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The application of Double-difference technique to improve localization of induced microseismic events at Pyhäsalmi copper mine, Pyhäjärvi, Finland.

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Pyhäsalmi mine, an underground copper mine at Pyhäjärvi, Finland, have been known to have induced seismicity due ore excavation for over half of a century. In 2002, the excavation depth increased as mining activity focused to Pyhäsalmi deep ore body, a potato shaped ore concentration that lies roughly from 1000 meter to 1425 meters below the surface. The stress level in the rock was detected to be very high with clear main direction and due to this microseismicity started occurring immediately when the construction of “new mine” section began. Thus a microseismic monitoring system was installed to trace this frequently occurring induced seismicity as seismic observations are one of the quickest ways to map mines state-of-health. The system consist over 25 geophones that are mainly around the excavation site. Since the installation, over 250000 events have been observed.
Currently the automated (triggered) and afterwards manually verified seismic events localization routine is applied by absolute location method that minimizes the penalty function of calculated location and origin time to match as good as possibly for corresponding events observed arrivaltimes. However with this method the best location accuracy is around 20 meters at center of the excavation, since it uses homogenous velocity model that have been applied to whole mine but in reality the seismic velocity structure is very complex with tunnels, fill material and ore. For mines seismic alarm purposes this suits well, but for more advanced source analysis this accuracy is not enough.
We apply Double-difference technique to relocate microseismic scale events at Pyhäsalmi mine. This iterative least-squares procedure method utilizes pairs of events with common receiver. The basic principle of the technique is that it relates the residual between the observed and the predicted phase traveltime difference for pairs of earthquakes observed at common station to adjustments in the vector that connects their hypocenters through the partial derivatives of the traveltimes for each event with respect to the unknown. Therefore a detailed seismic velocity model is not needed. By linearizing the individual events location problem, the common mode errors cancels, in particularly those related to the receiver-side structure. The Double-difference technique suits well on dense seismic clusters as the method also links individual events that are determined to be in the same clusters to enhance the relocation accuracy further as the basic assumption for clustering is that events within common cluster are associated on same seismic source.
Our interest is to study can Double-difference technique be applied to the microseismic data of Pyhäsalmi mine successfully since the technique has been developed for regional scale studies. Double-difference technique was tested for synthetic stations in different depths and for our network configuration. In the tests we used different forms of synthetic event clusters. The synthetic tests results showed that our network configuration is suitable for Double-difference technique. The relocation results from Pyhäsalmi mine have been encouraging and the relocated events have been positioned near known seismic zones at the mine.