Chemical compaction of overpressured shales

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Accurate pore pressure prediction is essential for well planning. Direct pore pressure measurements may be available from permeable reservoir formations. In mudrock sequences pore pressures can only be estimated indirectly, by empirical methods from seismic reflection data and wireline log responses.

In low temperature environments pore pressures can be estimated from porosity assuming that porosity loss is entirely mechanical and is driven by vertical effective stress according to Terzaghi's Principle. By establishing relationships between porosity and vertical effective stress for mechanically consolidated mudstones, pore pressure can be estimated from vertical stress (overburden thickness) and measured or log-inferred porosities.

In higher temperature environments, methods based on a porosity-effective stress relationship fail to deliver accurate pressure predictions. This is because in the deeper and hotter parts of basins porosity reduction continues due to chemical rather than mechanical compaction processes, and leads to underestimation of pore pressure. Temperature affects the kinetics and equilibrium of chemical processes; it causes mineral transformations, grain dissolution and cementation. The porosity-effective stress methods for estimating pore pressure must be used with extreme caution where siliciclastic or biogenic mudstones have been subjected to temperature-related mineralogical changes.

The overall objective of this project is to investigate the link between chemical compaction, the consolidation state of mudrocks and their physical properties as determined by wireline logs. We have selected three suites of samples, one from the Lower Cretaceous offshore mid-Norway, one from the Triassic of the Central Graben, North Sea and one from the Malay Basin offshore Peninsular Malaysia, all of which have undergone chemical diagenesis in a range of pore pressure environments. A set of different methodologies including XRD, SEM, EDX, SEM CL, FIB SEM, HRXTG, and MICP will be applied to describe the composition, texture and physical properties of mudstone samples. Results will allow us to test the extent to which mineralogical changes lead to porosity loss independent of pore pressure and the extent to which pore pressure signatures are retained by mudstone fabrics.

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