Geophysical Research Abstracts
Vol. 15, EGU2013-11246, 2013
EGU General Assembly 2013

3D geomechanical-numerical modelling of the absolute stress state for geothermal reservoir exploration

Karsten Reiter (a), Oliver Heidbach (a), and Inga Moeck (b)

(a) German Research Centre For Geosciences GFZ, Helmholtz Centre Potsdam, Telegrafenberg, 14473 Potsdam, Germany,
(b) Department of Earth and Atmospheric Sciences, University of Alberta, 1-26 Earth Sciences Building, Edmonton, AB T6G 2E3, Canada

For the assessment and exploration of a potential geothermal reservoir, the contemporary in-situ stress is of key importance in terms of well stability and orientation of possible fluid pathways. However, available data, e.g. Heidbach et al. (2009) or Zang et al. (2012), deliver only point wise information of parts of the six independent components of the stress tensor. Moreover most measurements of the stress orientation and magnitude are done for hydrocarbon industry obvious in shallow depth. Interpolation across long distances or extrapolation into depth is unfavourable, because this would ignore structural features, inhomogeneity's in the crust or other local effects like topography. For this reasons geomechanical numerical modelling is the favourable method to quantify orientations and magnitudes of the 3D stress field for a geothermal reservoir.

A geomechanical-numerical modelling, estimating the 3D absolute stress state, requires the initial stress state as model constraints. But in-situ stress measurements within or close by a potential reservoir are rare. For that reason a larger regional geomechanical-numerical model is necessary, which derive boundary conditions for the wanted local reservoir model. Such a large scale model has to be tested against in-situ stress measurements, orientations and magnitudes. Other suitable and available data, like GPS measurements or fault slip rates are useful to constrain kinematic boundary conditions. This stepwise approach from regional to local scale takes all stress field factors into account, from first over second up to third order.

As an example we present a large scale crustal and upper mantle 3D-geomechanical-numerical model of the Alberta Basin and the surroundings, which is constructed to describe continuously the full stress tensor. In-situ stress measurements are the most likely data, because they deliver the most direct information's of the stress field and they provide insights into different depths, a major benefit compared to surface information's. For this study, a very dense distributed dataset is available from the Alberta Basin and surrounding. The data base contains data from leak-off tests and hydro-fracturing, contributing minimum principal stress values, as well vertical principal stress values and qualitative values from borehole breakouts.

A new work flow will be tested during this study, from the generation of the geometrical model via geological modelling software gOcad, allowing incorporation of a great variety of geological and geophysical data. After the geometry construction, the model is discretized into finite elements with HyperMesh; solving of the numerical problem with Abaqus. Finally the visualization tool Tecplot allows directly comparison between model outcome and measured data. This workflow has little restrictions, related to variously input data, resolution, comparison methods, and possibilities of data output and transfer.

References:

Heidbach, O., Tingay, M., Barth, A., Reinecker, J., Kurfeß, D., & Müller, B. (2009). The World Stress Map Based on the Database Release 2008, equatorial scale 1:46,000,000. Geochemistry Geophysics Geosystems (Vol. 4, p. 1). doi:10.1594/GFZ.WSM.Map2009

Zang, A., Stephansson, O., Heidbach, O., & Janouschkowetz, S. (2012). World Stress Map Database as a Resource of Rock Mechanics and Rock Engineering. Geotechnical and Geological Engineering, 22. doi:10.1007/s10706-012-9505-6