Geophysical Research Abstracts
Vol. 13, EGU2011-11902-1, 2011
EGU General Assembly 2011

High resolution geophysical exploration ahead and around the drill bit by application of a directional seismic borehole source

Katrin Jaksch, Rüdiger Giese, and Matthias Kopf
Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany (kawi@gfz-potsdam.de)

In recent years the demand for an high resolution exploration of small-scale geological structures in the underground has increased dramatically. Despite of improvements in data processing, imaging and interpretation techniques it is often still difficult to identify potential targets like small layers for oil production or water bearing fault zones for geothermal heat and energy production. Furthermore, already small errors of a few percent in the determination of the seismic wave velocities can lead in greater depths to serious mistakes in the localization of these structures and the drill path may be wrong positioned. Thus, surface seismic surveys are often accompanied by borehole seismic measurements like Vertical Seismic Profile (VSP) or Seismic While Drilling (SWD) to improve the velocity model and to image the structures with higher resolution. The accuracy of structure localization of both methods still depends on the surveying depth because either the receivers (SWD) or the sources (VSP) are situated at the surface. Apart from that, disadvantages of these methods are the moderate signal-to-noise ratio in the case SWD and an elaborate and expensive technical realization of VSP measurements while drilling operations.

Since 2007 a system development for a new seismic exploration method ahead and around the drill bit is under progress. The project "Seismic Prediction While Drilling" (SPWD) comprises the seismic sources and receivers in one device, allowing an exploration with a resolution independent from depth. In a first step a laboratory prototype was developed and tested in two dry horizontal boreholes in a mine. The key component of the prototype is a complex source device consisting of four magnetostrictive vibrators emitting sweep signals from 500 Hz to 5000 Hz. The signal of each vibrator is independently controlled in amplitude and phase of each other to create a radiation pattern to focus the seismic wave energy to predefined directions. The emitted signals are detected by four three-component receivers installed in the borehole prototype as well as 30 three-component receivers mounted along three surrounding galleries in distances of up to 50 m.

The direct wavefield consists of a compression (P-) and two shear (S-) waves caused by the anisotropy of the gneiss. The enhancement and diminishment in the predefined directions of the radiation pattern is clearly exhibited. Comparing the incoming wave amplitudes at the geophones in the galleries the directional dependence of the complex borehole source is obvious. Using a three–component Fresnel-Volume-Migration to image the reflected wavefield the results show clearly the effect of the radiation pattern to the distribution of the seismic wave energy. The migration of the reflected wave field reveals an amplification of the reflected amplitudes at the galleries corresponding to the radiation pattern of the complex borehole source. Recently, further improvement has been realized to focus the seismic energy while using specially developed magnetostrictive vibrators with an advanced performance for frequencies lower than 2000 Hz.

The design of the successfully tested laboratory prototype was used to develop a wireline prototype for borehole measurements. The construction is currently in progress. First measurements in vertical boreholes are planned in the first half of 2011 to verify the exploration method for a directional investigation in boreholes. This project is funded by the German Federal Environment Ministry.