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High-resolution seismic imaging of the Kevitsa mafic-ultramafic Cu-Ni-PGE hosted intrusion, northern Finland

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Kevitsa, in northern Finland, is a large nickel/copper ore body hosted by a massive mafic-ultramafic intrusion with measured and indicated resources of 240 million tons (cutoff 0.1%) grading 0.30% Ni and 0.41% Cu. Mining started in 2012 with an open pit that will extend down to about 550-600 m depth. The expected mine life is more than 20 years. Numerous boreholes are available in the area, but the majority of them are shallow and do not provide a comprehensive understanding of the dimensions of the intrusion. However, a number of boreholes do penetrate the basal contact of the intrusion. Most of these are also shallow and concentrated at the edge of the intrusion. A better knowledge of the geometry of the intrusion would provide a framework for near-mine and deep exploration in the area, but also a better understanding of the geology. Exact mapping of the basal contact of the intrusion would also provide an exploration target for the contact-type mineralization that is often more massive and richer in Ni-Cu than the disseminated mineralization away from the contact.

With the objective of better characterizing the intrusion, a series of 2D profiles were acquired followed by a 3D reflection survey that covered an area of about 3 km by 3 km. Even though the geology is complex and the seismic P-wave velocity ranges between 5 to 8 km/s, conventional processing results show gently- to steeply-dipping reflections from depths of approximately 2 km to as shallow as 100 m. Many of these reflections are interpreted to originate from either fault systems or internal magmatic layering within the Kevitsa main intrusion. Correlations between the 3D surface seismic data and VSP data, based upon time shifts or phase changes along the reflections, support the interpretation that numerous faults are imaged in the volume. Some of these faults cross the planned open-pit mine at depths of about 300–500 m, and it is, therefore, critical to map them for mine planning.

The seismic 3D volume better represents the geology around the mine and in the vicinity of the known deposit, while the 2D seismic profiles were designed to provide information on larger-scale structures in the area. Both the 2D and 3D seismic data were used to create a 3D lithological and structural model of the entire complex. Information on the dimensions of the ore-bearing Kevitsa intrusion can be used for more effective exploration in the area. The base of the intrusion is particularly clear in the northern and western sectors of the seismic data. Toward the east, the base is mostly defined by disruption of the reflectors internal to the intrusion.

Recent tests using prestack migration methods on the 3D data show partial improvements in the image, especially at shallow depths. 3D seismic tomography has also been performed and the results indicate low velocity zones crossing the open pit that can be interpreted as zones of weakness. Future studies will focus on using the tomography results as the input velocity field for prestack depth migration of the 3D data and also improving the 3D geological model of the study area.

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