Paper Number: 5143

Singularity Theories and Methods for Quantitative Assessment of Concealed Mineral Resources in Covered Areas

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Concealed mineral deposits beneath covers (drifted rocks, young volcanic rocks, deserts, soils, fluvial deposits and vegetation etc.) may provide strategic economic mineral resources although these frontier regions have not yet been thoroughly explored and the situation of mineral resources in these regions are not well understood. Growing activities of mineral exploration and resource utilization in these areas highly require innovative research and development of theory and techniques suitable for mineral resource assessments and mineral deposit prediction. Due to the mask effect of the covers a limited amount of information about mineralization can be directly observed by the traditional mineral exploration techniques with classical models for data processing and interpretation. In this paper, we show that the recently developed nonlinear singularity theories and methods can be used to recognize the weak but complex geo-anomalies for the prediction of mineral deposits in areas covered by deserts, regolith, vegetation and young lava flow. The theories and models of singularity and generalized self-similarity developed in the context of multifractals are proposed for analyzing the weak anomalies caused by buried mineralization. Anomalies can be extracted from the multi-element geochemical data and geophysical data as well as from integration of diverse geo-data.

Theoretical work can prove that the singularity index involved in the local singularity analysis method reflects the fractal dimension of fractal density. Utilization of singularity analysis and fractal filtering techniques determines the essential dimensional property of the geochemical and geophysical anomalies that are independent of the geometrical scale of anomaly. Therefore, the singularity properties mapped from geochemical map and geophysical fields by the means of the local singularity analysis method are capable of enhancing the weak geochemical and geophysical anomalies caused by the deeply buried sources. Several case studies are introduced for prediction of igneous activity related iron, copper, lead-zinc, tungsten and molybdenum mineral deposits in Eastern Tianshan, Inner Mongolia, and Fujian, China. Systematic methods (pattern recognitions, anomaly enhancement, anomaly-background unmixing, diverse data integration and weak predictor boosting) were successfully applied to process the regional stream sediment and soil geochemical maps, gravity map and aeromagnetic map with the aim of extracting the weak anomalies to reveal the locations of mafic volcanic rocks, felsic to intermediate intrusions, skarn and hydrothermal alterations in the study areas. Significant target areas are delineated by the integrated approaches with drilling validation.