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Sensitivity of kinematic and dynamic parameters of induced seismic events to sensor coverage (Garpenberg Mine, Sweden)

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Garpenberg Mine (Sweden) is a seismically active underground mine. A permanent seismic system, installed in 2012, monitors the seismic activity in the whole mine. A temporary local seismic system concentrated in a small are area was installed in 2015 for study of local site effects from seismic events in a small area prone to seismicity and possibly rockbursting. Tests for estimation of kinematic and dynamic parameters using data from database for each seismic system and merged database were made on data for period October 8-13, 2015. The tests included seismic events with moment magnitude between -1.5 and 0.8. Data were processed manually, individually for each of the three databases. Special attention was paid to the sensor coverage in each database, and the events were divided into two categories: events with ‘good’ and ‘bad’ coverage.

The initial tests were carried out with the IMS (Institute of Mine Seismology) Trace software. It was found that the hypocenter locations calculated with data from the local and permanent systems differ in some ‘bad’ coverage cases by up to 300 m but for the ‘good’ coverage cases the difference was 50 m in average. The dynamic parameters also differed between the databases. The parameters that were most affected by the sensor coverage were the radiated energy, apparent stress, source radius, and stress drop. The parameter Es/Ep ratio used as a proxy of the source mechanism type was also very sensitive to the coverage. The other dynamic parameters as seismic moment and magnitude were less affected.

The same seismic events were processed also with LOKI, automated seismic event location method based on waveform stacking. This is a noise robust and picking free location method that exploits the full waveform information content of seismic recordings. Starting from raw seismograms, the first step of the location process consists in the computation of a P-phase and a S-phase stacking functions. For the P phase we use the STA/LTA of the vertical energy trace, whereas for the S we use the STA/LTA of a trace obtained using the principal eigenvalue of the instantaneous covariance matrix (Vidale 1991, BSSA). For a given source location, we sum both P and S stacking functions along the theoretical travel times corresponding to the selected hypocenter. To locate a seismic event we iterate this procedure for all samples of the recorded traces and for all possible source locations within a predetermined seismogenic volume. In this way we retrieve a multidimensional coherence matrix whose absolute maximum corresponds to the spatio-temporal coordinates of the seismic event. The results obtained by LOKI and Trace were compared and conclusions were made about their applicability and accuracy in case of ‘good’ and ‘bad’ coverage. Recommendations were made for using the data from both seismic systems and their merging in the routine monitoring of mining-induced seismicity. Further studies are needed for understanding the extreme change in the dynamic and kinematic source parameters in case of ‘bad’ coverage.