Anomaly Detection Using Variogram and Machine Learning Can Reveal Potential Orefields: Case Studies from the United Kingdom and Australia

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The use of machine learning for mineral exploration has increased in recent years, with most applications focusing on supervised learning approaches for mineral prospectivity mapping; however, unsupervised learning approaches for anomaly detection also have significant potential and deserves further investigation. In this study we integrate variogram modelling as a preprocessing tool for machine learning-based anomaly detection. The method is demonstrated through a case study on detecting large orefields in the using national-scale geochemistry survey from United Kingdom (UK) and Australia. Multicomponent geochemical stream sediment data comprising major and minor oxides, and a variety of base and strategic metals were used to produce variograms. These variogram data was then input into an unsupervised learning method to produce data clusters which were compared with known orefields. Our results from UK case study demonstrate the potential to detect geochemical anomalies that may be spatially related to orefields, whether exposed or hidden. Additionally, the approach can identify similarities between such anomalies, which can aid mineral exploration by enabling comparisons between orefields and previously underexplored areas. One particular observation is that the method highlights several anomalous regions in Scotland that are not currently considered orefields, indicating a larger untapped potential in the northern part of UK, compared to the south However, the method could not be replicated successfully using the Australian dataset, likely due to lower data density and other contributing factors. This highlights the need either for a new geochemical mapping campaign with denser sampling comparable to that of the UK, or for the compilation of levelized, publicly available geochemical datasets. Nevertheless, we envisage that this method can be applied successfully in other countries that have the required data density, and that it may also be suitable for project-scale exploration, where even higher data density is available.