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Reflection seismics for structural 3D modeling of Pyhäsalmi mining area

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The Pyhäsalmi Zn-Cu ore deposit in Central Finland is a volcanogenic massive sulphide (VMS) that has been actively mined since 1962. As a part of the ProMine project of the European Union, a geological 4D-model of this area with high ore potential is created. During the HIRE-project (High resolution reflection seismic for ore exploration 2008-2010) by Geological Survey of Finland, six crooked 2D-seismic profiles were acquired in Pyhäsalmi area. These seismic data are an important component in the current efforts to provide a 4D-model.
Acoustic drill hole logging measurements were conducted in three selected holes in Pyhäsalmi mine area during 2010. Sonic and density logging results show that, in general, the contacts between mafic volcanites and any other rocktypes cause detectable reflections as difference in acoustic impedance is more than 2.5 x 10 5 kg/m2s. The density and seismic P-wave velocity values measured from the ore differ dramatically from any other measured values and thus the massive sulphides of Pyhäsalmi should be seen as bright reflectors or diffractors in reflection seismic data.

Commercially processed HIRE-data revealed a complicated reflectivity caused by complex geology of the area. Volcanic rocks of Pyhäsalmi has undergone a polyphase deformation and the area is cut by network of faults. The main reflectivity of the area is the 1-2 km thick structure dipping towards E-NE in the eastern part of the survey area. This structure is connected to the known deep ore deposit (at $\sim$1000-1500m depth) and it is subhorizontal in the central part of the area. Based on the surface geology and drilling, the structures close to surface are mainly vertical and only recently the deep drill holes (>1000 m) have penetrated also subhorizontal features. Based on drilling, at least some of these subhorizontal, strongly reflective features contain massive sulphide mineralizations. The weak reflectivity in the uppermost 1 km in the seismic sections can be attributed to vertical structures.

Even though the commercially processed data are of good quality, reprocessing using unconventional techniques and careful parameter selection tailored for Pyhäsalmi case will improve the resolution and imaging power of the seismic data. Reprocessing of the seismic data aims at (i) gaining more information about structures and lithological contacts from shot gathers, (ii) enhancing the stack quality especially in the shallow part of the section, (iii) imaging better steeply dipping structures and (iiii) making an improved velocity model that could be utilized in the interpretation of the data

The reflectivity texture of the seismic profiles is used for lithological modeling. Adjustment and validation of the seismic interpretation is aided by drill hole data, geological modelling, and the results of the full waveform sonic and gamma-gamma density logging obtained from exploration drillholes. The goal is to improve the robust 3D-model of the Pyhäsalmi area that can be used in exploration and extend it to depths greater than 1.4 km.