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Porosity estimation and characterization of a geothermal carbonate reservoir in the South German Molasse Basin based on seismic inversion and attribute analysis

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The Molasse Basin is one of the most promising areas for deep geothermal exploration in Germany and a very ambitious project in this region is to power the entire district heating system of the city of Munich with renewable energies by 2040; a major part of this will consist of geothermal energy. As part of a joint project (financed by the German Federal Ministry For Economic Affairs And Energy; FKZ 0324332B) the Leibniz Institute for Applied Geophysics (LIAG) works together with the Munich City Utilities (Stadtwerke München), to improve reservoir characterization and sustainable reservoir exploration within the German Molasse Basin. The target horizon for hydrothermal exploration is the aquifer in the Upper Jurassic carbonates. A major problem is the strong heterogeneity of the carbonates. Compared to quantity and quality of the structural data of the reservoir, the database of reservoir properties such as density, porosity and permeability, which describe the geothermal potential, is insufficient. Therefore, it is necessary to generate such data in order to improve the value of the structural information. A 3D seismic survey cannot only provide structural information, but also important reservoir properties such as elastic parameters and seismic attributes. One of the most important attributes is the acoustic impedance, which can be determined with a seismic inversion and used to estimate a porosity volume.

The data basis for this study was the 170km² GRAME-3D seismic survey measured in Munich, a structural geological model, and drilling and logging data from the geothermal site “Schäftlarnstraße”.

The inversion results show low impedance values at the top of the reservoir, but also at the middle part. Spatially, the intermediate block of the Munich fault shows low values but also the eastern part of the hanging wall block and the western part of the footwall block. Based on a well correlation a relationship between acoustic impedance and porosity could be determined and a 3D porosity volume was calculated. In the upper part but also in the middle part of the reservoir areas with increased porosity (>10%) are shown, which might indicate a high geothermal potential.

For a better classification, an attribute analysis was performed. The intermediate block and the eastern part of the hanging wall block show strongly fractured rocks. In contrast, there are hardly any conspicuous features in the western part of the footwall block, although high porosities are

also expected here. This suggests that the presence of faults is not the only factor favoring high porosities in carbonates. More likely is a combination with karstification processes, which is why even areas that do not show enhanced tectonic deformation have high porosities.