Monitoring of microseismic activity around the GeneSys deep geothermal drilling site, Hannover (Germany)

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1. Abstract

In the framework of the GeneSys project (Generated Geothermal Energy Systems) a borehole was drilled at the Geozentrum Hannover down to a depth of 3900 m. The aim of the project is to extract geothermal energy from one single borehole to heat the buildings of the Geozentrum. The borehole is drilled in mid-triassic sandstone formations of the Northern German Basin.

Collaterally to the drilling and the upcoming heat production phase BGR has installed a seismic network around the drilling hole to monitor and analyze possibly induced seismic micro-events, especially induced by hydraulic fracturing activities which are planned in the beginning of 2011. Altogether, the network consists of 13 seismometers or geophones respectively. 5 geophones are installed in 100 m deep boreholes and build the inner circle of the network within a radius of approximately 1 km around the geothermal borehole. A second circle with a radius of 4 km is equipped with 1 Hz seismometers. Two additional geophones are installed in boreholes of 180 m depth.

Due to the position of the borehole in direct vicinity to the major city of Hannover and several highways nearby the noise conditions are relatively bad for the detection of small seismic events. The noise conditions as well as the position of Hannover in a more or less aseismic area allows us to detect only a few seismic events up to now. These are for example a controlled detonation of an aircraft bomb in a distance of about 3 km or mining induced events of magnitude 3.5 - 4.0 in the Polish mining area. The only event which is directly connected to the geothermal project and we have recorded so far, is the perforation shoot which took place at a depth of 3706 m on the 20th June 2010.

In the poster we present the design of the seismic monitoring system, the data flow as well as an automatic detector which is tested on the data streams to detect small events in case of difficult signal-to-noise conditions.

2. The GeneSys project

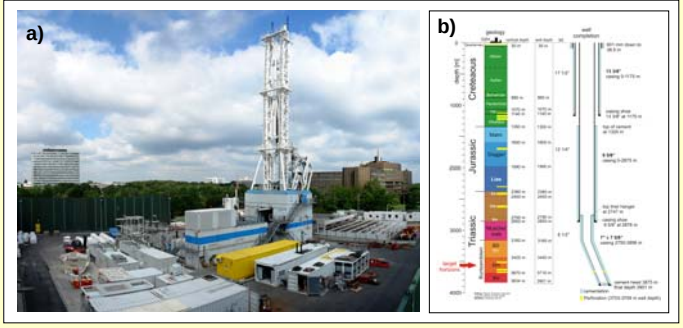


Fig. 1: From June to December 2009 a 3900 m deep geothermal well has been drilled at the premises of the GEOZENTURM in the city of Hannover (a). Target rocks are the formations of the Mid Triassic (b). In a depth of 3700 m to 3900 m, these thick formations have a temperature of 160°C to 170°C. These rocks are a common type for northern Germany. In most cases, their permeability is not sufficient for the conventional production of hot water. Therefore, an artificial fracture will be created in the bedrock which acts as a heat exchanger. The hydraulic fracturing is planned to take place in spring 2011.

3. Seismic monitoring system

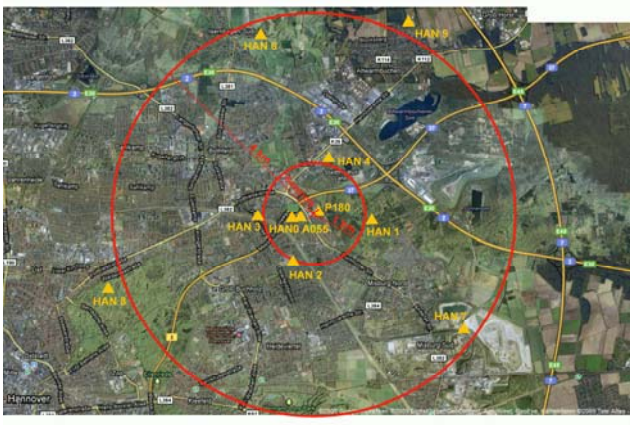
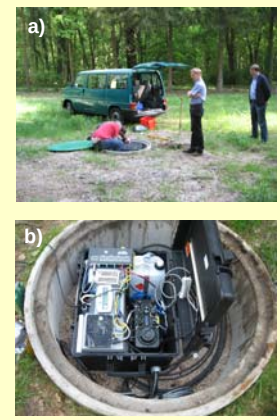


Fig. 2: Configuration of the seismic monitoring system at the GeneSys-borehole location (source of the background: Google Maps). The monitoring system consists of two circles centered at the borehole. The inner circle with 4 stations has a radius of approximately 1 km and is equipped with 4.5 Hz geophones in 100 m deep boreholes. The outer circle with radius of approximately 4 km is build up by 4 stations which are installed at the surface and equipped with 1 Hz Lennartz seismometers. Additionally, two borehole seismometers (depth 100 m and 180 m) and one broadband seismometer are maintained in direct vicinity of the borehole.



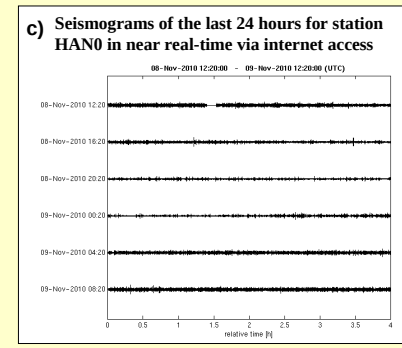


Fig. 3: a) Installation of station HAN1 b) Vault containing digitizer, battery and fuel cell c) Near real-time seismograms of station HAN0 available at the BGR internet site for the last 24 hours (update every 10 minutes). Current example covers the time span of 8th to 9th November 2010.

4. Communication with the broad public

Internet access:

www.genesys-hannover.de

⬇

Aktuelles

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Seismische Registrierungen

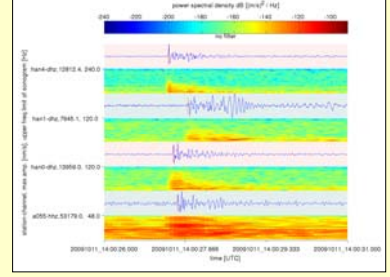
Good acceptance by nearby residents:

- Regular public meetings, starting before drilling
- Near-realtime internet access to registrations of the monitoring network (see Fig. 3c and Fig. 4)
- Credibility that claims due to possible damage will be fairly evaluated

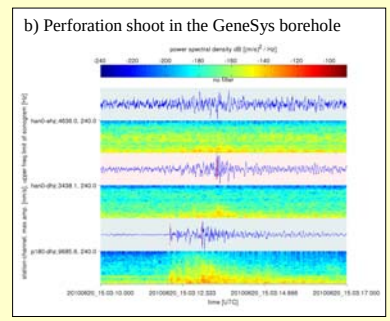
Fig. 4: For the public, information about the GeneSys project is available on the Website www.genesys-hannover.de. Special details on the seismic monitoring system can be found on subfolders (middle column) as well as near-realtime registrations of the monitoring network.

5. Data examples

a) Detonation of an aircraft bomb (11.10.2009)



b) Perforation shoot in the GeneSys borehole



Due to the position of the borehole in direct vicinity to the major city of Hannover and several highways nearby the noise conditions are relatively bad for the detection of small seismic events. The noise conditions as well as the position of Hannover in a more or less aseismic area allows us to detect only a few seismic events up to now. These are for example a controlled detonation of an aircraft bomb in a distance of about 3 km (Fig. 5a) or mining induced events of magnitude 3.5 - 4.0 in the Polish mining area. The only event which is directly connected to the geothermal project that we have recorded so far is the perforation shoot which took place at a depth of 3706 m on the 20th June 2010 (Fig. 5b).

In order to detect small events with small signal-to-noise ratio, we have developed an automatic detector which is tested on the data streams of the GeneSys-seismic-monitoring system. The detector is sensitive to amplitude und frequency changes in seismic data as expected from weak events at distances of a view kilometers from the sensor. In Fig. 5 the seismic data with the corresponding spectrograms is shown. The automatically detected P and S phases are marked by vertical red lines.

Fig. 5: Data examples: a) Detonation of an aircraft bomb at a distance of 3 km to the GeneSys borehole, b) Perforation shoot in GeneSys borehole at a depth of 3706 m.