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Using multifractal modeling as a standard tool in geochemical exploration for predicting mineralized areas

Mario A. Gonçalves
Dept. Geology and IDL, Fac Ciencias U Lisboa, Lisboa, Portugal (mgoncalves@fc.ul.pt)

It has been 20 years since the pioneering work of Cheng et al (1994) first proposed a quantitative relationship for the areas enclosing concentration values of an element above given thresholds and their distribution in the field, known as concentration-area (CA) method, which is based in multifractal theory. The method allows the definition of geochemical anomalies in wide set of geological backgrounds but it took nearly 15 years before it became a widely used methodology for mineral exploration. The method was also extended to 1D and 3D data sets. It is worth noting the variety of methods that spanned from the theory of fractals. Building on previous models, including multiplicative cascades and size-grade relationships, increasing evidence points to the powerful tools of fractal theory to describe and model ore deposit distribution and formation. However, while much of these approaches become complex and not easy to use, the CA method is remarkable for its utter simplicity and disarming results obtained when confronted with the geological reality in the field. This is most valued by companies and professionals undertaking geochemical exploration surveys for the characterization or refining of potential ore targets or known mineralized areas. Several approaches have combined the CA method with geostatistic modeling and simulation and other established statistical techniques in order to enhance anomalous threshold identification. Examples are not restricted to geochemical exploration alone, other applications being studies on environmental change. Some of these examples will be addressed as they have been applied to different regions in the world, but particular emphasis will be put on geochemical exploration surveys in different geotectonic units of the Variscan basement in the Iberian Peninsula. These include quartz-vein gold mineralization in Northern Portugal and several surveys for base metals over two wide areas, which served to re-evaluate much of the scattered geochemical data sets that have been accumulating for decades of mining exploration in Southern Portugal. The studied zones include: the tectonic controlled quartz-vein Au-Sb mineralizations, the gabbroic and ultramafic complex of the southern border of the Ossa-Morena Zone, and the rocks belonging to the World-class massive sulfide province, the Iberian Pyrite Belt (IPB). The methodology used the CA method but also variogram analysis and modelling to outline and classify different sets of mineral deposits before confirmation in the field. This diversity of geologic contexts serves to show how effective and powerful the CA method can be, since it not only enhances already known mineralizations, it allowed the screening and identification of several new mineralized spots that have been previously overlooked. This has been of particularly economic importance because a major re-analysis of data and new exploration campaigns are currently under way for the next years in the IPB, with the potential for opening a new paradigm in the exploration for massive sulfide deposits in the region.

Cheng et al, 1994, J. Geochem. Explor., 51, 109.