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Velocity and density versus depth in mudstones offshore Norway - Implications for basin modelling and seismic interpretation

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Changes in sediment density and velocity as a function of increasing burial are the result of complex compaction processes involving mechanical and chemical compaction. These compaction processes are sensitive to variations in mineralogy, textural relationship and grain size. Compaction trends expressed as density-depth and velocity-depth trends should therefore not be expected to be uniform for different lithologies. Well data from the northern North Sea have been used to study the velocity-depth and density-depth trends for sedimentary units with differences in clay mineralogy. Smectite rich mudstones of Eocene and Oligocene age have lower densities compared to mudstones consisting mostly of kaolinite and mica at the same depth. At about 2 km depth the smectite rich clays have velocities that are 300-400 m/s lower than other clays at the same depth. This is consistent with data from experimental compaction which show a low compressibility of smectitic clays. The smectite rich clays are also characterized by very low permeability. The low velocities may partly be due to reduced effective stress caused by overpressure. At burial depths less than 2 km (< 80 $^{\circ}$C) compaction of mudstones is mostly mechanical, except in carbonate cemented intervals where the density and velocity is very much higher. In the log data from the Upper Mesozoic and Cenozoic mudstones the minimum velocity and density curve is mainly the result of mechanical compaction since the minerals are stable. A statistical analysis was applied to the well log data to find compaction trends for different lithologies based on minimum sonic velocities and densities. At greater depth with increasing temperature (2.0 - 2.5 km) a significant increase in density and velocity is observed. This probably reflects the onset of chemical compaction, which includes dissolution of smectite and the precipitation of illite and quartz cement. The

velocity-depth trends are the result of both the progressive compaction processes in each lithology and the change in lithology as a function of depth. Using the North Sea well database, we can compare the compaction trends for the same stratigraphical interval and lithology buried to different depths. This gives additional information that assists the interpretation of seismic data, and provides a more exact basis for basin modelling than using general average velocity and density trends.