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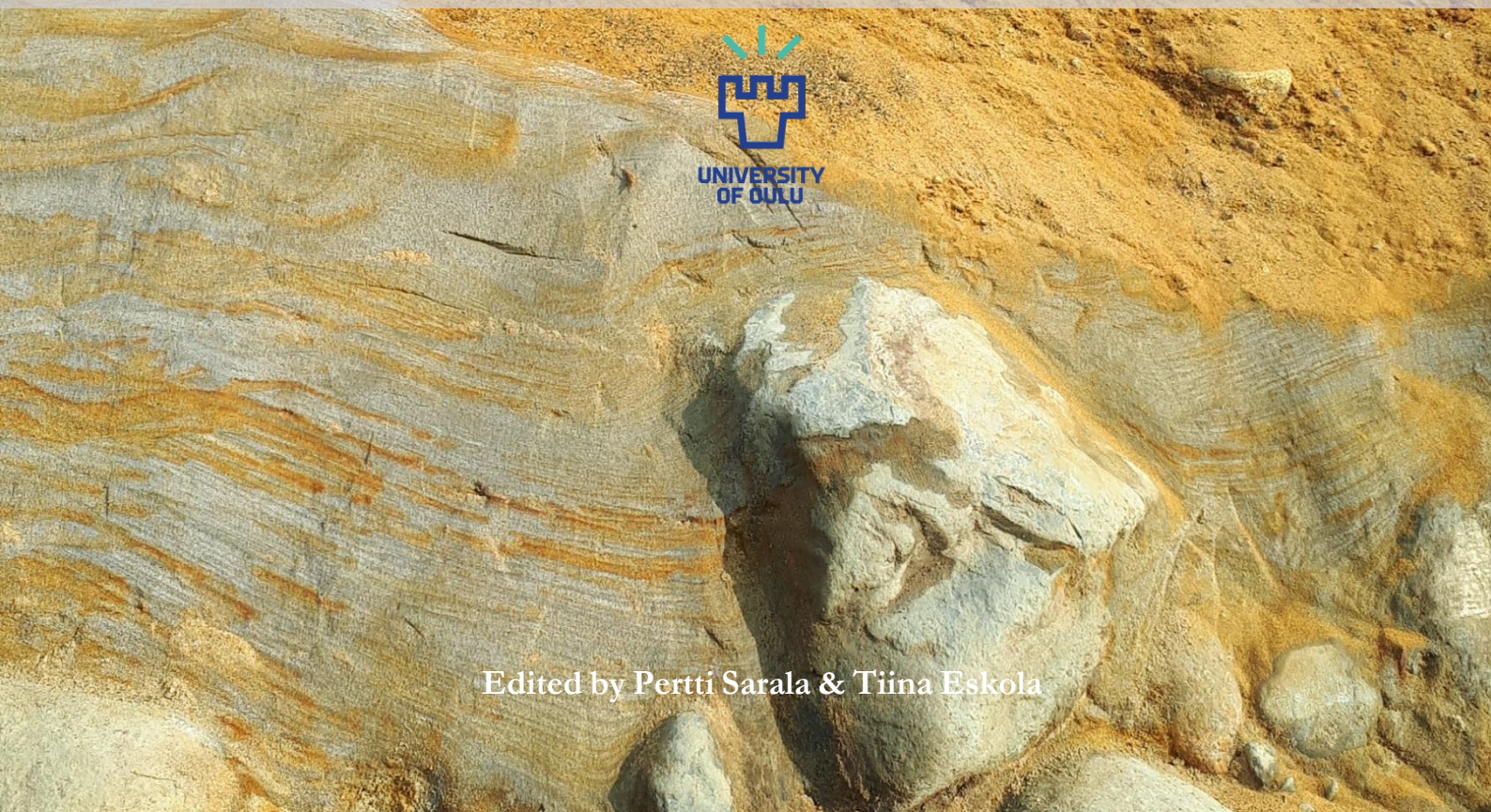

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Exploration targeting of anorthosite-related Fe-Ti-V mineralization around Suwałki, northeastern Poland

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The Suwałki Anorthosite Massif in northeastern Poland hosts significant Fe-Ti-V mineralisation associated with anorthosite-related mafic intrusions (Mikulski et al., 2022), commodities that are considered critical by the European Union (European Commission, 2023). Deposits in this area lie under a thick sedimentary cover of about 800 metres. Computer-based prospectivity modelling is a cost-effective and robust tool for delineating areas with high mineral potential, integrating diverse geospatial datasets. This study employs knowledge-driven fuzzy inference systems (FIS) to assess and model the mineral potential of Fe-Ti-V deposits in the region.

FIS is a symbolic artificial intelligence technique that enables a computer to apply geological reasoning by incorporating expert knowledge and defining fuzzy membership functions for key mineralisation indicators, such as magnetic anomalies, gravity data, and structural features. The GIS predictor maps, or evidence layers, are derived based on a mineral systems model, which also determines the structure of the FIS. The mineral system model for Fe-Ti-V mineralisation related to ultramafic-mafic intrusions includes (1) Primitive, mantle-derived, metal-rich magmas emplaced in an extensional setting, serving as metal sources; (2) trans-lithospheric faults and suture zones acting as magma pathways; and (3) dilatational zones of high, fracture-related permeability and localised structures that physically trap the mineralising fluids, allowing fractional crystallisation to generate evolved, oxide rich anorthosites. The evidence layers are then combined using logical if-then rules defined by the mineral systems model to produce a continuous prospectivity map.

Data availability is a serious challenge in this particular case where the mineralisation is deep-seated. Modelling warrants innovative data engineering to extract valuable features from any geoscientific data available. Geophysical data in the form of magnetic and gravity data is available for the entirety of Poland. Besides, a 3D model of p-wave velocities is compiled from seismic data by Grad et al. (2016). From these datasets, several features, such as a potential deep-seated magma reservoir, fluid transporting structures, fluid trapping structures, and intrusive bodies, were mapped. Predictor maps were then obtained and integrated as per the mineral systems model in the FIS. The resulting prospectivity map highlights previously untested targets, aiding mineral exploration efforts in the Suwałki region.

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