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Application of Fractal and Multifractal Analysis to Mineralized Systems with Special Reference to the Mount Isa Inlier

Thesis submitted by

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James Cook University

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STATEMENT OF CONTRIBUTIONS

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"IF WE KNEW WHAT WE WERE DOING, IT WOULD NOT BE CALLED RESEARCH, WOULD IT?" - EINSTEIN

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ABSTRACT

Previous studies have suggested that controls on mineralization can be inferred from fractal analysis of mineral deposit distributions. However, many of these potential controls have been suggested on a qualitative rather than a quantitative basis. Whereas fractal analysis of mineral deposit distributions simply considers the location of the deposits, multifractal analysis can examine variation in values of attributes assigned to each deposit location such as deposit size. Yet no comprehensive study of the multifractal properties of mineral production data has been presented.

Coupled deformation and fluid flow modelling has been used to verify sites of importance for mineralization in both two- and three-dimensional modelling space. Numerical modelling in three-dimensions of strike-slip faulting has yet to fully examine the effect of variation in fault geometry. Quantitative analysis of model outputs can provide criteria for ranking of different fault geometry parameters in terms of their relative prospectivity.

The Proterozoic Mount Isa Inlier is a rich base metal province in northwest Queensland, Australia. As a well studied and well mineralized terrain, with comprehensive literature, and detailed geological and mineral deposit databases available, the Mount Isa Inlier is an ideal study area for investigating and verifying new techniques for brownfields exploration targeting. A quantitative examination of the controls on base metal deposition in the Mount Isa Inlier has substantial implications for future exploration in the region, with the techniques being readily applicable to other study areas and commodities.

A new method is presented which evaluates mineral occurrence distributions by combining fractal analysis of clustering with Weights of Evidence (WofE). Variation in clustering of copper occurrences from the Mount Isa Inlier has a strong positive correlation with variation in clustering of fault bends (R=0.823), fault intersections (R=0.862), and mafic intrusions (R=0.885). WofE analysis as quantified by contrast values indicates that the copper occurrences have a strong spatial association with fault intersections, and fault bends. Correlation of the variation of clustering of copper

occurrences and geological features shows a linear relationship with the contrast values indicating that the geological features controlling the clustering of the copper occurrences may be the same features controlling their localization.

A fractal dimension can be used to quantify geological complexity, which characterises the distribution of faults and lithological boundaries. Two-dimensional analysis of geological complexity in the Mount Isa Inlier suggests that there exists a strong spatial relationship between geological complexity and copper endowment (R=0.914). A weak inverse relationship exists between complexity gradients and copper endowment. The results indicate that geological complexity could be used as an exploration targeting tool for copper in the Mount Isa Inlier.

The de Wijs model was developed to describe the distribution of element enrichment and depletion in the crust. An expansion of the de Wijs model is presented to investigate the distribution of ore tonnage as well as grade. The expanded model produces a log-normal relationship between ore tonnage and grade. Multifractal analysis suggests that ore tonnage values from the expanded model are not multifractal. Analysis of production data from the Zimbabwe craton displays a log-normal relationship between ore tonnage and grade, and indicates that ore tonnage is not multifractal, as suggested by the expanded de Wijs model.

Variation of fault bend and fault jog system geometry parameters during coupled deformation and fluid flow modelling of strike-slip faulting reveals that having a low dipping fault, a contrast in lithology and a wide fault width generates the highest dilation and integrated fluid flux values which can be considered proxies for prospectivity. It is demonstrated that little difference is seen between the results obtained for restraining and releasing fault bend and fault jog geometries. The fault geometries observed in the modelling to be the most prospective could be incorporated into exploration targeting strategies.

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