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Cu ANOMALY SEPARATION BY MULTIFRACTAL MODELLING OF SOIL GEOCHEMISTRY DATA FROM FERREIRA DO ALENTEJO TO SERPA (PORTUGAL)

A. Jesus[1], A. Mateus[2], M.A. Gonçalves[3], V. Oliveira[4]

[1] CREMINER, Faculdade de Ciências da Universidade de Lisboa, Portugal, ana.jesus@fc.ul.pt
[2] Dep. Geologia & CREMINER, Faculdade de Ciências da Universidade de Lisboa, Portugal, amateus@fc.ul.pt
[3] Dep. Geologia & CREMINER, Faculdade de Ciências da Universidade de Lisboa, Portugal, macg@fc.ul.pt
[4] Instituto Geológico e Mineiro, Beja, Portugal

Abstract

The Cu soil geochemistry data set covering 570 km^2 of the Ferreira do Alentejo – Serpa region is examined in detail by means of complementary numerical procedures. The obtained results show that it is possible to discriminate promising exploration targets concerning different mineralising systems on the basis of threshold values and spatial anisotropy parameters.

Introduction

In the Ferreira do Alentejo – Serpa region, there are several evidences supporting the presence of different mineralising systems, namely those involving Cu-bearing sulphides (*e.g.* Oliveira, 1986; Mateus *et al.*, 1998; Jesus, 2002). These systems represent a variety of geological settings, ages, and thermal ore-forming conditions achieved during the Variscan Orogenic Cycle, some being characteristic of the Ossa Morena Zone southern border. That is the case of: 1) Ni-Cu(-Co) sulphide disseminations in deformed and metamorphosed wehrlite-troctolite rocks of the Beja-Acebuches Ophiolite Complex (*e.g.* Palmeira prospect); 2) Ni-Cu(-PGE?) sulphide disseminations in some gabbroic layers belonging to the lower sequences of the Beja Igneous Complex (BIC) (*e.g.* Balona site); 3) Cu(-Ni) veins and stockworks within metasomatic haloes developed in the upper layered gabbroic series of BIC (*e.g.* Castelo Ventoso quarry); 4) Cu(-Ag-Au?) epithermal type mineralisation related to the late porphyry intrusives of BIC (*e.g.* Caeirinha prospect); 5) Cu sulphide disseminations in strongly carbonatised rocks adjoining WNW-ESE shear zones (*e.g.* Western Mombeja prospect); and 6) Sb-Cu(A-Au?) quartz-carbonate lodes closely related to N-S to NE-SW strike-slip fault zones and/or to their particular secondary structural features (*e.g.* Ventosa prospect). Considering such a large diversity of coexisting Cu-bearing systems, is it possible to accurately discriminate promising exploration targets of each type on the basis of soil geochemical data? Theoretically yes, because differences in threshold values and in the anisotropy of the anomalies (ellipse axial ratio and orientation) are expected for each system provided a minimum disturbance of the soil geochemical signal occurs (strong physical erosion, surface run-off, topography driven creep). In the Ferreira do Alentejo – Serpa region, significant mixing of geochemical signals due to different mineralising systems is hard to occur because of a relatively uniform and smooth topography and a very mature drainage system. Therefore, this region seems suitable to test numerical procedures aiming the separation of soil geochemistry anomalies having different causes and thresholds, determining also their spatial anisotropy. An immense Cu soil geochemistry data set covering a large area (570 km^2), following a regularly closely spaced grid (usually 100 x 100m) was numerically processed – Fig. 1A – and the results were cross-validated with the accessible geological knowledge of some areas.

Numerical procedures

The multifractal character of the geochemical data set was determined by computing its multifractal spectrum for different areas using the method of moments (Halsey *et al.*, 1986), and correcting for edge effects (Gonçalves, 2001). Anomaly separation and threshold computation used the Area-Concentration multifractal model (Cheng *et al.*, 1994). This model has proven useful for the identification of anomalies either at a local or regional scale in different metallogenic settings (Gonçalves *et al.*, 2001). Geochemical maps were produced by ordinary kriging, but a substantial effort was put into variogram modelling as a way to study spatial variability and anisotropy. Experimental directional variograms were computed and fitted with theoretical models. Anisotropy ratio and direction was modelled with VARIOWIN (Pannatier, 1996). The output maps use the computed thresholds as cut-off for the contoured areas.

Results

Table I summarize the most relevant results categorized according to the 1:25000 Portuguese topographical maps number. The geographical positioning of these maps is shown in Fig. 1A, together with the location of the selected examples shown in Fig. 1B, 1C, 1D and 1E.

		498U	***498 C***	***498L***	***509***	***510***	***520***	***521***	***522***	***532 U***	***532 L***
MF DI (ppm)	Regional threshold	19			46	26	40	37	24	29	
	1st order local threshold	482			397	159	274	236	214	171	
	2nd order local threshold				719			481		289	
Ordinary Krigging	Nugget effect	15	120	310	550	120	295	380	160	210	400
	Sill	5.6	100	120	500	110	438	290	175	450	700
	Range	640	340	1200	1900	520	3200	1500	960	2000	1000
	Anisotropy (A_{AR})	1.8	4.3	1.8	2.9	2.7	4	2.4	1.7	2.1	2
	A_{AR} direction (º)	298	342	288	340	344	288	338	340	285	298

Table 1- MF DI- Multifractal dynamic interpolation; *U, C, L* – upper, central and lower parts of the 1:25000 maps. Exponential model was fitted to all maps, except ***498***, where a Gaussian model is used; parameters are the result of the best fit of these theoretical models to the experimental points of the semi-variograms obtained along four main directions (NS, EW, NW-SE, NE-SW).

Conclusions

From the very briefly reported results, some conclusions can be drawn. Values of regional threshold are variable and reflect mainly the prevalence of some rock types: >40 ppm when gabbroic and porphyry rocks of BIC dominate over Palaeozoic metabasaltic sequences; 30-40 ppm when a mixing of gabbroic rocks of BIC and BAOC exists; 20-30 ppm when different kinds of BIC intrusive rocks are present; and <20 ppm when the Cainozoic sediments cover a significant part of the surveyed area. The obtained local anomalous values (V_a) and anisotropy axial ratios (A_{AR}) strongly suggest that: 1) V_a≤500 ppm and 1.8≤A_{AR}≤2.5 (avg. = 2.1) concern Cu-anomalies developed within gabbroic rocks without remarkable structural control; 2) V_a≤500 ppm and 2.2≤A_{AR}≤2.9 (avg. = 2.4) indicate Cu-anomalies associated with major shear zones and/or subsidiary structures; 3) V_a≤600 ppm and 1.5≤A_{AR}≤3.3 (avg. = 2.6) point to very local Cu-anomalies that usually define alignments related to strike-slip fault zones; and 4) V_a≤600 ppm and 1.8≤A_{AR}≤2.2 (avg. = 1.9) correspond to Cu anomalies that follow major lithological contacts (namely between intrusive rocks of BIC and the Proterozoic sequences). The latter case is the only one that does not have any direct relationship with the present known mineralising systems in the surveyed area, corroborating the hypothesis stated in Mateus *et al.* (1998) concerning the high probability of Cu-skarns development in the Ossa Morena Zone southern border; further work is however needed to confirm such a geological reasoning.

Acknowledgements

Access to the Cu soil geochemistry database of IGM is appreciated.

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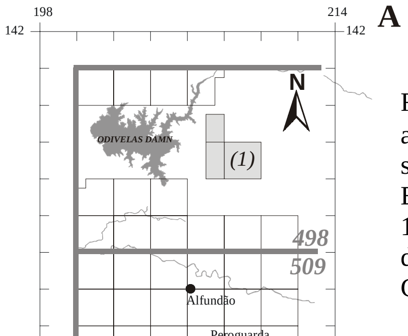
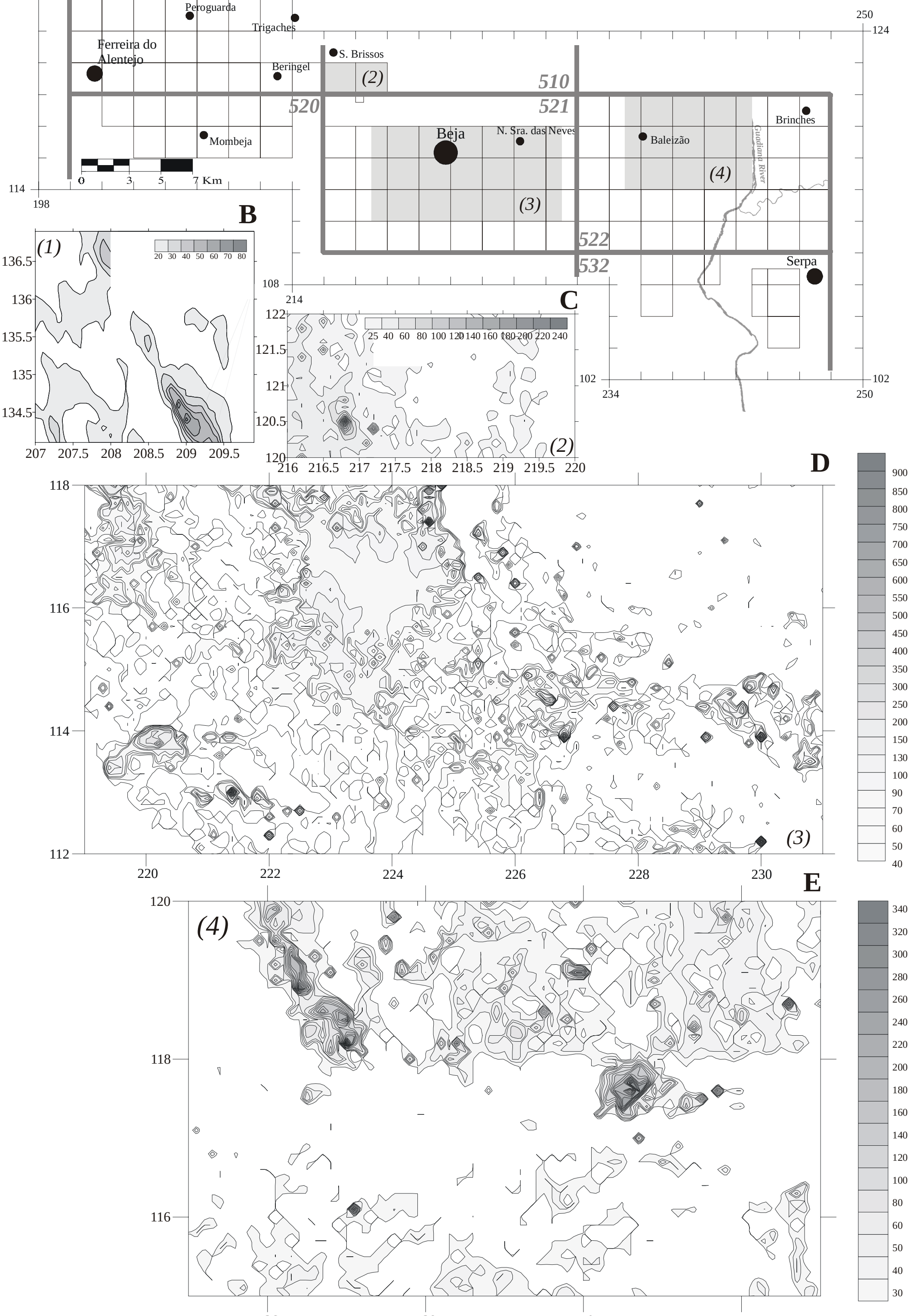

Fig.1 – A: Geographical positioning of the surveyed area following a regular grid (usually 100×100 m) originally defined in 1:5000 scale maps; the coordinate system used is the International Gauss Ellipsoid Lisbon Datum. The numbers and limits of the Portuguese 1:25000 topographical maps are also shown, as required by results displayed in Table 1. Areas in grey mark the selected examples of Cu-anomalies (B, C, D and E); greyscale in ppm.