Sedimentary copper mineral systems: Large scale resistivity footprints in the Adelaide Rift Complex, South Australia

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SUMMARY

A significant challenge for the global mineral exploration industry is to identify the deep signature of world-class mineral deposits and the conceptual understanding of terrane scale fertility under cover at which mineral systems operate (Griffin, Begg, & O'Reilly, 2013; Groves & Santosh, 2015; Tassara et al., 2017). The fundamental caveat of the mineral systems approach is that ore deposits are part of a much larger system, evident at a variety of temporal and spatial scales (Hronsky & Groves, 2008; McCuaig & Hronsky, 2014). It is this scale dependency that is fundamentally important in exploration targeting, as the direct detection of ore deposits at the project scale is very difficult due to upper crustal heterogeneity, but potentially easier to predict at lithospheric scales (Hronsky & Groves, 2008).

In the sedimentary copper mineral system, it's generally agreed that the first order control is their location adjacent to failed rift basins and passive margin settings (Hitzman et al., 2010), that typically form during the breakup of the super-continents. The basinal architecture allows the deposition of oxidised syn-rifted red beds, sometimes with mafic or bimodal volcanics, which act as the source for the leaching of metals (Hitzman et al., 2010). Post rift marine and lacustrine sediments deposited later can produce areas of contained organic rich reductants necessary to form a chemical trap for the precipitation of sulphides, sometimes with large lateral extent (Hitzman et al., 2010). Evaporite sequences above the permeable post-rift sediments act as a hydrological seal, and occasionally as a source for downward moving brines through evaporite dissolution, which allows the possibility of long lasting intra-basinal fluid flow systems within which convective cells can develop with additional heat (Hitzman et al., 2010).

The Adelaide Rift Complex, itself part of the larger Adelaide Superbasin, is a large Neoproterozoic to middle Cambrian sedimentary system composing the Adelaide Rift Complex (ARC), the Torrens Hinge Zone, the Stuart Shelf, and the Coombalarnie Platform (Lloyd et al., 2020; Preiss, 2000). The stratigraphy of the ARC comprises five major successive rift cycles, evident by associated faulting, minor volcanism and distinct depositional sequences (Preiss, 2000; Lloyd et al., 2020), with the development of the ARC commencing as Laurentia began to rift from Australia-East Antarctica with Rodina.

In this study, we collect broadband MT data from 82 sites across the Northern Mount Lofty Ranges in the Adelaide Rift Complex. Sites are arranged at 10 km intervals in a rectangular grid covering 100 km N-S and 80 E-W. We supplement our newly collected MT sites with a further 80 long-period MT and broadband MT sites from previous surveys in the region and invert the entire dataset using a 3D inversion algorithm. The resulting 3D resistivity model reveals a localised elongated upper crustal conductor (~ 5 Ohm.m) spanning from the Burra to Kapunda Copper deposits which is constrained by structural dynamics from basin inversion during the Delamerian Orogeny. We argue that that this crustal conductor, is essentially the large-scale footprint of a sedimentary copper mineral system where highly saline fluids were sourced from evaporitic dissolution from the Callana Group strata.

Keywords: Sedimentary copper mineral systems, camp-scale, mineral exploration