EAGE

Mo PP1A 02

Geo-pressure on the Australian North West Shelf

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SUMMARY

Zones of elevated geo-pressures have been encountered throughout the Australian North West Shelf. These represent a significant drilling hazard, and are often a challenge for field development. Geo-pressure generating mechanisms can be separated into two broad categories – stress-related (e.g. compaction disequilibrium) and fluid expansion. The shallower, shale dominated sections typically exhibit compaction disequilibrium, while the overpressures in the deeper sections typically are due to fluid expansion, hydrocarbon column effects and Lateral Pressure Transfer.

A regional geo-pressure study has been carried out where overpressured zones were identified and described. In phase one 100 wells from the Carnarvon, Browse and Bonaparte Basins were analysed for both types of overpressure using traditional industry methods. In phase two compaction disequilibrium overpressure was estimated in 3D by well calibration to a high quality regional velocity model covering the entire North West Shelf.

With the analysed wells providing the framework of the study, the regional 3D geo-pressure model provides very valuable insight into the spatial distribution of the pore pressures, including how they are linked to stratigraphy, and how they are connected between the wells.

Introduction

The North West Shelf (NWS) is Australia's premier hydrocarbon province and comprises a series of sedimentary basins: the Carnarvon, Canning/Roebuck, Browse, and Bonaparte Basins. It initiated as a marginal rift with pre-rift Permo-Triassic intracratonic sediments which were subsequently overlain by Jurassic to Cainozoic syn- and post-rift successions.

Zones of elevated geo-pressures have been encountered throughout the area. These represent a significant drilling hazard and are also often a challenge for field development. Geo-pressure generating mechanisms can be divided into two broad categories – stress-related (e.g. disequilibrium compaction) and fluid expansion mechanisms.

A regional pore pressure study has been carried out with analysis of 60 wells in the Carnarvon Basin and 40 wells in the Browse and Bonaparte Basins plus a high quality 3D regional velocity model tied to 877 wells which covers the entire North West Shelf. A regional seismic interpretation from Totterdell et.al. at Geoscience Australia has been used to provide stratigraphic control.

Pore pressure analysis

Pore pressure analysis in wells can use a number of measurements and detect several types of overpressure. Analysis of velocity data away from wells can only detect compaction disequilibrium overpressure, and if we do not know the lithology it can only be detected in shales. This analysis relies on Terzaghi's effective stress principle (Terzaghi 1948), which defines the effective rock stress as the difference between the overburden pressure (vertical stress) and the pore pressure. Shales have the lowest NCT (Normal Compaction Trend velocity) of most sedimentary rocks. When we compare velocity data against the shale NCT, and we do not know what kind of lithology we have, shales with compaction disequilibrium will be identified.

Figure 1 from well Brewster 1A shows the pressure interpretation of all well data with a red line. An interpretation of shale compaction disequilibrium overpressure from the sonic log plotted in green. The two match down to about 2800m. The deeper section has a different type of overpressure which velocity data do not detect, this is considered to be due to fluid expansion, most likely hydrocarbon tgeneration.

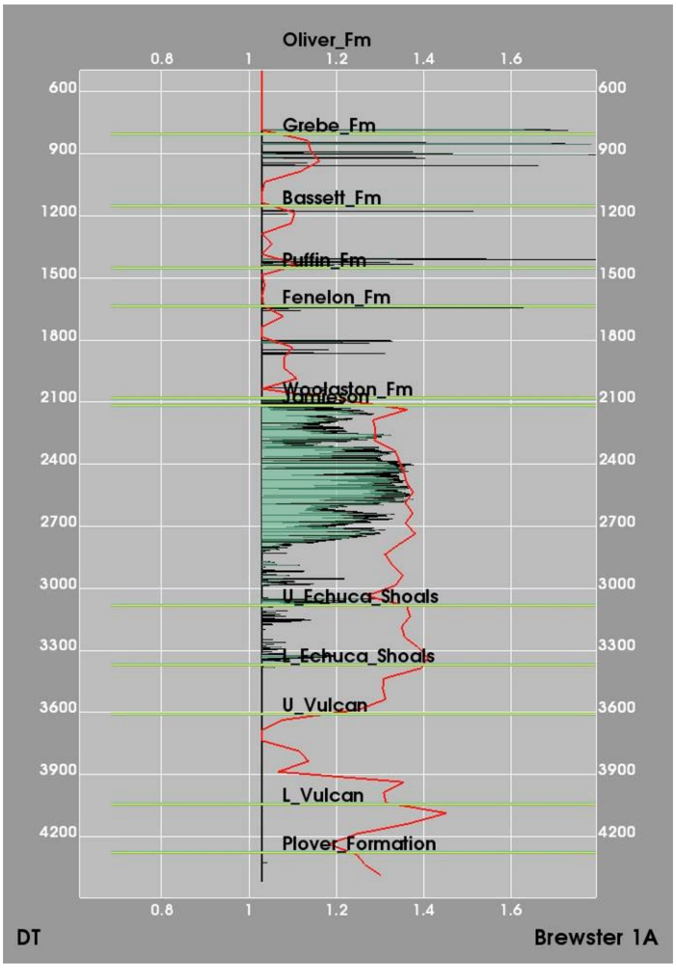

Figure 1 *Pore pressure matching plot in Brewster 1A.*

Figure 2 shows a cross-section from the 3D model through well Brewster 1A, with a lithology attribute at the top and pore pressure at the bottom. The log curve shown is the analysed pore pressure (red line in Figure 1). The 3D model gives a very good image of the distribution of compaction disequilibrium overpressure away from the well. The fluid expansion overpressure at the bottom of the well is below a regional unconformity in a reservoir section which has several large gas accumulations.

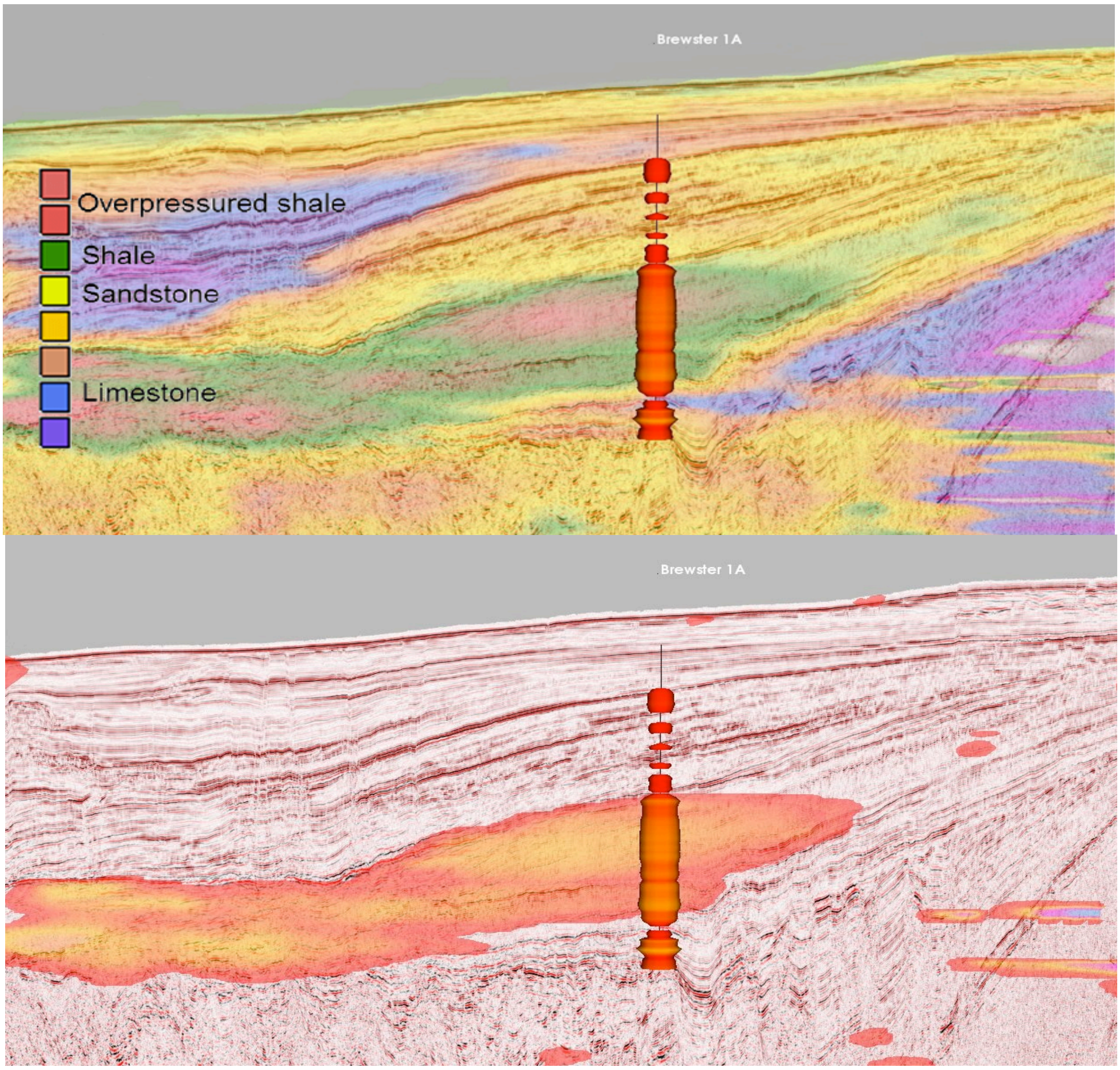

Figure 2 *Lithology and pore pressure attributes from 3D model through Brewster 1A.*

Conclusions

Regional pore pressure studies which integrate well analysis and velocity models can provide detailed insight into the nature and distribution of geo-pressure in a region. The use of a regional velocity model with limited vertical resolution but very large regional extent was a success. This type of study can be recommended as a companion to the high-resolution studies which are done for well planning.

References

Terzaghi, K. [1948]. Theoretical Soil Mechanics. Chapman and Hall, London.

Totterdell, J., Hall, L., Hashimoto, R., Owen, K. and Bradshaw, M. [2014]. Petroleum geology inventory of Australia's offshore frontier basins. *Record* 2014/09, GeoCat 79058