Spatial Estimation with Machine Learning of Multiple-Fluid Phase Veining in Shear-Hosted Intrusion-Related Deposits Using Geospatial Features—A Case Study from Pogo Mine, Alaska

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ABSTRACT

At Pogo, a shear-hosted, intrusion-related gold deposit in Alaska, the mineralisation is often hosted within 12 m thick quartz veins, exhibiting multiple fluid phases, where gold concentration frequently occurs near the vein margins. The mosaic mineralisation style, when estimated using Ordinary Kriging (OK), fails to reflect the resolution required across the thickness of the vein to manage mining dilution appropriately. Categorical Indicator Kriging (CIK) is utilised to sub-domain grade populations within the same quartz vein. This traditional approach relies on subjective decisions, including the geologist's domain expertise, variogram modelling, cut-off grade selection, and threshold probability determination. In this case study, a machine learning (ML) model was developed without requiring assumptions of stationarity or linearity. The proposed ML model improves performance by applying feature engineering to the original coordinates through polynomial transformation and incorporating a fixed reference point. The initial training utilised several ML algorithms, each contributing to distinct learning patterns. Model performance was further enhanced by employing a stacking approach with diverse base learners and using a meta-learner to ensemble the predictions. The performance of the meta-learner model was evaluated against the CIK model. This case study highlights the ML model's ability to accurately represent the training data while eliminating cognitive bias from human input. It underscores the superior effectiveness of the ML model in estimating this type of mineralisation, positioning it as a compelling alternative to the CIK model.