Geophysical Research Abstracts
Vol. 15, EGU2013-659, 2013
EGU General Assembly 2013

Imaging of Fractures around mines and tunnels

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The locations and properties of fractures are of particular interest to industries including Radioactive Waste Disposal and Deep Underground Mining. At present there is limited knowledge regarding imaging of fractures at distances of 1 to 100m. We explore the potential of seismic noise, such as that present in tunnels and mines due to excavation processes, to image fractures at depth. Microseismic monitoring is a powerful tool but its resolution depends on the characteristics e.g. wavelength and frequency content, of the recorded seismic signals. We use finite element analysis to model a fault within mudstone, a potential host rock for geological disposal, to define the optimum seismic signals that permit its identification. Our analysis is based on the principle that the smaller the wavelength of a seismic wave, the better the achieved imaging resolution.

A small fault in a fracture zone within a single rock mass was considered. An induced seismic event was used to detect material changes via reflection and refraction through the host rock. The numerical model was a time dependent analysis of the propagation of a seismic wave within the rock mass induced by a short duration pulse. The magnitude and location of the pulse was varied in order to exemplify induced seismic signals, commonly found in tunnel construction sites and mines. A monitoring point was established on the rock surface.

We use silent boundaries to separately model the arrival times of the incoming and reflected waves for various seismic signals. Due to a change in material properties, reflection and refraction of the waves always takes place through the fault. We use this property to obtain threshold values for the frequency content and the wavelength of the seismic waves for which detectable reflection and refraction no longer takes place through the fault.

We use the numerical analysis to identify the characteristics i.e. wavelength, frequency content and amplitude of seismic waves generated by induced sources and their evolution over depth. Our methodology can be used for the design and optimization of seismic monitoring systems for subsequent field application, in order to achieve maximum detection for imaging of small faults and fracture zones.