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Full Moment Tensor Inversion and Rupture Modelling of Mining Induced Seismicity

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We analyse sources of mining induced seismicity using full waveform and amplitude spectra inversion techniques in order to better understand rupture processes following mining activities. We focus on a coal mining seismicity dataset. The data were recorded in the region of Hamm (Ruhr area), Germany, by a temporary network deployed by the Ruhr University Bochum. Data were processed to build a seismic catalogue, which includes more than 7000 events with ML magnitudes ranging from -1.7 to 2.0. The time and spatial distribution of seismicity shows high correlation with the mining activity, source depths and epicentral locations mostly correspond to the region of active longwall mining; a few clusters at further distances are also observed. We limit our study to events of magnitude above ML -0.5 and successfully perform double couple and full moment tensor inversion for more than 1000 events. We use a full waveform inversion approach and test different 1D layered velocity models. The inversion is carried out in several steps both in the frequency and in the time domain, providing information about centroid location, focal mechanism, scalar moment and full moment tensor. We invert for the best double couple (DC) and full moment tensor (MT), which is decomposed into DC, compensated linear vector dipole (CLVD) and isotropic (ISO) components. We analyse and discuss the focal mechanism of DC and MT results, showing that most of solutions can be classified into few different faulting type clusters. Finally, extended source models are investigated for the largest events, in order to discriminate the rupture plane and to better understand failure processes induced by longwall mining. Point source inversion results indicate a strong dominance of normal faulting focal mechanisms, with one steep (dip 55°-70°) and one subhorizontal plane. Fault plane strikes are in most cases parallel to the direction of mining. Full moment tensor results suggest a combination of opening crack and normal faulting source mechanisms, while kinematic inversions indicate that the rupture most likely occurred along the sub-vertical planes. Whereas 1D velocity models could be used successfully for this work, mining environments are more often characterized by strong structural heterogeneities which can only be accounted for employing 3D velocity models and waveform modelling. In view of a future extension of our inversion code, we discuss and compare preliminary results for forward modelling in 1D and 3D velocity models. This study is funded by the project MINE, which is part of the R&D-Programme GEOTECHNOLOGIEN. The project MINE is funded by the German Ministry of Education and Research (BMBF), Grant of project BMBF03G0737.