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Asymmetry and anisotropy of surface effects of mining induced seismic events

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Long-lasting exploitation in underground mines and the complex system of goaf - unmined areas - excavation may cause the occurrence of seismic events, whose influence in the excavation and on the free surface is untypical. We present here the analysis of surface effects of a series of ten seismic events that occurred in one panel of a copper-ore mine. The analysis bases on a comparison of the observed ground motion due to the studied events with the estimates from Ground Motion Prediction Equations for peak horizontal (PHA) and vertical (PVA) acceleration of motion in the frequency band up to 10Hz, local for that mining area. The GMPE-s take into account also relative site amplification factors. The posterior probabilities that the observed PHA-s are not attained according to GMPE-s are calculated and mapped.

Although all ten considered events had comparable magnitudes and were located close one to another their ground effects were very diverse. The analysis of anomalies of surface effects shows strong asymmetry of ground motion propagation and anisotropy of surface effects of the studied tremors. Based on similarities of surface effects anomalies, expressed in terms of the posterior probabilities, the events are split into distinct groups. In case of four events the actual PHA-s on most of the stations are greater than the respective estimated medians, especially in the sector N-SE. The PHA values of the second group are at short epicentral distances mostly on the same level as the predicted estimates from GMPE. The observed effects, however, become abnormally strong with the increase of epicentral distances in the sector NE-SE. The effects of events from next groups abnormally increase either in NE or NE – SE direction and the maximum anomalies appear about 3km from the epicenter. The extreme discrepancies can be attributed neither to local site effects nor to preferential propagation conditions along some wavepaths. Therefore it is concluded that the observed anomalies of ground motion result from sources properties. Integrated analysis of source mechanism of these events indicates that their untypical and diverse surface effects result from complexity of their sources expressed by tensile source mechanisms, finite sources, directivity of ruptures and nearly horizontal rupture planes. The above features seem to be implied by a superposition of coseismic alterations of stress field and stress changes due to mining.

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