Forward Induced Seismic Hazard Assessment – FISHA
Application to the Synthetic Seismicity Catalogue by Discrete Element Fluid Injection Modeling

Amir Hossein Hakimhashemi, Jeoung Seok Yoon, Arno Zang, Oliver Heidbach, Gotfried Grünthal, GFZ Potsdam

The Forward Induced Seismic Hazard Assessment – FISHA (Hakimhashemi et al. 2014a,b) is a general workflow which links the output of hydromechanical-numerical models of geothermal reservoirs, either in terms of seismicity catalogue (Hakimhashemi et al. 2014a) or in the form of spatiotemporal changes in the stress field (Hakimhashemi et al. 2014b), to a time-dependent probabilistic seismic hazard assessment in terms of the time dependent occurrence rate of the Seismic Events of Economic Concern – SEECo. SEECo refer to the seismic events of low to moderate magnitudes which may not be destructive but can cause economic losses due to damage to the infrastructure (see also Grünthal, 2014). Therefore, the FISHA has the capability to a priori test different stimulation/production strategies and to develop a priori knowledge about how the reservoir should be treated to mitigate the risks associated with SEECo.

This study tests the FISHA using the outputs of the fluid injection modeling, in the form of synthetic seismicity catalogue. Fluid injection modeling used in this study is prepared by Particle Flow Code 2D (PFC2D, Itasca). Fluid injection modeling is done on a granitic geothermal reservoir with an inclined through-going fault zone and subjected to different stress regimes (Yoon et al. poster presented in the workshop). For all modeling cases tested synthetic seismicity catalogues are produced and analyzed by the FISHA concept. The synthetic catalogues include the occurrence time, the coordinated hypocenter as well as the moment magnitude for the events. These are used to calibrate the magnitude completeness Mc, as well as the parameters of the frequency-magnitude relation, i.e. a and b. Using these parameters, time dependent occurrence rate of SEECo is computed for different modeling cases and prediction/assessment on the potential risks associated with occurrence of SEECo are addressed. Finally the results according to different scenarios are analyzed and compared in order to assess in which geological and operational settings the risks associated with SEECo would be the highest.

References:

Grünthal, G. (2014): Induced seismicity related to geothermal projects versus natural tectonic earthquakes and other types of induced seismic events in Central Europe. Geothermics, 52, p. 22-35.

Hakimhashemi A., Yoon J.-S., Heidbach O., Zang A., Grünthal G. (2014a): Forward induced seismic hazard assessment: application to a synthetic seismicity catalogue from hydraulic stimulation modelling. Journal of Seismology, 18, 3, p. 671-680.

Hakimhashemi A., Schoenball M., Heidbach O., Zang A., Grünthal G. (2014b): Forward modelling of seismicity rate changes in georeservoirs with a hybrid geomechanical–statistical prototype model. - Geothermics, 52, p. 185-194.