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Porosity Prediction from Shallow Subsurface Seismic Investigation - A Rock Physical Model Approach

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Summary

In this paper, we present a rock physical model to estimate the porosity from the seismic velocities and compare it with existing rock physical models. A parameter sensitivity analysis is also conducted and the various models are validated with lab data. We also propose a workflow to predict the porosity from seismic velocities at field scale and apply it to a case study.

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All engineering and development projects require reliable ground models that are used to characterize the soil conditions and address potential Geohazards (e.g., excess pore pressure, landslide areas, spatial variability in soil conditions). Whereas many of the ground models are qualitative, there is a tendency towards establishing quantitative ground models, i.e., models at which the various soil properties can be determined within a certain range.

Several approaches exist to populate geological models with soil properties, like geostatistic methods, geophysically-guided geostatistics, machine learning and empirical correlations. Porosity is one key parameter, and obtaining detailed knowledge of the porosity further allows determining additional geotechnical and physical properties. In order to do so, we need to have a suitable soil physical model that relates the physical properties (essentially P- and S-wave velocities) to the porosity.

For this paper, we used various rock (or soil) physical models (e.g., Wood, Gassmann, Foti, and in-house Madshus model) that allows determining the porosity from seismic velocities from the shallow sub-surface, and compared the validity of the porosity predictions from the different models. We also investigated the sensitivity of each of the key parameters (e.g., P- and S-wave velocities, density, lithology) through a parameter sensitivity analysis for every model. We further validated the different models using laboratory data measurements as well as empirical correlations. Finally, we present a workflow to estimate the porosity from seismic velocities at field scale and apply it to a case study, the Holland Kust Zuid offshore windfarm in the southern North Sea where we have access to geophysical data (P-wave reflection) as well as geotechnical data (including seismic CPTU).

The proposed workflow is scalable depending on the available field data. As a minimum, field data should include high-resolution seismic and few geotechnical borehole for calibration. Optionally, high-resolution and multi-components 2D seismic data would make the workflow more robust and reliable.