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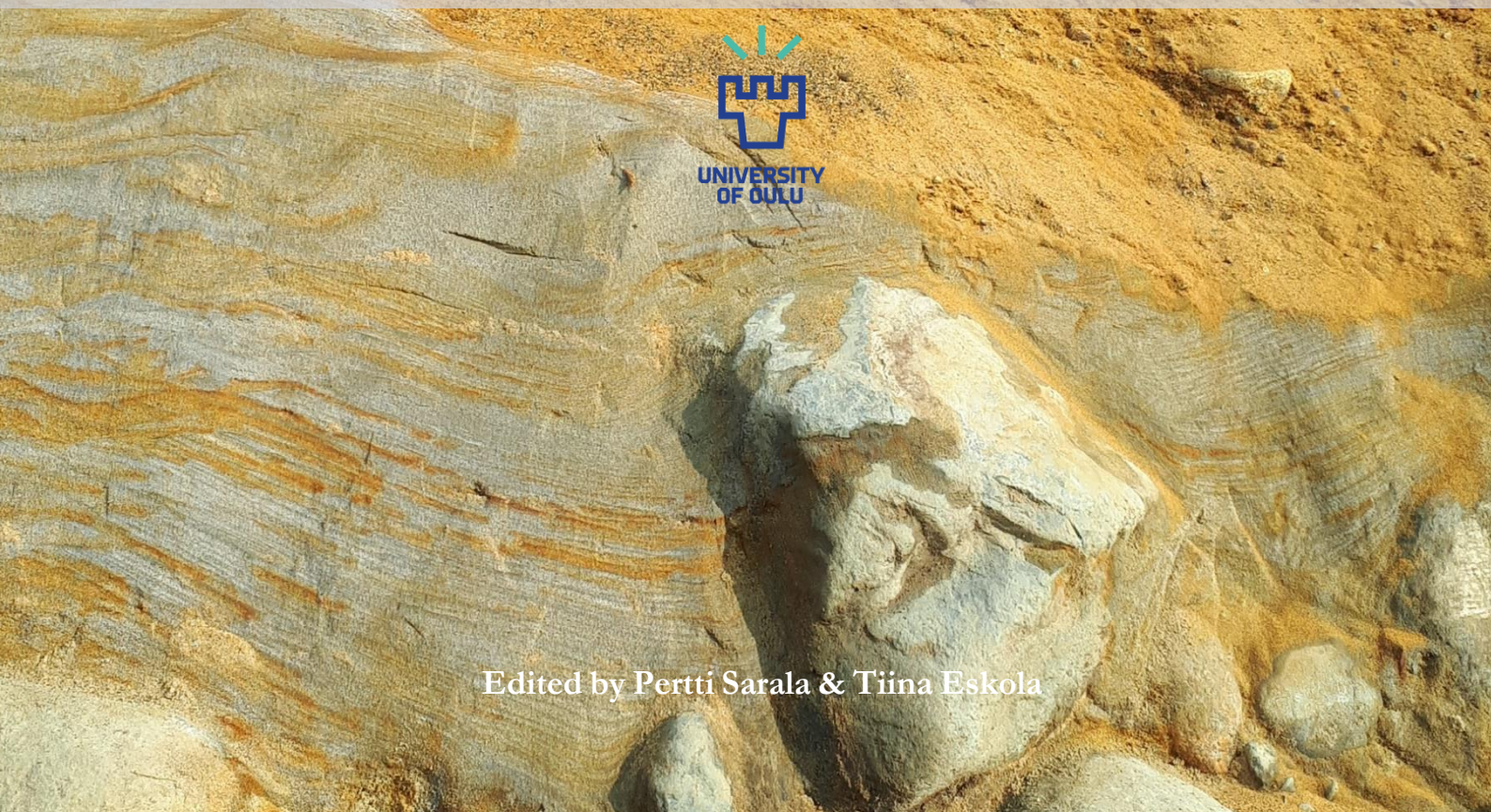

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Transforming Drilling Operations: The Power of Machine Learning for Cost Reduction and Precision

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Drilling in mineral exploration or during active mining stages is crucial for successful mining operations. It facilitates the study of the shape and subsurface characteristics of potential ore bodies, yielding essential information such as mineral grade (Revuelta, 2017; Dumakor-Dupey & Arya, 2021; Jung & Choi, 2021). Current geostatistical methods typically necessitate closely spaced drill holes to accurately estimate variables in unsampled regions. However, constraints related to budget and technical capabilities hinder the execution of detailed drilling (Sadeghi & Cohen, 2023; Lindi et al., 2024).

Unlike traditional geostatistical approaches that rely on the data within a spatial search window for interpolation, machine learning (ML) techniques offer a promising alternative by leveraging learned patterns and behaviors from datasets (Cevik & Ortiz, 2020; Jung & Choi, 2021). This study aims to employ ML for mineral resource estimation by minimizing the volume of data needed for analysis through quadratic sampling. The focus will be on datasets from the Ransko Ni-Cu-(PGE) deposit in Czech Republic, where systematically reduced data will serve as a basis for training and evaluating the performance of various ML models.

The research specifically investigates the application of ML methods, such as Extreme Gradient Boosting and Random Forest, to enhance mineral resource estimation in the Ransko Ni-Cu-(PGE) deposit. These ML techniques represent a significant advancement by predicting target variables in unsampled locations while utilizing sparse and distantly located data, thereby minimizing environmental impact and costs associated with drilling exploration. Furthermore, ML can effectively integrate geological interpretations and address spatial continuity, which potentially improves the accuracy of resource estimates and leads to more efficient and sustainable exploration practices. By employing distant exploration drill holes, the overall costs of mineral exploration can be substantially reduced, paving the way for innovative strategies within the industry.

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