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Geostatistical inference and stochastic inversion of near-surface wide angle seismic data conditioned to well-log and reflection seismic data

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Chalk Group rocks constitute reservoirs to a large part of the Danish North Sea oil reservoirs. In the North Sea the Upper Cretaceous Chalk Group is buried at relatively large depths, and therefore it is difficult and expensive to investigate high resolution details of the lithological variations of the Chalk Group rocks in the North Sea. At Stevns, Southern Sjælland, Denmark, the Chalk Group section has been investigated with near-surface refraction/wide-angle reflection seismic data in order to study the seismic velocity variation of the Chalk Group. The refraction/wide-angle reflection seismic data have been collected along a 7.5 km long N–S trending profile and a P-wave velocity model of the Chalk Group has been established along this profile. Two boreholes have been drilled and logged near the northern and southern end points of the seismic line. We present a study in which we perform geostatistical analysis of the available borehole and reflection seismic data. From a statistical analysis of two velocity well logs we can identify four distinct chalk sections. For each section we can determine a vertical 1D trend model as well as a 1D vertical covariance model. The same four sections are found in both well logs. From a coincident seismic reflection profile, we infer the horizontal correlation length of the velocity section. The reflection seismic profile indicates a close to horizontal layering in some intervals. Thus, from these data sets we can set up a model of the subsurface velocity structure at Stevns as a four-layer model with each layer having a distinct 2D covariance model and trend model. We make use of the deterministic velocity model obtained by inverting the travel travel time data to parameterize the non-linear inversion of the first arrival refraction data. We parameterize the inverse problem as a four-layer model. For each layer, we assume that the variability can be described by the prior covariance found from the well log and reflection seismic data. The deterministic velocity model is used as a starting model. We then perform nonlinear inversion of the wide angle first arrival time data conditioned to the well log data. This procedure enables us to generate a number of realizations of the posterior probability density function, conditioned to the geostatistical information extracted from the borehole data and the reflection seismic profile. In the future we hope that the geostatistical models inferred from the Stevns data can help identifying similar Chalk Group units in seismic sections from the Danish North Sea.