns. Although climate has a profound effect on hydrological cycles, tectonics exerts a co-equal influence on lacustrine deposition (Bohacs 1999). Factors such as accommodation, drainage, sediment and water supply also determine lake formation.

If a fluvial environment dominated basin fill history, seismic reflectors are likely to appear highly truncated, similar to cross bedding observed in outcrop, reflecting river dynamics. The Parmeener Supergroup is a fluvial-marine sequence (Seymour & Calver 1995). The inability to trace reflectors over short distances is a characteristic of a fluvial deposition on seismic sections (figure 6.4).

Interpreted faults and the geometry of stratigraphic packages have helped to redefine the structural evolution of the Longford Sub-basin. The structural trend in the basin consists of NW-SE faulting synchronous with a minor NE-SW trend. These trends are consistent with those observed in the Bass Basin indicating that structurally the basins are probably related (Hill et al. 1995).

Major normal faults that dip steeply to the NE control basin development. Basin formation along these faults occurred during the Late Cretaceous to early Palaeocene. Hill (1995) recognised regional uplift during the mid-Cretaceous from fission track thermochronology of Precambrian and Mesozoic rocks near Poatina. If basin formation occurred post-Jurassic to pre-Tertiary, then evidence of Cretaceous sediments may have been stripped away.

Displacement along major faults decreases to the south (figure 6.2), possibly indicating an oblique slip sense of movement along these fault planes.
Gross consists of a western graben and eastern half-graben, separated by a small horst structure (figure 6.4). The western fault boundary is clearly recognised on up to 4 seismic sections, where Tertiary reflectors onlap the Bracknell Fault. However the opposing SW dipping faults can only be inferred on the symmetrical geometry of Tertiary sediments. The basin forming faults occur to the west of Hummocky Hills. Hummocky Hills is part of a series of tilted blocks (figure 6.5). Growth faulting along synthetic faults is interpreted from the thickening of overlying sediments.

Seismic, and especially gravity data, show a significant NE-SW structural trend (figure 6.14). This structure appears to be a zone of accommodation or transfer fault that was active during initial extension, and possibly later reactivated.

7.2 Conclusions

The most important outcomes of this study are presented following a detailed basin analysis of the area using seismic, well logs and potential field datasets.

- The stratigraphy of the Longford Sub-basin can be subdivided relatively easily from seismic stacking patterns:
    - Palaeocene coal-rich lacustrine facies (S6 and S5)
    - Early to mid Eocene lacustrine facies (S4, S3 & S2)
    - Late Eocene fluvio-lacustrine facies (S1)

- Basin infill began in the north under conditions of closely matched rates of deposition and subsidence along the Bracknell Fault. As the basin continued to fill up, sedimentation extended southward. By the Middle Eocene, deposition was occurring in both the eastern and western sub-basins that were within a large lake. A depositional hiatus occurred during the late Eocene, marked by a regional unconformity. Finally fluvial-lacustrine deposition covered the entire Longford Sub-basin.

- Major NW-SE faulting along a pre-existing fabric initiated basin formation during the Late Cretaceous-early Palaeocene. The major basin forming faults are the Bracknell Fault and newly identified Faults A and B. All these structures dip between 60^0 and 70^0 towards the NE with displacements decreasing to the south. The normal faults may also have a degree of oblique slip towards the NW.

- Gravity data indicate a NE-SW structural trend. This zone is interpreted as a transfer fault. Faults with this orientation are important in distributing stress and across major faults. Extension along the Bracknell Fault dies out to the south, and is transferred along a NE structure to Fault B. Increased extension along Fault B initiated increased deposition into the eastern sub-basin

- The gross structural form of the basin is a graben and half graben separated by a central horst. The central horst is offset along strike due to differential extension. The half-graben geometry involves a series of tilt blocks bound by growth faults.

7.3 Economic Implications and Future Work

The Longford Sub-basin contains approximately 800m of Tertiary sediments. The burial of organic material beneath such cover would not bring about catagenesis, so in the case of the Longford Sub-basin migration of hydrocarbon from underlying mature rocks is the most probable play in this environment. From this study, several potential structural traps can be identified within the Longford Sub-basin.

Structural Traps

The most obvious structural trap is the dome identified in the north of the basin. From the seismic this structure is interpreted to have formed as a result of mid to late Eocene transpression or uplift. The structure has a four-way closure with a cross section width of 2km and a height of 0.4 TWT (sec) or 300m. Although this structure is not huge in terms of its size, it does offer multiple targets. Within the dome a seismic facies change has been identified. Gas accumulations produce increased contrast (enhanced reflection) at the gas-sediment interface (Gibbons 2001). Below the contact reflections are masked, and the low amplitude reflections of the seismic facies change could be the effect of masking.

The high incident of Tertiary and pre-Tertiary faulting in the basin increases the possibility of migration paths and structural pinchouts. Faulting within the eastern sub-basin is more complex with synthetic tilt blocks ideal for hydrocarbon migration into the basin and structural traps beneath the basin. A large hydrocarbon resource has been found within tilted blocks in the Gulf of Suez (Morley 1995). The NE trending sub-basin is interpreted as a transfer zone. Transfer zones also have increased structural complexity. The economic benefits of exploring for hydrocarbons in this identified NE trending transfer zone is the reduced cost in drilling by avoiding Jurassic dolerite.

Water

The Longford Sub-basin is situated in a rain shadow, shielded from the seasonal northerly and southeasterly rains by the Wild Dog Tiers/Great Western Tiers and the Ben Lomond Range respectively. Artesian aquifers in the Longford Sub-basin, efflux at topographical level, that ranges from 220 to 170m (Matthews 1983, figure 3). Outflow of water occurs in Tertiary basalt, Tertiary sediments, Jurassic dolerite and rocks of the Parmeener Supergroup. Major northwest faults identified in the seismic data influence the position and outcropping relationships of these rocks.

Faults A, B and the Bracknell Fault (figure 6.15, 7.3) are interpreted as potential aquifer conduits. These faults strike in the same direction as major faults to the north and south indicating that they are apart of a larger NW trending fault system. The topographical higher catchments of the Macquarie Tiers south of the Longford Sub-basin would be a likely area of recharge, possibly along older Mesozoic fault lines such as the Macquarie Tiers Fault.

Future Work

Recommendations for future work are in regards to any future planned seismic data acquisition and processing of current data. The design of the seismic survey should be carefully thought through. The lack of tie lines over the Longford Sub-basin restricted correlation of specific horizon mapping. Where the lines did tie, were often areas that caused difficulties in data acquisition.

To fully understand the fault geometries, the data needs to be reprocessed, especially at depth. Experimenting with higher frequency band pass filters may increase the seismic resolution at depth. At faulted margins, where dolerite crops out, the seismic data is poor. The velocities used in processing in these areas are too low (2000msec^{-1}) and should be increased 3 fold. In the search for stratigraphic and structural hydrocarbon traps defining faults and the juxtaposition of rock unit is essential.

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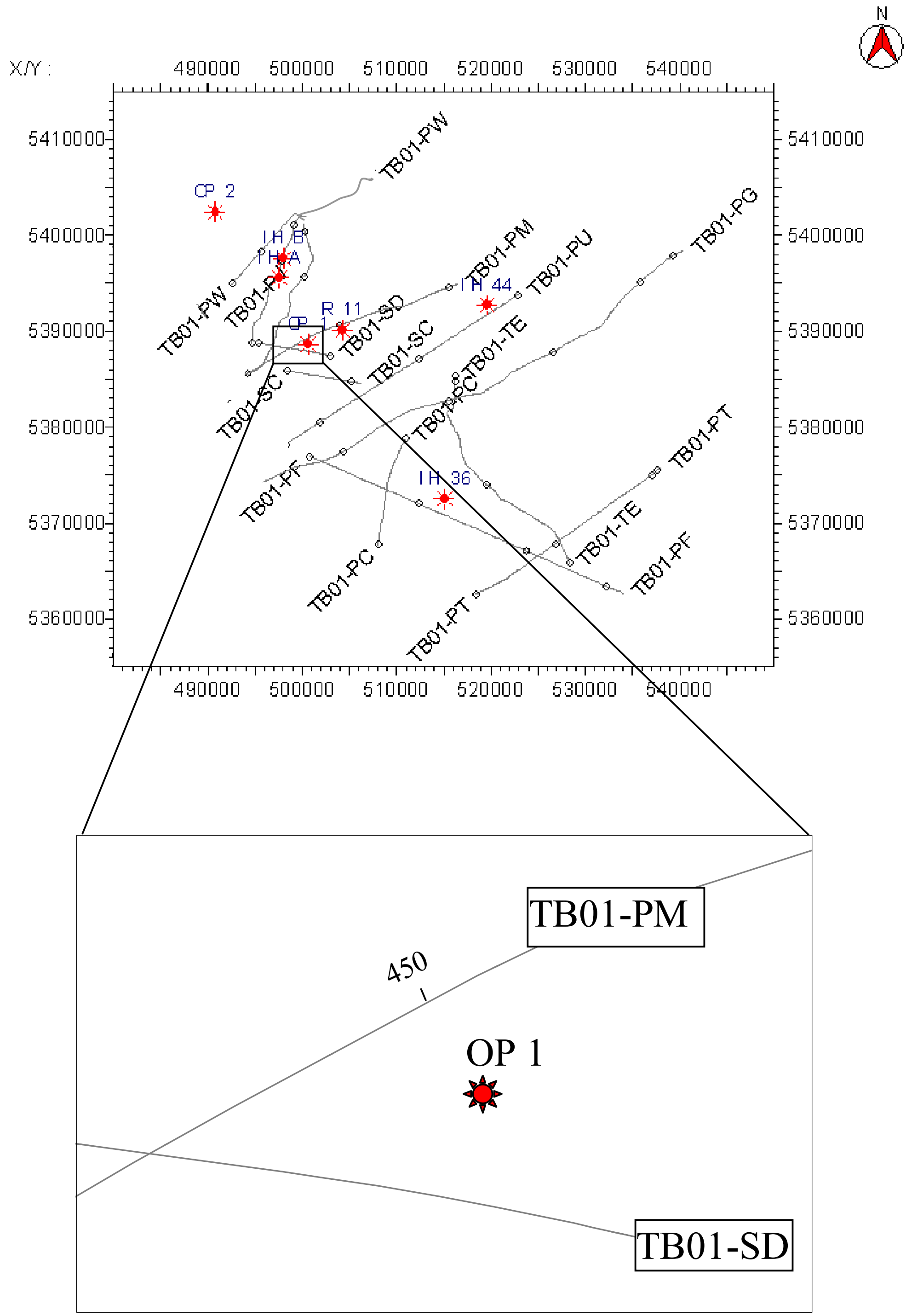
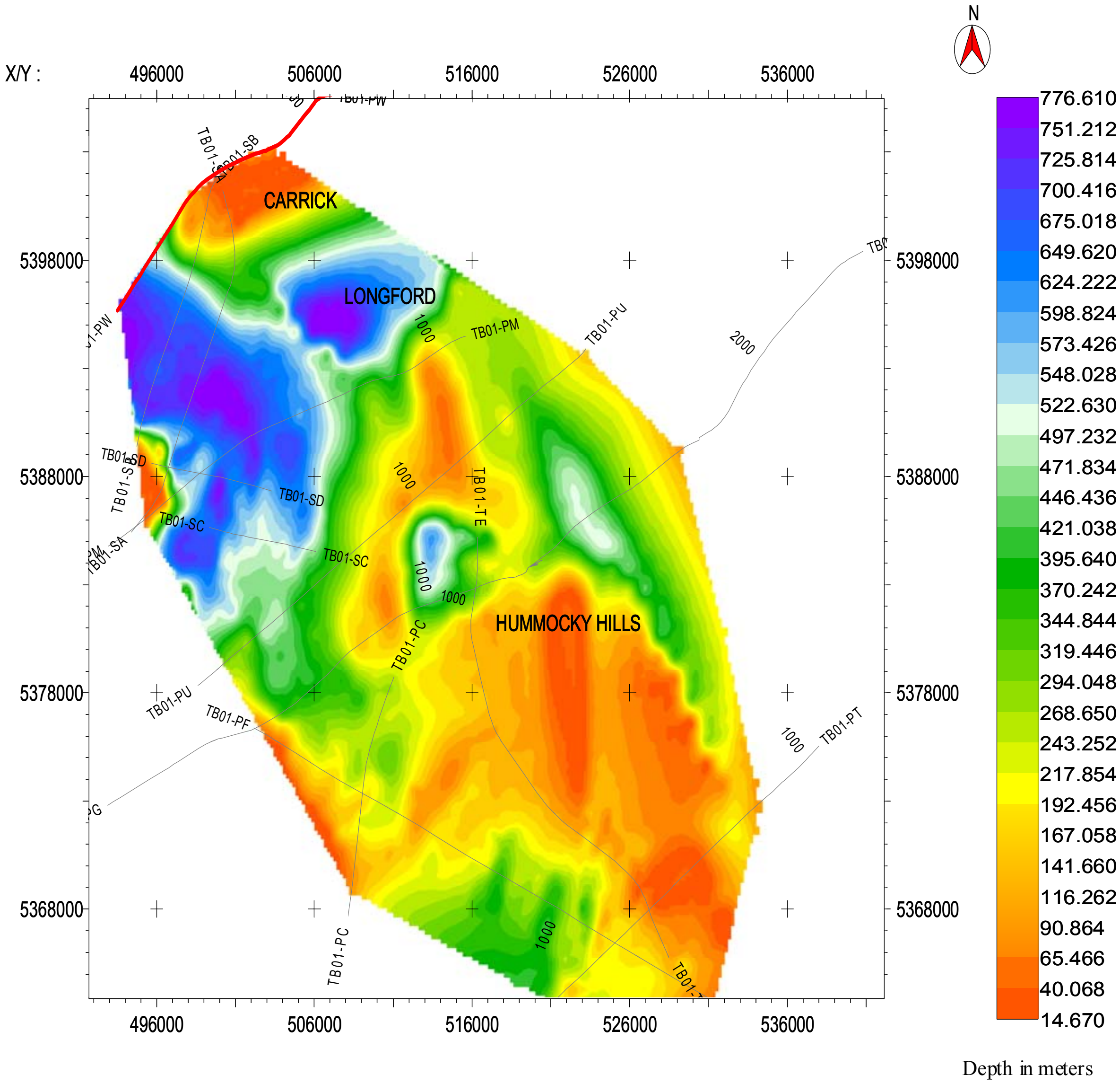
Appendix 1

APPENDIX 1



Appendix 1: Position of OP1 used in the calibration of seismic data.

Appendix 2



Appendix 2: Isopach map of the Longford Sub-basin.