Geochemical inversion of alteration assemblages for the mineralisation fluid: examples for Proterozoic base-metal mineral systems

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The last fifty years have seen significant advances in quantitative modelling of geochemical processes related to the formation of mineral deposits, including reactive transport modelling. With exploration efforts increasingly focussed on deeply buried mineral resources, there is a challenge of utilising geochemical data on variably altered "hard-rocks" to discriminate between barren and prospective sedimentary basins. To be of discriminative value models of geochemical processes need to be able to reproduce the observed geochemical data. The general problem is that geological samples from regional exploration drilling come without the knowledge of what part of an alteration system (downstream, upstream) they belong to.

Here we present an approach to rationalise empirical observations on a set of >13,000 samples of variably altered lithologies from the Greater McArthur Basin and Mt Isa Orogen (Northern Australia). We focus on a series of the strongly altered Paleoproterozoic basalt units of 1790-1710 Ma age. These units are often suggested to be the Pb-Zn±Cu metal source for the major basin-hosted deposits of the Carpentaria Zinc Belt. The questions we are addressing are whether (1) the variety of the observed geochemical changes can be attributed to the same (or, at least similar) large-scale flow of fluid of a particular composition; (2) whether the observed alteration assemblages can be statistically attributed to particular clusters corresponding to specific alteration zones and whether we can quantitatively match (2) to (1); and (3) what are the changes in geophysical responses (magnetic susceptibilities and densities) of the large-scale geochemical processes.

In order to answer questions 1 to 3 quantitatively we introduce a clustering technique to identify the major alteration lithologies in the observed data and derive a misfit function between the model predictions and the clusters that accounts for the characteristics of the clusters. Such a misfit function provides the foundation for geochemical inversions for mineralisation fluids.