SEEMS DEEP – GEOPHYSICS BASED 3D GEOMODELING FOR MINERAL EXPLORATION

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In the project SEEMS DEEP, we are developing geophysical methodologies for deep imaging of the bedrock for mineral exploration. The test area of the project is the Koillismaa area, Finland, that provides a full-scale natural laboratory with geophysical anomaly that has been of interest for geoscientist several decades. This anomaly is a 50 km long zone connecting the distant parts of the same mafic intrusion, and it is observed with gravity, seismic reflection and AMT surveys. The recent drilling of 1700 m long diamond drill core has confirmed that the anomaly reflects the presence of 2.45 Ga mafic-ultramafic intrusions. The deep borehole has detailed geological and geophysical logs suitable as prior constraints to inversion and interpretation that lead to 3D geomodel. The rocks of the age group of the intrusion are very potential for several commodities included in the EU critical material listing. We aim to improve the deep exploration success date in order to supply the raw materials needed for the energy transition and especially for the battery industry, and 3D geomodels provide a means to visualize results of various surveys also in a form understandable for wider audience.

Petrophysical data analysis provides links between different physical rock properties and lithologies which need to be understood in order to conduct successful geophysical imaging or geomodeling.

The background petrophysical data from Koillismaa region include density, magnetic susceptibility and remanence, seismic P-wave velocity and galvanic specific electrical resistance measurements from drill core samples. Low-fold seismic and sparsely sampled AMT measurements indicate high acoustic impedances and elevated electrical conductivity values, respectively, of the ultramafic rocks at depth. We have created a 3D geomodel based on the petrophysical data analysis and available data set. This model will consist of surfaces representing the lithological contacts, fracture zones, dikes and faults and ultimately it will be converted into a volumetric model populated with interpreted rock-physical properties. The geomodel is currently used for geophysical modelling and inversion of synthetic seismic and EM/ERT/IP data. These simulations will facilitate optimized survey design for the large field data acquisition campaign planned for autumn 2023. Later the results of new geophysical measurements are used to improve the current geomodel.

Koillismaa geomodel aim to facilitate strategic drilling, which means that roughly 20-50% less exploration drill holes will be needed to achieve sufficiently detailed characterization of the deep geological environment or 3D delineation of the ore hosting rock units. To reduce the number of exploration drilling during the exploration phase, geoscientists need to limit the geological uncertainties with more reliable geophysical data, which leads to more reliable 3D geomodels.