Seismic imaging of deep massive sulphides in Pyhäsalmi, Finland
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Abstract

The giant (>70Mt) Pyhäsalmi Zn-Cu ore deposit in Central Finland is a Volcanogenic massive sulfide (VHMS) that has been actively mined since 1962, and expected mine life extends to 2018. The architecture and structure of the deposit indicate a substantial ore potential beyond known reserves which motivates active exploration using a combination of deep penetrating geophysical techniques and drilling. The Pyhäsalmi deposit is enclosed within the rocks of contrasting acoustic properties, such as mica-cordierite schists, felsic volcanics and unaltered mafic rocks. Contacts between these rock units are likely detected with reflection seismic method. HIRE (High Resolution Reflection Seismics for ore Exploration 2007-2010) is a project led by the Geological Survey of Finland and participated by 11 industrial partners. Pyhäsalmi is one of the 16 targets of the reflection survey. The survey contained a network of 2D seismic reflection lines with the total length of almost 30 km. The shot and receiver group intervals were 50 m and 12.5 m, respectively. The aims of the Pyhäsalmi survey are to gain understanding about geological structures at depth, to study the possible seismic signal produced by the known ore deposit, to better understand the structural control of the ore deposit and to provide new drilling targets for exploration. The commercially processed seismic data of the HIRE-survey revealed a complicated reflectivity patterns caused by the complex geological structure of the area. The main feature of the area is a strongly reflective 1-2 km thick structure which dips towards E-NE in the eastern part of the study area, but which is subhorizontal in the western part. The deep ore body lies at an interface between mica schist and unaltered rocks on top of this large-scale structure. Due to strong deformation, lithological contacts close to surface are mostly subvertical, which causes difficulties to reflection seismic technique better suited for imaging the horizontal and moderately dipping structures.
Although the commercially processed data are of good quality, reprocessing using unconventional techniques and careful parameter selection tailored for Pyhäsalmi case may 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 (iii) making an improved velocity model that could be utilized in the interpretation of the data. Pyhäsalmi mine is part of the ProMine project of the European Union with aims to build a 4D model of the mineralized region. The HIRE seismic data will also be incorporated in this model. Adjustment and validation of the seismic interpretation will be aided by new drill hole data, geological modelling, and the results of the full waveform sonic and gamma-gamma density logging obtained from recent exploration drillholes. The final goal of this currently ongoing work is to obtain a geologically and geophysically robust 3D model of the Pyhäsalmi area with indications of promising exploration targets.

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