Complex Mineral Systems and Scale Reduction in Mineral Exploration Under Cover: Can Prospecting Drilling Bridge the Critical Gap Between Camp and Deposit Scale?

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Mineral systems are complex volumes of rock with a high degree of three-dimensional spatial variability from the scale of microns to 100s of kilometers. Ore deposits are discrete volumes within the mineral system (but only a tiny fraction of the mineral system) that reach certain threshold values in terms of grade, volume, and a range of mining and processing parameters. In areas where prospective geology is exposed, the exploration process of scale reduction (from mineral system toward ore deposit) can be continually referenced to observations that are relatively cheap to collect and spatially coherent. In areas where the prospective rocks are buried, our options are more limited. Remotely gathered, spatially coherent data (for example, potential field geophysical data) are extremely useful for mapping purposes but ultimately provide only proxies for the mineral system (e.g., magnetite distribution, density). In order to understand the buried mineral system, we need samples, and to get samples we need to drill.

Drill holes potentially return a great deal of geological information, but on a vanishingly small volume of the mineral system. We are faced with a situation where tiny volumes of the system are measured in great detail as a result of extraordinary effort, over an extended period, at great cost, but are so sparsely distributed that they provide little information that would contribute to the scale-reduction problem. They do not adequately answer the question, “Where do I drill next?”

The Deep Exploration Technologies Cooperative Research Centre is developing technologies aimed at reducing the time and cost of drilling, sampling, and sensing, with aims such as dramatically increasing the density of observations within the deep exploration search space. These technologies include a coiled tubing drilling rig for mineral exploration, downhole geophysical sensing built into the drilling workflow, and Lab-at-Rig® geochemistry and mineralogy delivered in near-real time. We envisage a future exploration work flow that employs a “prospecting” style of cheap, rapid drilling and real-time analysis to quickly provide spatially coherent data in the critical range between camp and deposit scale.

In this talk we present three case studies from mineral provinces of varying commodity focus: the Eastern Goldfields of WA, the Mount Isa inlier, and the eastern Gawler craton. In each province, within the context of previous sampling, we explore the spatial patterns and population distributions of a range of components of the mineral system (focusing on commodity elements, pathfinder elements, and alteration minerals). We compare these with the known (and potential) endowment of mineral deposits in the province and derive some qualified scaling relationships in order to answer the following questions relevant to a prospecting drilling strategy: (1) What is the critical scale of observation (i.e., sample density) required to map (and understand) the mineral system? (2) What is the critical scale of observation required to vector toward deposits within that system? (3) What are the key observations to be made? (4) How do those observations translate to informed decision-making during the exploration process?