

The Challenge of Pore Pressure Prediction in Complex Environments – Jeanne d’Arc Basin, Eastern Canada

Sam Green (sgreen@ikonscience.com), Stephen O’Connor and Richard Swarbrick,
Ikon GeoPressure, Mountjoy Research Centre, Stockton Road, Durham, DH1 3UZ, UK

Introduction

The dominant mechanism for generating pore pressure in shales is disequilibrium compaction, the inability of fluids to escape from a compacting sediment under increasing vertical load. Disequilibrium compaction requires a constantly increasing load to inhibit fluid escape. By contrast a sand-rich sediments may have sufficient porosity/permeability to allow fluids to escape, therefore maintaining normal pressure.

Where sand-rich sequences exist the depth at which overpressure develops beneath can be much deeper than in a clay-rich sequence. The impact of deep onset of overpressure is that the rapid transition from normal pressure to high magnitudes of overpressure leads to potential drilling/well control issues, e.g. Nautilus C-92.

Recognising the existence of a pressure regime dominated by rapid transitions from normal pressure to high overpressure is very important when planning exploration wells in frontier areas. If accurate predictions of the shale pressure cannot be made then there is the chance for wells to penetrate highly overpressured sediments with a low mudweight leading to a potentially hazardous kick.

Pressure prediction in shales from wireline data is reliant on the ability to define a normal compaction trend, and deviations from this trend allow calculation of the magnitude of pore pressure. Standard practice is to calibrate the normal compaction curve to the shallowest data as these data are most likely to be normally pressured. In areas with variable clay type and particle distributions, there may be more than one normal compaction curve required to solve for pore pressure.

Case Study: Jeanne d’Arc Basin

The Jeanne d’Arc Basin (JDB) in Eastern Canada has a complex history of extension and compression, tectonic evolution and contains mixed lithologies (e.g. sand, shale, carbonate). Carbonate intervals, e.g. Rankin Formation, can have complex diagenetic histories which do not provide a relationship between porosity and pore pressure/effective stress.

There are multiple wells in the JDB that contain data (WFT, Kick, Mudweight) showing rapid pressure transitions to highly overpressured sediment. The pressure transitions are not linked to a single stratigraphic interval, therefore forecasting the depth of the onset of high overpressure difficult.

Prediction of the pore pressure in the Jeanne d’Arc Basin is further complicated by the presence of regional unconformities that are major breaks in the sedimentary sequence. The rocks above and below the unconformity will have had very different compaction histories and, as such, may need to be treated as separate intervals with the correct calibration data applied.

Conclusion

Prediction of pore pressure in the Jeanne d'Arc Basin relies not only on derivation of the normal compaction trend(s) for shales and accurate measurement of the reservoir pressure but also on a geological understanding of the depositional, structural and diagenetic history.