Multi-physics imaging of an iron-oxide copper gold (IOCG) deposit under thick cover

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SUMMARY

Exploration for Iron-Oxide Copper Gold (IOCG) systems beneath thick sedimentary cover is a significant challenge due to the limitations of individual geophysical methods in resolving deep subsurface structures. This study focuses on the Vulcan IOCG prospect in southern Australia, located about 30 km northeast of the Olympic Dam mine and under 850 m of sedimentary cover. To overcome the constraints posed by thick cover, a multi-physics approach integrating broadband magnetotellurics (MT), ambient seismic noise tomography (ANT), fuzzy c-means (FCM) clustering, and natural-field induced polarization (IP) was employed.

A 100-site broadband MT and ANT array was deployed over a 9 x 9 km area, with 1 km grid spacing. Three-dimensional inversion of MT responses and 3D velocity model delineated four distinct structural domains:

1. **Cover Stratigraphy**: The sedimentary cover, comprising limestone, quartzite, and shale, exhibited resistivities of 1-30 Ω.m, corresponding well with changes in shear-wave velocity from ANT data.
2. **Brecciated Hematite Zone**: Beneath the cover, the brecciated hematite zone showed lower resistivity (<60 Ω.m) compared to the surrounding country rock (>100 Ω.m).
3. **Vertical Conductive Zone**: A highly conductive vertical zone (<30 Ω.m) extending over 5 km depth was imaged northeast of the Vulcan breccia. This zone is linked by low shear-wave velocity regions at 1-2 km depth. Regional MT inversions along a 200 km line suggested this conductive zone connects to the lower crust, potentially indicating magmatically derived CO2-rich fluids precipitating graphite in a reducing environment.
4. **Basement Low Velocity Anomaly**: A basement velocity anomaly, coinciding with a gravity high

Natural-field IP was utilized to detect disseminated sulphides associated with the Vulcan prospect. By using Earth's external magnetic field variations as the polarizing source, phase shifts in horizontal electric fields were observed up to -5 degrees in regions of brecciated hematite, where drill holes intersected pyrite.

Keywords: Mineral Exploration, Magnetotellurics, Ambient Noise Tomography, Natural-field Induced Polarization