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Investigating the whole-lithosphere architecture of a mineral system, including the sources and pathways of ore-forming fluids

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SUMMARY

The whole-lithosphere architecture controls the genesis, evolution, and transport of ore-forming fluids. Transient tectonic and geodynamic processes, occurring at various spatial and temporal scales, control the structure of the lithosphere. However, there remains questions about the source mechanism for ore-forming fluids and their depth of genesis. Thus knowledge of the deep structural framework can advance understanding of the development and emplacement locations of mineral systems. Deep geophysical exploration studies carried out with this in mind may be crucially important for targeting new ore deposits in unexplored and underexplored regions.

As a case study, we investigate a gold-copper metal belt located at the margin of an Archean-Paleoproterozoic microcontinent in central Mongolia. We explore three-dimensional models of the electrical resistivity generated from a regional-scale array of magnetotelluric data. In addition, we examine models of shear-wave velocity throughout the lithosphere.

Directly beneath the metal belt, and the surface expressions of known mineral deposits and occurrences, the electrical resistivity model reveals narrow, vertical, finger-like low-resistivity features within the high-resistivity upper-middle crust, which are connected to a large low-resistivity zone in the lower crust. A broad low-resistivity zone is imaged in the lithospheric mantle. This is well aligned with a zone of low shear-wave velocity. We carry out a quantitative correlation analysis between electrical resistivity and shear-wave velocity and observe a close correlation within the zones of interest.

In the upper-middle crust, the low-resistivity signatures give evidence for ancient pathways of fluids below the metal belt constrained by structure along a tectonic boundary. In the lower lithosphere, the low-resistivity and low-velocity signatures are interpreted to represent a fossil fluid source region. We propose that these signatures are caused by a combination of factors. In particularly, factors related to refertilization and metasomatism of the lithospheric mantle by long-lived subduction at the craton margin, possibly including iron enrichment, F-rich phlogopite, and metallic sulfides, are analysed and discussed.

Keywords: mineral exploration; mineral system; fluid pathways; electrical resistivity; shear-wave velocity