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Variations of fluid overpressure, sonic velocity and density in North Sea shales

The assumption that overpressured shales have higher porosities than otherwise similar, but normally pressured shales is the basis for compaction modelling in most basin modelling software. Yet, surprisingly few data sets which demonstrate this assumed relationship seem to have been presented. To the contrary, most porosity variations which have been attributed to elevated fluid pressures could equally well be caused by lithological variations within the shale units.

To avoid this ambiguity, analyses of sonic and density log responses were carried out in 81 North Sea wells. The data were analysed for each individual stratigraphic unit, thereby permitting analyses of lithology - independent log response variations among the wells. Pore pressure profiles were available throughout each well. Based on these data, correlations between overpressures and sonic velocity and shale density were sought for.

The analyses demonstrated a significant scatter of the log responses within each formation. None of the investigated stratigraphic intervals displayed relationships between log responses and fluid pressure. As these log responses should reflect the porosity of the investigated strata, it was concluded that no relationship existed between overpressures and elevated porosity in the investigated data set.

These results suggest that basin modelling of shale compaction in this area should not rely on porosity vs. effective stress relationships. The results also suggest that pore pressure detection from log responses or from seismic data can be seriously inaccurate in the North Sea and possibly also in other areas