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Structure of Akanvaara Cr-V-PGE deposit in Northern Finland, obtained by passive seismic coda wave interferometry and gravimetry

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The development of cost-effective and environmentally friendly methods for the exploration of critical raw materials (CRM) is important in the modern world as such platinum-group metals (PGM) as nickel (Ni), cobalt (Co), vanadium (V), copper (Cu) are irreplaceable in a wide set of EU strategic sectors such as aerospace, digital industry, and defense sectors. Orthomagmatic mineral systems include mafic layered intrusions and conduit-type sulphide deposits, which host many of the above-mentioned CRMs. In the EU, there is currently only one orthomagmatic sulphide deposit (Kevitsa Ni-Cu-PGE-Co, Finland) and one orthomagmatic oxide deposit (Kemi Cr, Finland) in production. However, there are potential deposits in different countries, among which is the Akanvaara Cr-V-PGE deposit, which was extensively studied by the Geological Survey of Finland (GTK) during the 1990s. Within these studies, more than 100 diamond drill holes were drilled with comprehensive geochemical analyses across the whole stratigraphy. The layered rocks and occurrence of thick magnetite gabbro motivated the selection of Akanvaara as one of the sites in the SEMACRET project ("Sustainable exploration for orthomagmatic (critical) raw materials in the EU: Charting the road to the green energy transition") for testing of advanced geophysical techniques for orthomagmatic mineral deposits exploration. Within this project, an innovative passive seismic method based on coda wave passive seismic interferometry has been developed. To test this method, we recorded continuous three-component seismic data along two profiles, crossing the mineralized zones of the deposit. In total, we used 746 three-component seismometers provided by the FINNSIP (Finnish Seismic Instrument Pool www.finnsip.fi). The instruments were installed in two profiles and recorded continuous seismic data from 2.11.2023 to 9.12.2023 (606 instruments) and from 28.08.2024 to 2.10.2024 (140 instruments), respectively. Results of passive seismic data processing by the developed method show converted arrivals originated at mineralization zones and other structural features of the deposit. To interpret these arrivals, we used the gravity data measured by the GTK during the 1990's. This data was measured with 20 m point separation, whereas line separation was 200 m. Data has been reduced to Bouguer anomaly by the GTK. We removed the regional field from the Bouguer anomaly data with upward continuation and applied a high-pass filter to remove the high-frequency part. Three-dimensional unconstrained inversion was done with the UBC-GIF Mag3d inversion software. Joint interpretation of obtained density models and seismic sections shows a good correlation between structures with different densities and converted arrivals, which makes the results interpretable. In

this study, we describe details of data acquisition and processing as well as the interpretation of Akanvaara Cr-V-PGE deposit models obtained by passive seismic coda wave interferometry and gravimetry. The joint application of these methods looks promising for brownfield exploration of massive orebodies.