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Seismic architecture of the Chalk Group from onshore reflection data in eastern Denmark

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The Upper Cretaceous-Danian chalk is well exposed in the 14 km long coastal cliff of Stevns Klint (eastern Denmark). The cliff is a world renowned for its spectacular exposure of the Cretaceous-Palaeogene boundary. Based on regional geological knowledge of the field and cores, the characteristics of the Chalk Group have been well constrained. Distinct sedimentary facies have been encountered; the sedimentology, the biostratigraphy, the diagenesis and the reservoir properties have been thoroughly investigated and reported. Stimulated by the intensive geological research, the field studies have been completed with the acquisition of an extensive set of subsurface data. The data include high resolution 2D multichannel seismics onshore and offshore, a seismic refraction profile, two entirely cored boreholes including wireline logs, GPR cross-hole tomography, thermographic analysis, etc. We intend to compile and merge the geological and geophysical datasets to investigate the variation of the Chalk Group properties and their signature in the subsurface.

In this communication, the seismic reflection data are being analysed. Very high resolution litho-, bio- and cyclostratigraphy can be correlated with the seismic stratigraphy. Several seismic facies are identified in the Chalk Group: the 'transparent' (white chalk), the stratified (marl-chalk alternations), the crudely stratified (flint-rich chalk) and the hummocky (bryozoan mounds). The units notably vary in thickness at a relatively small scale. The variations confirm the complex shelf organisation which was highly influenced by bottom currents. In addition to the stratigraphic observations, peculiar deformation structures can be recognised. The area has been supposedly tectonically stable since deposition as the coastal cliff lacks fault offset but the succession has been uplifted of c. 1 km. The main fracture patterns are associated with the recent unloading of the ice, opening shallow horizontal fractures. Subvertical fracturation affects also the Chalk and contribute to most of the permeability. Observation of the seismic reflection profiles shows intensive fracturing association with local folds and offsets of reflections reaching 20 metres. The seismic signal is particularly damaged by swarms of fractures which resemble flower structures or polygonal fracture networks. Even if some of the fracture swarms seem to reach the Earth's surface, most of the deformations appear to be restricted to the white chalk, whereas the stratified seismic facies are comparatively less disturbed. The origin of the structures observed in the white chalk can either be associated with the regional stress field or with differential diagenetic evolution between strata inducing anisotropic volume changes.

Prediction of the chalk mechanical properties from seismic reflection data is challenging but essential. We believe that improvement in linking lithofacies, fossil content, fracturation regime and diagenesis will improve our general comprehension of the Chalk Sea system but also enhance the accuracy of the geophysical imaging.