Geophysical Research Abstracts
Vol. 18, EGU2016-15219, 2016
EGU General Assembly 2016

Updating the thermo-mechanical structure of the European lithosphere with subsurface temperature data

Jon Limberger (1), Jan-Diederik van Wees (1,2), Magdala Tesauro (1), Damien Bonté (1), Lindsay Lipsey (1,2), Jeroen Smit (1), Fred Beekman (1), and Sierd Cloetingh (1)

(1) Utrecht University, Earth Sciences, Utrecht, Netherlands (j.limberger@uu.nl), (2) TNO – Geological Survey of the Netherlands, Utrecht, the Netherlands

As part of the EU FP7-funded Integrated Methods for Advanced Geothermal Exploration (IMAGE) project we developed a methodology to obtain an improved, physics-based thermal model of the European lithosphere. On the basis of geophysical data, the model is divided into a four layer geometry consisting of sediments, upper crust, lower crust and lithospheric mantle. The horizontal resolution is 10 by 10 km, while the vertical one is 250 m. The prior steady-state temperature distribution is calculated using vertical heat flow only. imposing as boundary conditions fixed temperatures at the surface and at the base of the lithosphere, respectively. Thermal properties, including radiogenic heat production and temperature- and pressure-dependent bulk thermal conductivity, are assigned on the base of the broad-scale lithological variation within the European crust.

Further improvements of the thermal model, aiming at consistency between temperatures and heat flow observations and tectonic model predictions, are obtained by applying data assimilation. An Ensemble Kalman Filter (EnKF) is used to assimilate temperature data and improve the prior estimates of the thermal properties and the thermal field. One of the advantages of EnKF is that multiple model realisations yield uncertainties for both the thermal properties and the thermal field. Borehole temperature data are directly used for this procedure, when publically available. Regional thermal models - originally based on borehole data - are used for areas lacking any (public) borehole temperature data. A larger error is assigned to the temperature values derived from these models, in order to account for the higher uncertainty compared to direct-measured temperatures.

The thermal model is also used together with compositional data to estimate the integrated strength of the lithosphere. The result is an updated thermo-mechanical model of the European lithosphere with estimated uncertainties for the thermal properties and the thermal field. The new thermal model allows to better explain the observed temperature variations within the upper crust (including the sedimentary basins) and to assess the effect of differences in lithosphere structure, thermal properties, convective fluid flow and tectonic processes. The mechanical model is a starting point for modelling the (local) stress field, which is important for the drilling and operation of geothermal wells. Identification of key processes and properties at multiple scales together with quantification of model uncertainty will help to reduce the risks for geothermal exploration.