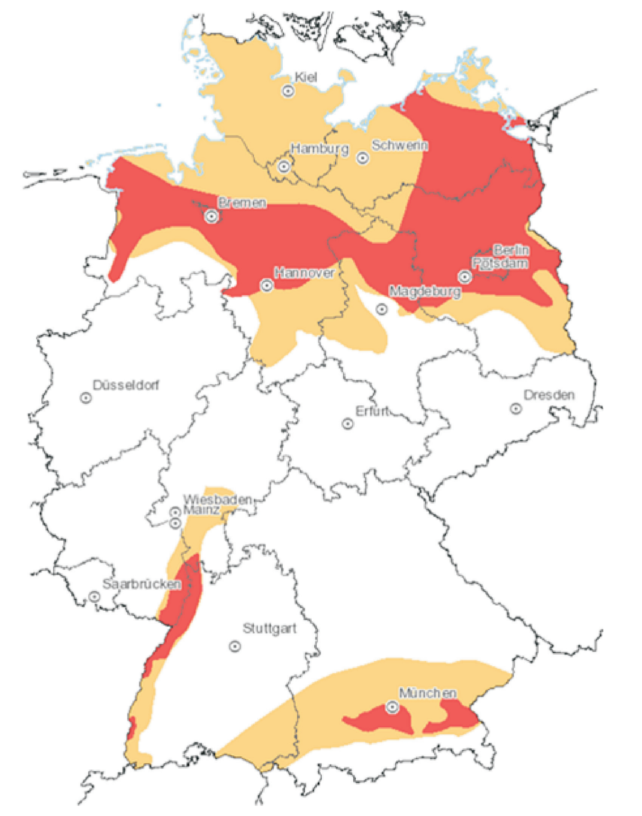
MAGS - Microseismic Activity of Geothermal Systems

M. Vasterling[1], U. Wegler[1], C. Bönnemann[1], M. Bischoff[1], J. Ritter[2], J. Groos[2], J. Wassermann[3], T. Megies[3], T. Spies[1], J. Schlittenhardt[1], J. Kopera[1], S. Shapiro[4], C. Dinske[4], C. Langenbruch[4], M. Hou[5], T. Kracke[5], H. Konietzky[6], R. Mittag[6]

[1] Bundesanstalt für Geowissenschaften und Rohstoffe, [2] Karlsruher Institut für Technologien, [3] Ludwig-Maximilians-Universtät München, [4] Freie Universität Berlin, [5] Technische Universität Clausthal / Energie-Forschungszentrum Niedersachsen, [6] Technische Universität Bergakademie Freiberg

Geothermal Energy in Germany

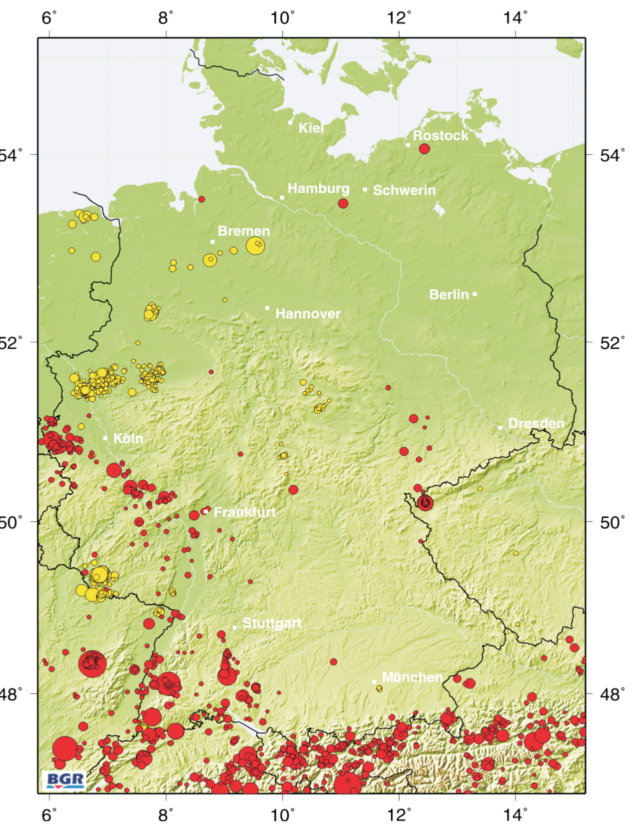


The utilisation of deep geothermal energy can contribute to climate protection and enable for a future-proof sustainable power supply as it does not depend on seasonal or climate conditions and is available everywhere.

The highest potential for hydorthermal application in Germany show the North German Basin, the South German (Bavarian) Molasse Basin and the Upper Rhine Graben (Fig. 1). Here, several plants are operating and further are planned.

***Fig. 1** Potential for hydrothermal energy in Germany. Orange: aquifer temperature 60°C; red: aquifer temperature 100°C. (Schulz et al., 2007)*

Seismicity



Seismicity caused by anthropogenic activities like mining or frac operations is called induced seismicity (Fig. 2), whereas natural seismicity is caused by teconic stress.

In general, seismic events that occure during reservoir stimulation, are not felt. However, they play an important role in reservoir characterization. Due to recent events of magnitude M_L <= 3.4 (Häring et al., 2008) discussions arouse regarding seismic hazard in context with geothermal power generation.

***Fig. 2** Tectonic (red) and possibly induced seismicity (yellow) in Germany since 2000 (BGR catalogue)*

Project Aims

- Development of concepts for limiting microseismic activity when utilising deep geothermal systems for energy production
- Gaining improved knowledge of the processes, causing fluid induced seismic events
- Cooperation with industry and authorities for safe deep geothermal energy production

Analysis of Seismicity

Aim of EP1 is the improvement of the seismological data pool in the Südpfalz by conducting real time registration in the vicinity of geothermal power plants (Fig. 3). Detailed analyses of the seismically activated volume in the Landau area are performed.

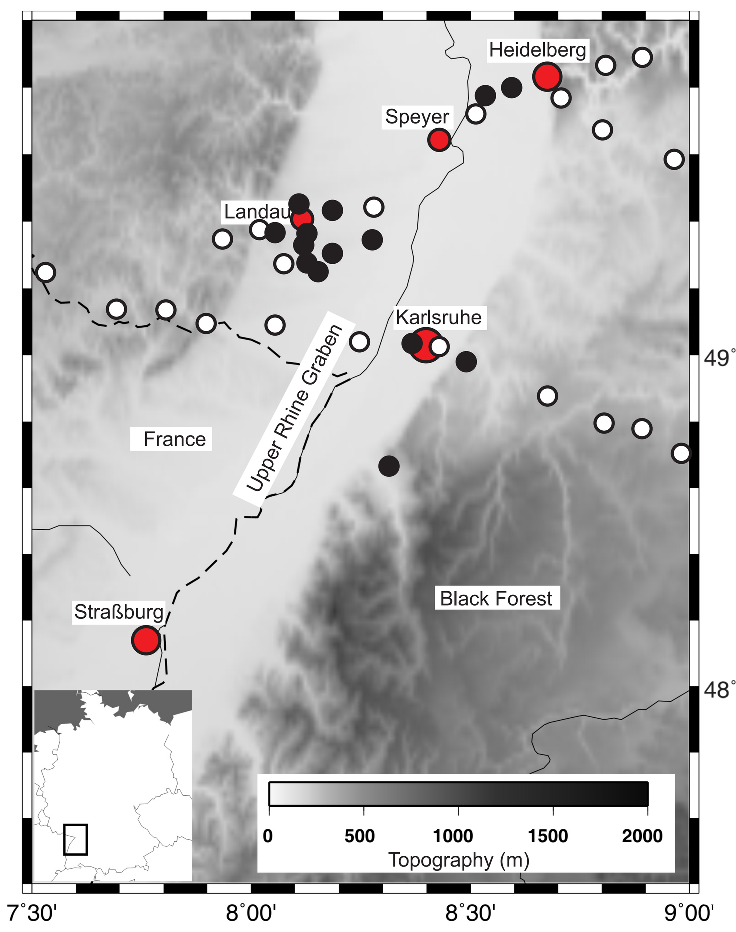


***Fig. 3** Seismologic stations at the Südpfalz black: TIMO2 (recent), white: TIMO (2004 - 2006)*

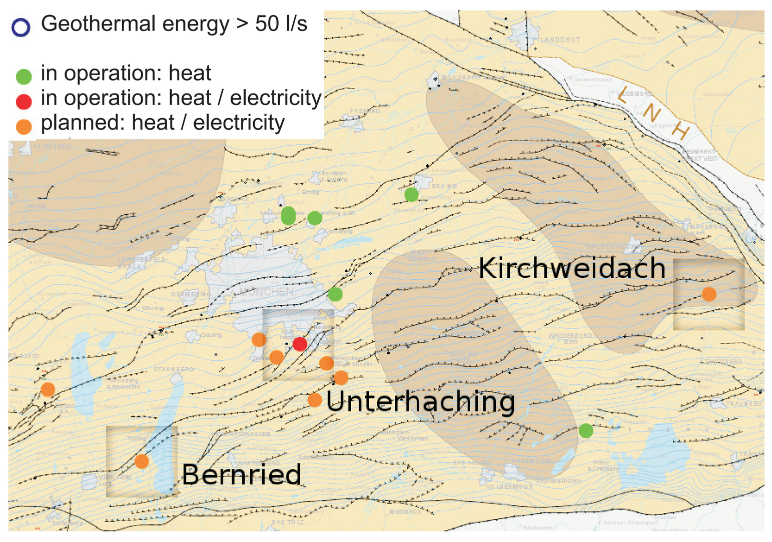
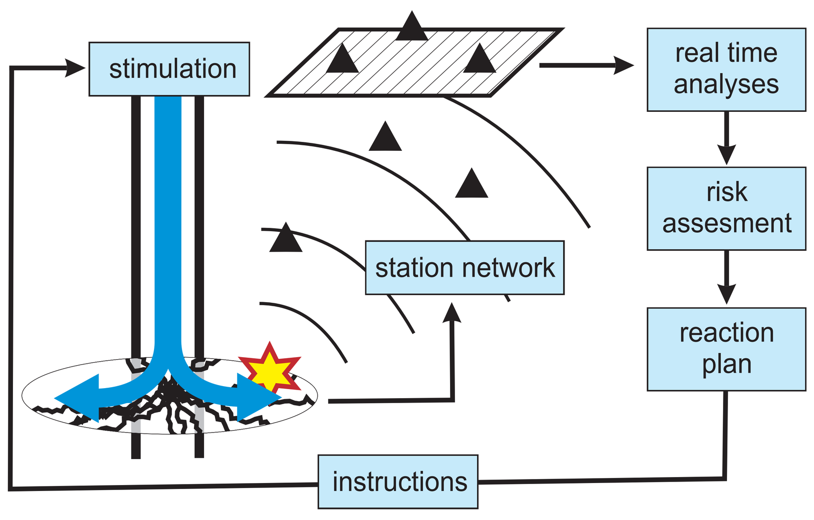


***Fig. 4** Locations of geothermal power plants and faults in Malm (modified from Bayerisches Landesamt für Umwelt, 2008)*

Within EP2 the occurence of microseismicity associated with geothermal utilisation of hydrothermal aquifers is analysed. Seismological networks are installed at locations of geothermal power plants within the Bavarian Molasse (Fig. 4) even bevor the plants start operation.



Estimating the time dependancy of seismic hazard during stimulation from real time analyses and developing a reaction plan on how to modify hydraulic parameters in case of increasing seismic hazard are the subjects of EP3 (Fig. 5).

***Fig. 5** Scheme of an automatic system for minimizing risk during hydraulic stimulation*

EP7 aims at analysing natural and induced seismicity at a deep mine in the area of Aue during and after flooding. The large pool of geological, geomechanical and seismological data (Fig. 6) is promising regarding the analyses and prognoses of fluid triggered events.

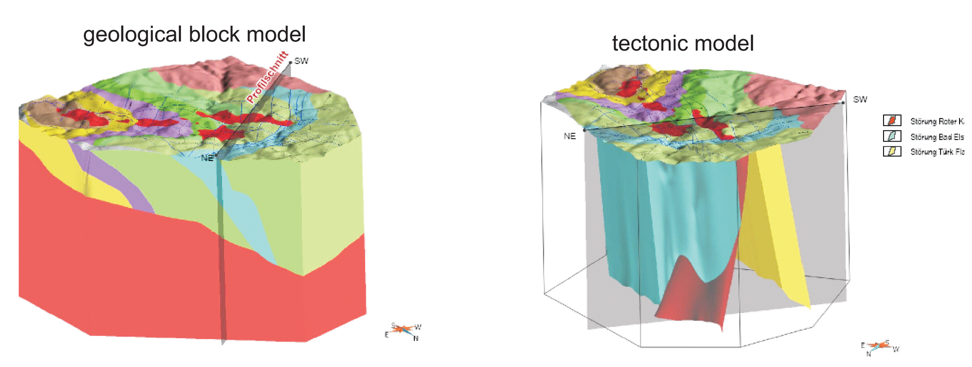


***Fig. 6** Study are Aue (Appendix 3 of "Forschungsbericht Tiefengeothermie Sachsen„ LfULG Sachsen)*

Modelling

EP4 is working on the quantification of seismic hazard due to natural and induced seismicity in the vicinity of geothermal power plants by applying deterministic and probabilistic methods (Fig. 6).

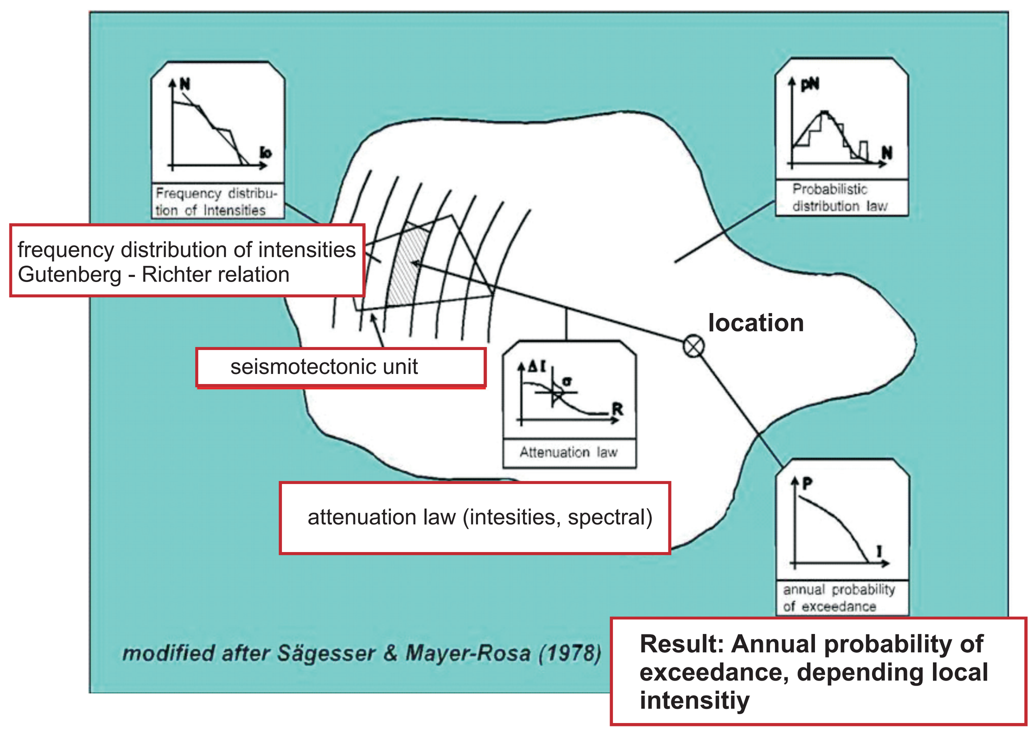
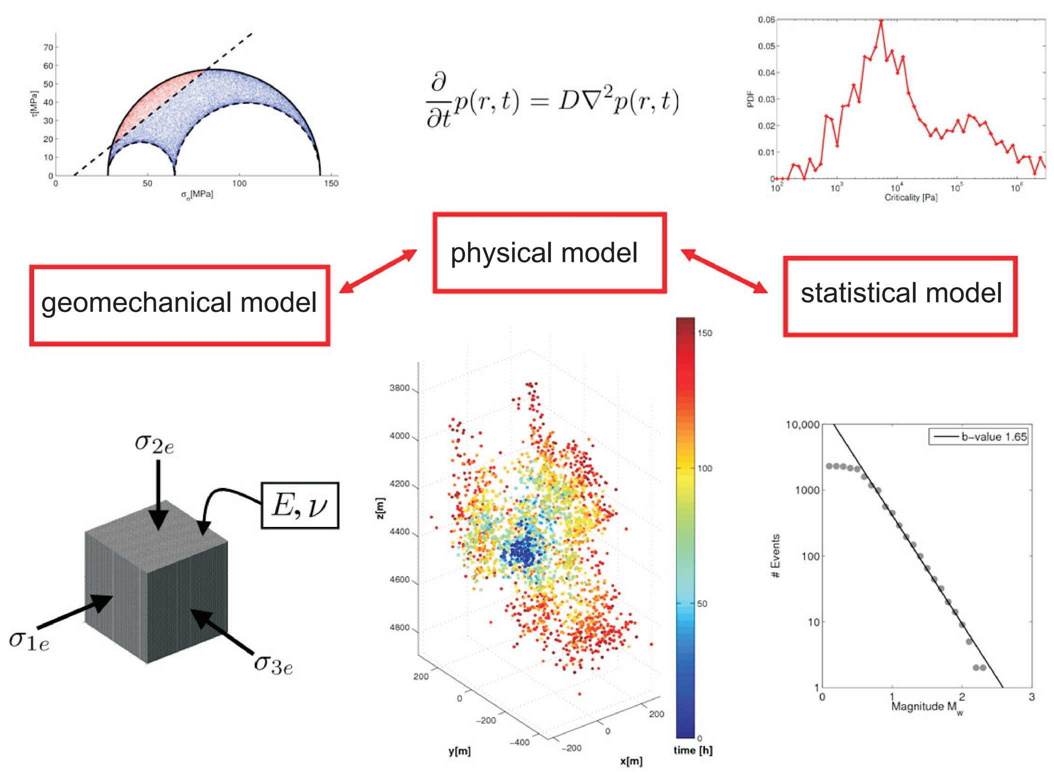


***Fig. 6** Probabilistic risk assessment*

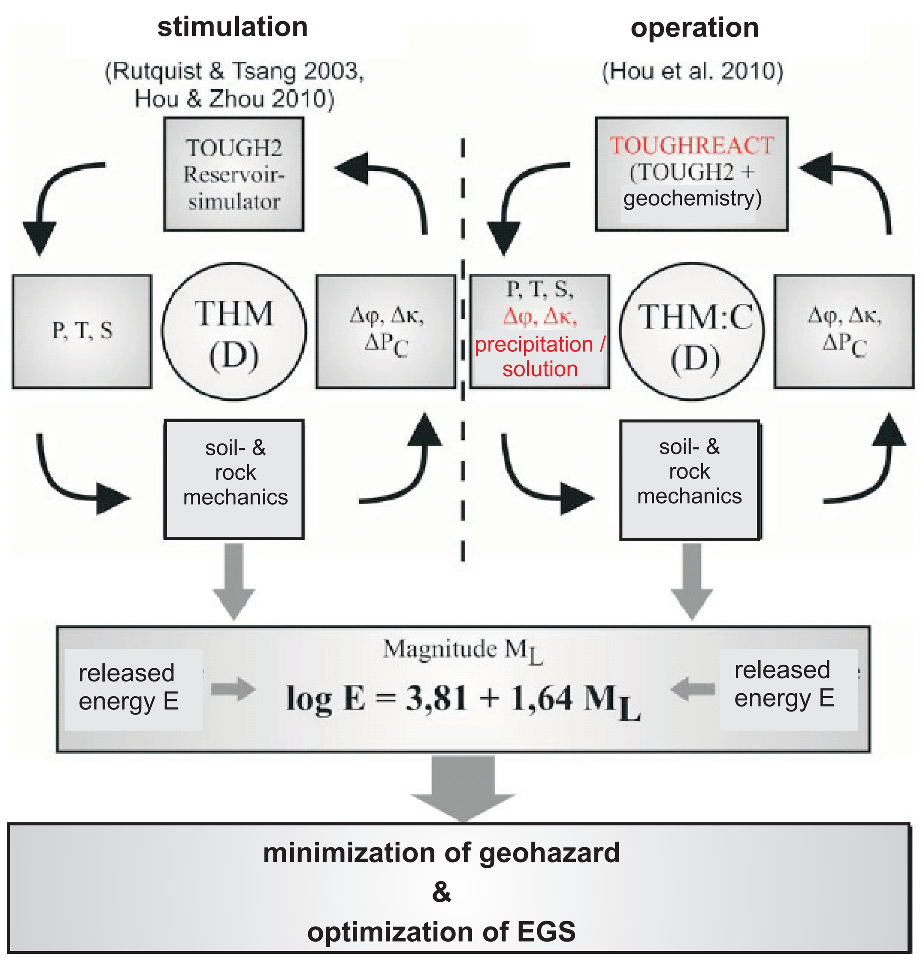


EP5 aims at modelling the probability of fluid induced earthquakes with a given magnitude. A model containing physical, statistical and geomechanical elements (Fig. 7) is developed and will be verified using real data.

***Fig. 7** Modelling of propability of fluidinduced seismicity*

Subject of EP6 is to analyse the mechanisms causing seismicity during stimulation and operation by applying THM(D)*, resp. THM:C(D) coupled process simulations (T: thermal, H: hydraulic, M: mechanic, C: chemical, dynamically (D) calcluated) (Fig. 8). A tool for forecasting and minimization of geohazard from new geothermal projects is developed.

***Fig. 8** Scheme of model concepts for stimulation (left) and operation (right) in consideration of THM and THM:C coupled processes*



Research Group

Project „MAGS - Konzepte zur Begrenzung der mikroseismischen Aktivität bei der energetischen Nutzung geothermischer Systeme im tiefen Untergrund" is funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

References

Häring, M., Schanz, U., Lader, F., Dyer, B. C., 2008. Characterisation of the Basel 1 enhanced geothermal system. Geothermics 37, doi: 10.1016/j.geothrmics.2008.06.002 | Hou, M.Z., Gou, Y. & Rutqvist, J. 2010: Integration of the codes FLAC3D and TOUGHREACT for THMC coupled geo-process simulations in reservoirs. 72nd EAGE Conference & Exhibition incorporating SPE EUROPEC 2010, Barcelona, Spain, 14-17 June 2010. | Hou, M.Z. , Zhou, L., 2010. THM gekoppelte dynamische Simulationsmethode zur Vorausberechnung der freizusetzenden Deformationsenergie und ihre erste Anwendung zur Nachsimulierung der DHM Basel induzierten seismischen Ereignisse. DGMK Tagungsbericht 2010-1. DGMK/ÖGEW-Frühjahrstagung 2010, Fachbereich Aufsuchung und Gewinnung, Celle, 12./13. April 2010. | Rutquist, J. & Tsang, C.F. 2003: TOUGH-FLAC: A numerical simulator for analysis of coupled thermal-hydrologic-mechanical processes in fractured and porous geological media under multi-physe flow conditions. Proceedings of TOUGH Symposium 2003, Lawrence Berkeley National Laboratory, Berkeley, California, May 12-14, 2003. | Sägesser, R., Meyer-Rosa, D., 1978. Erdbebengefährdung in der Schweiz. Schweizerische Bauzeitung, Heft 7/78, Zürich | Schulz, R., Agemar, T., Alten, A.-J., Kühne, K., Maul, A.-A., Pester, S. & Wirth, W. (2007): Aufbau eines geothermischen Informationssystems für Deutschland. - Erdöl Erdgas Kohle 123, 2: 76-81; Hamburg | http://www.umwelt.sachsen.de/umwelt/download/Forschungsbericht_TGT_Sn_02.12.10.pdf | http://www.umwelt.sachsen.de/umwelt/download/Forschungsbericht_TGTSN_Anlagen.pdf.

Contact: Margarete.Vasterling@bgr.de

Bundesanstalt für Geowissenschaften und Rohstoffe

GEOZENTRUM HANNOVER