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Mapping the unseen: Smart tools for detecting and characterising geochemical boundaries in regolith-basement interfaces

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In deeply weathered terrains, accurate identification of regolith-basement lithological interfaces and characterising critical geochemical transition zones within them are essential for mineral exploration of blind deposits. Conventional geological logging methods often rely on subjective interpretations, leading to inconsistencies in resolving subtle geochemical variations within mineralogically consistent phases. Recent advances in field-based data acquisition provide an opportunity to leverage data analytics and machine learning techniques for more objective boundary detection, overcoming the instrumental limitations. In this study, two different approaches have been sought to recognise and characterise geological boundaries by integrating on-site geochemical, spectral, and petrophysical data acquired from drillholes.

Continuous wavelet tessellation method can be used to detect multi-scale boundaries within sequential spatial or time-series data. This approach was applied to a suite of geochemical, spectral and petrophysical data obtained from drillholes in areas of thick regolith cover in the Cobar Basin and Delamerian Orogen in eastern Australia. Initial unsupervised classification was cross validated using an automated boundary detection workflow. This framework incorporated various preprocessing steps to isolate the most effective suite of variables, followed by supervised classification techniques and silhouette scores to detect and objectively characterise boundaries. These include identifying critical zones within the weathered profile and zones of alteration related to mineralisation in bedrock.

The combined application of these tools on drill core from mineral deposits at Wilga Downs, McKinnons and Wagga Tank in central New South Wales (NSW) provided valuable insights into key regolith features that assist in detecting patterns related to underlying Au and base metal mineralisation in complex weathering-induced geochemical and related physical dispersion settings. By reducing subjectivity and enhancing reproducibility, this framework offers a robust solution for rapid geological boundary detection in mineral exploration which could facilitate real-time decision making while drilling. It provides new insights into regolith evolution which can improve targeting strategies in covered terrains through cost-effective and non-destructive measurement techniques.