Seismic ore exploration in the Outokumpu area, eastern Finland: Constrains from 3D seismic full waveform modeling and processing considerations

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Seismic forward modeling is used to get better understanding of the seismic signature of the Outokumpu assemblage rocks (serpentinite, carbonate, skarn and quartz rocks) and associated Outokumpu-type semi-massive to massive sulphide Cu–Co–Zn–Ni–Ag–Au deposits, and to develop tailored hard-rock reflection seismic data processing schemes for aiding seismic ore exploration in the Outokumpu area. Reflection seismic line OKU1 at the southwestern end of the Outokumpu area was chosen to be the main focus of the forward modeling efforts because it is located in the close vicinity of 2.5 km deep Outokumpu Deep Drill Hole, which provides direct lithological control for the observed reflectivity and well-documented acoustic properties of the Outokumpu rocks. Thus, a detailed geological model could be built based on the Outokumpu Deep Drill Hole data and OKU1 reflection seismic line. SOFI3D full waveform finite-difference code was used to calculate theoretical shot gathers which were then processed with the same processing schemes as the real OKU1 reflection line.

We conclude that within mica schist hosting them, the Outokumpu assemblage rocks (and black schist enveloping them) form internally strongly reflective packages typically characterized by numerous diffraction hyperbolas in the stacked sections. The reflectivity characteristics can be used to target the potentially ore-bearing Outokumpu assemblage rocks at depth, and the reflection seismic data provide a good basis for setting regional exploration targets in the Outokumpu area. Based on the results of this study, it seems also possible that the Outokumpu-type sulphide mineralizations could be even directly observed as high-amplitude anomalies in the reflection seismic sections. However, the physical properties of the Outokumpu assemblage rocks and Outokumpu-type sulphide mineralizations significantly vary across the Outokumpu area, and new seismic velocity measurements across the Outokumpu area, as well as more and better constrained density data, are required to study the seismic response of the Outokumpu assemblage rocks and the Outokumpu-type sulphide mineralizations in more detail. Nevertheless, careful crooked-line data processing sequence should be able to preserve the direct signals, if present in the data, except for very shallow signals that are more likely to get distorted by the crooked-line effects. The crooked-line effects can also potentially produce high-amplitude anomalies and care is required when interpreting the high-amplitude anomalies in light of ore exploration.