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The geothermal energy potential in Denmark - updating the database and new structural and thermal models

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Knowledge of structural, hydraulic and thermal conditions of the subsurface is fundamental for the planning and use of hydrothermal energy. In the framework of a project under the Danish Research program 'Sustainable Energy and Environment' funded by the 'Danish Agency for Science, Technology and Innovation', fundamental geological and geophysical information of importance for the utilization of geothermal energy in Denmark was compiled, analyzed and re-interpreted. A 3D geological model was constructed and used as structural basis for the development of a national subsurface temperature model. In that frame, all available reflection seismic data were interpreted, quality controlled and integrated to improve the regional structural understanding. The analyses and interpretation of available relevant data (i.e. old and new seismic profiles, core and well-log data, literature data) and a new time-depth conversion allowed a consistent correlation of seismic surfaces for whole Denmark and across tectonic features. On this basis, new topologically consistent depth and thickness maps for 16 geological units from the top pre-Zechstein to the surface were drawn. A new 3D structural geological model was developed with special emphasis on potential geothermal reservoirs.

The interpretation of petrophysical data (core data and well-logs) allows to evaluate the hydraulic and thermal properties of potential geothermal reservoirs and to develop a parameterized numerical 3D conductive subsurface temperature model. Reservoir properties and quality were estimated by integrating petrography and diagenesis studies with porosity-permeability data. Detailed interpretation of the reservoir quality of the geological formations was made by estimating net reservoir sandstone thickness based on well-log analysis, determination of mineralogy including sediment provenance analysis, and burial history data.

New local surface heat-flow values (range: 64–84 mW/m^2) were determined for the Danish Basin and predicted temperatures were calibrated and validated by borehole temperature observations. Finally, new temperature maps for major geological reservoir formations (Frederikshavn, Haldager Sand, Gassum and Bunter Sandstone/Skagerrak formations) and selected constant depth intervals (1 km, 2 km, etc.) were compiled.

In the future, geothermal energy is likely to be a key component in Denmark's supply of energy and integrated into the district heating infrastructures. A new 3-year project (GEOTHERM) under the Innovation Fund Denmark will focus on addressing and removing remaining geological, technical and commercial obstacles. The presented 3D geothermal model will be an important component in more precise assessments of the geothermal resource, production capacity and thermal lifecycle.