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Determination of source parameters and full moment tensors of seismic events in a very heterogeneous mining environment

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Using seismic data from 5 blasts and 5 induced events recorded in the Pyhasalmi ore mine, Finland, we propose and test a strategy for the inversion of moment tensors from waveforms in a very heterogeneous mining environment. The heterogeneities are caused not only by presence of the ore body in the host rock, but especially by presence of a system of tunnels and by large excavation areas in the mines. We show that the moment tensor inversion is feasible even in such a complex velocity model.

First, locations of events needed in the inversion can be determined using the eikonal solver, provided a detailed geometry of the tunnels and the cavities is well documented and the velocities of rocks are known with a good accuracy. The solver takes into account refractions and diffractions and it is applicable even in strongly heterogeneous media where ray tracing may be problematic. Second, the Green's functions needed for the waveform moment tensor inversion can be calculated by the full waveform modelling capable to reproduce complex interactions of waves with the structure. We use the 3-D finite difference viscoelastic code and run it on a model specified using the spatial grid of 2 m and with the sampling frequency of 10 kHz. The computational time is reduced using the reciprocity principle. Third, the moment tensor inversion is performed in the time domain using the generalized linear inversion. Compared to the computation of the Green's functions, the inversion is computationally undemanding. To suppress the sensitivity of the inversion to inaccuracies in the locations and in the velocity model, we analyse data in the frequency range from 30 to 80 Hz.

The analysis of 5 blasts and 5 induced microseismic events proved that the moment tensor inversion was successful. As expected the blasts display high percentage of the positive ISO components attaining values from 60 to 80%. However, we cannot exclude that some minor shear faulting was triggered during the blasting. On the other hand, the microseismic events display significant negative ISO and CLVD components, the DC component being less than 60%. This indicates that the predominant mechanism of the events was probably related to a collapse of the rock due to the excavation activity.