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Laboratory simulation for mechanical compaction and velocity distribution in Cenozoic sediments of the North Sea

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The velocity distributions recorded from well logs in sedimentary basins provide important information about mechanical and chemical compaction as well as pore pressure. The published velocity-depth curves from well logs from the Cenozoic sediments of the North Sea have shown two distinct velocity trends (Thyberg et al. 2000; Storvoll et al. in press). The sharp increasing trend of velocity with increasing depth has been observed for Plio-Pleistocene (PP) sediments, whereas the velocity distribution remains nearly constant or even sub-vertical for Eocene-Oligocene-Miocene (EOM) sediments. The abnormal variation of velocity distributions from PP to EOM sediments may be influenced by the compaction behavior of individual clay minerals present in Cenozoic sediments. The PP sediments consist predominantly of marine sands and shales with glaciomarine sediments towards the top. The clay minerals present in this sequence are mainly chlorite, illite, kaolinite and a minor amount of smectite. On the other hand, the Eocene-Oligocene sequence is primarily consisting of smectitic mudstone with some thin silt, sand and dolomite layers (Deegan and Scull, 1977), where smectite is the major component in the clay fraction. A pronounced upward shift in the mineralogical composition occurs in Miocene where chlorite increases up-section, concomitant with a reduction in the concentration of smectite (Thyberg et al. 2000). Laboratory measurements were carried out for mechanical compaction and measuring the acoustic velocity to explain abnormal velocity variations of Cenozoic sediments. Experimental compaction of a glaciomarine clay specimen show similar trend of velocity development and porosity reduction as PP sediments with increasing stress. Laboratory measurements of brine saturated smectitic clay-representatives of EOM sediments-have also shown increasing velocity trend

with increasing effective stress. To maintain proper drained condition, a very slow rate of compaction (12 days) was applied during experimental compaction of smectite. The velocities observed within the compacting smectitic clays at 10 to 20 MPa effective stresses are 1.6 to 1.7 km/s. These values are lower than the values observed from the well logs for EOM sediments which are in between 1.8 to 2.1 km/s at depth 1.0 to 2.0 km. From experimental compaction, it can be concluded that the glaciomarine clays which are representative of the Plio-Pleistocene sequence is compacted more readily than the underlying Eocene-Oligocene-Miocene sequence. The velocities observed in the well logs from EOM sequence are however somewhat higher than the experimental result and that may be due to the difference in composition and effects of cementation of EOM sediments.

References

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