

Using Seismic Velocity and Density to Map Lithology and Alteration in Porphyry Au–Cu Systems

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The mineralogical and structural features of porphyry deposits are expressed in terms of petrophysical variations in: (1) magnetism related to magnetite content within alteration zones (calc-potassic alteration) and primary rock type (e.g. magnetite-bearing intrusions); (2) density related to lithology (e.g. basalt versus volcanoclastic sediment); and, (3) conductivity related to pyrite and other sulfides detected by electrical methods. To these petrophysical constraints add seismic velocity, since this is sensitive to lithology, structural orientation and alteration across scales. Critically, the inherently three-dimensional nature of passive seismic data provides robust depth constraints where other methods lack depth sensitivity, enhancing our understanding of subsurface architecture, including the location of possible alteration and associated mineralisation.

Here we present a case study from the Macquarie Arc, Australia, that demonstrates how passive seismic shear-wave velocity models derived from ambient noise tomography (ANT) are able to map the multiscale architecture of a porphyry system. At the camp scale, high velocity and high density domains delineate mafic volcanics beneath Permian and younger cover, while zones of lower velocity and density likely represent volcanoclastic and sedimentary domains with possible plutonic bodies at depth. At the deposit scale, low- to intermediate-velocity zones spatially correlate with calc-potassic and phyllic alteration associated with Au–Cu mineralisation.

By reconciling velocity with magnetism, density, and drillhole data, we move toward a holistic petrophysical characterization of the porphyry environment across scales, proving valuable for exploration drill targeting.