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Autor: Vários

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Modelação do jazigo de sulfuretos maciços de Caveira (Faixa Piritosa Ibérica) com base em geoquímica de solos e inversão gravimétrica

Soil geochemistry and gravity inversion modelling of the Caveira massive sulphide deposit, Iberian Pyrite Belt

Matos, J. X.[1*]; **Batista, M. J.**[2]; **Represas, P.**[2]; **Pereira, Z.**[3]

[1] Laboratório Nacional de Energia e Geologia, I.P., R. Frei Amador Arrais 39rc. Ap. 104 - 7801.902 Beja, Portugal, joao.matos@lneg.pt

[2] LNEG, Ap. 7586 - 2610-999 Amadora, Portugal

[3] LNEG, Ap. 1089 - 4466-901 S. Mamede Infesta, Portugal

Resumo

Explorada até 206 m de profundidade, desde a época romana até 1973, a mina da Caveira localiza-se no setor NW da Faixa Piritosa Ibérica, numa estrutura antiforma do Complexo Vulcano-Sedimentar (CVS), de direção NNW-SSE e inclinação NE, cujo núcleo é constituído pela Unidade Corona Inferior do Grupo Filito-Quartzítico, de idade Givetiano inferior. O CVS é formado por: i) xistos negros da Formação Lousal-Caveira (Estruniano) e rochas vulcânicas quartzo-feldspato porfiríticas de idade Famenniano, com mineralizações associadas de sulfuretos (maciças, semi-maciças e stockwork) distribuídas pelos setores oeste (Poço Helena – comprimento 106m e espessura <26m) e NE (Poço Luísa - comprimento 200m e espessura <18m); ii) unidade superior (de idade Viseano?) formada por xistos com nódulos, sedimentos vulcânicos, chertes, jaspes, rochas vulcânicas básicas intrusivas e extrusivas, xistos negros, siliciosos e violeta. A SW o CVS contacta com o Flysch da Formação de Mértola (Viseano Superior). Apresenta-se a modelação gravimétrica e a geoquímica de solos (Cu, Zn e Pb) da estrutura de Caveira. As conclusões têm como base a cartografia de detalhe, logs de sondagens, gravimetria, magnetometria, densidade de rochas e geoquímica de solos (Cu, Zn e Pb). Indicam-se os principais guias de prospeção, com destaque para o setor oriental, onde se evidenciam anomalias relacionadas com as unidades estrunianas do CVS, com elevado potencial mineral.

Palavras-chave: Jazigo de sulfuretos de Caveira, gravimetria e geoquímica de solos, Faixa Piritosa Ibérica

Abstract

Located in the northwest sector of the Iberian Pyrite Belt (IPB), the Caveira massive sulphide deposit was mined (from Roman times to 1973), up to a depth of 206 m. The geology is dominated by NNW-SSE trending and NE dipping complex antiform, with Phyllite-Quartzite Group (PQG), Corona Unit of lower Givetian age in the centre, surrounded by the Volcano-Sedimentary Complex (VSC), that includes: i) a Lower Unit (Strunian age) represented by shales of the Lousal-Caveira Formation, felsic quartz-feldspar porphyritic volcanics and associated sulphide mineralizations; ii) an Upper Unit (Visean?), represented by volcanic sediments, shales with nodules, cherts, jaspers, black shales, basic intrusive and extrusive volcanics, purple shales and siliceous shales. To the SW the VSC contacts with the Mértola Formation (Upper Visean) shales and greywackes. Two sulphide ore (massive, semi-massive and veins) horizons are considered: western sector (Helena shaft) <26 m thickness/106 m length; eastern sector (Luísa shaft) <18 m thickness/200 m length. The Caveira mine modelling was undertaken and supported by mapping, borehole interpretation, gravity, magnetometry, rock density and Cu, Zn, Pb soil geochemistry. Stratigraphic guidelines are defined considering future PQG/VSC exploration. Caveira eastern sector shows favourable gravity and geochemistry anomalies related to Lower VSC, presenting favourable scenarios to massive sulphide occurrences.

Keywords: Caveira massive sulphide deposit, gravity and soil geochemistry exploration, Iberian Pyrite Belt

Caveira mine - geological setting

Mined until 1973 the Caveira IPB massive sulphide deposit was explored by the EEM, Mines et Industrie, SPE-SEREM-EDMA, SMRA and Maepa/Avrupa mining companies, that developed gravimetry, magnetometry, soil geochemistry, electromagnetic surveys for targeting and drilling 16 boreholes. The geology is dominated by NNW-SSE antiform, with phyllites and quartzites in the centre, representing the Phyllite-Quartzite Group (PQG) Lower Corona Unit of lower Givetian age (Matos et al. 2014, Matos et al. 2011b, Pereira et al. 2008), limited by the Volcano-Sedimentary Complex (VSC) including, from base to top: i) a lower unit represented by the black shales of Lousal-Caveira Fm. (late Strunian age) and associated felsic quartz-feldspar porphyritic volcanic rocks and massive sulphide mineralizations; ii) an upper unit, of Visean age (?), represented by volcanic sediments, shales with nodules, cherts and jaspers, black shales and basic intrusive and extrusive volcanics, purple and siliceous shales. The Caveira mineralization is hosted by Strunian age black shales and felsic volcanics. Two main ore horizons are considered (Matzke 1974): western sector (Helena shaft/Salvador open pit), Noroeste/São João and Salvador/ Esperança lenses; and northeastern sector (Luísa shaft), Canal/Frederico/Francisco and Augusto/ António lenses. Variscan deformation including folding, thrusting and shear zones are present.

Modelling and data integration

The Caveira geological study was based on the update of the geological 1/2500 mapping (Matos 2006, Fig.1) and reinterpretation and stratigraphic study of 11 exploration boreholes. The gravity data used in this study was produced using the available LNEG database, consisting of geophysical land surveys, with a distance between readings of ~100 m-200 m. Borehole rock density SMRA data (Castelo Branco 1994) were combined and measured in the different rock lithologies.

The Cu, Pb and Zn soil geochemistry maps were produced using 464 sample results of the SMRA exploration data (Castelo Branco 1994) distributed in NE-SW profiles, considering a global grid of ~100 m – 120 m. The soil samples were superficial (~20 cm) and the <80 mesh fraction was analysed by AAS. Geochemical mapping was done using the minimum curvature method that produces a grid by repeatedly applying an equation over the grid in an attempt to smooth it. Each pass over the grid is iteration. The minimum versus maximum iterations calculated were 16-100, respectively. Ternary maps were produced using RGB colours of Cu-Pb-Zn, respectively. The Cu/Zn map and ternary map were considered to try to avoid the old exploitation related anomalies.

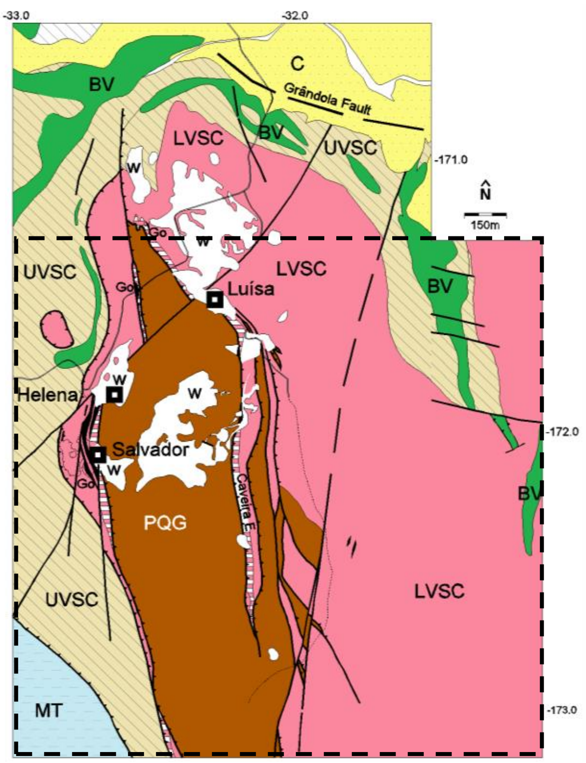

Fig. 1. – Caveira geological map: PQG - Phyllite-Quartzite Gr.; LVSC - Lower VSC, pink/white lines – Lousal-Caveira Fm. (Strunian age); Go – Gossan; UVSC - Upper VSC, BV – basic volcanics; MT - Mértola Flysch; C – Cenozoic; W - mining waste. Dash line – Fig. 2 gravity work area. Hayford-Gauss D73 coordinates in km.

Gravity data and inversion

The Caveira residual gravity map reflects the local geodiversity and differences in rocks density between PQG (ρ ~2.72), VSC sediments and felsic volcanics (ρ~2.65-2.73), VSC basic volcanics (ρ~2.81-2.95) and semi-massive and massive sulphide ore (ρ ~3.16). The residual anomaly was determined by the removal of a regional anomaly, calculated by a 300 m upward continuation, from the complete Bouguer anomaly. The residual gravity field was inverted using a stabilized non-linear inversion method developed by Camacho et al. (2002). With this technique the geometry of the sources of the observed gravity anomalies is determined by the adjustment of a 3-D model of prismatic cells which adopt a priori values of density contrast (positive and negative). The algorithm looks for the sources of the anomalies by a 3-D aggregation of the prismatic cells, which are filled, in a growth process, by prescribed positive or negative density contrasts, until it reaches a model that minimizes the residuals between the observed data and the models response. The best results (Fig. 2) were obtained considering min. and max. density contrasts of -100 and 100 kg/m^3, which is in accordance with the measured density data.

Soil geochemistry

Soil geochemistry gives a superficial distribution of the chemical elements, and therefore reveals the human influence, thickness of the overburden, organic matter content and the topography, which introduces changes in the chemical elements distribution, not related with the outcropping rocks and mineralizations. Copper and zinc data were carefully selected to avoid mine waste dump data. Even so, the Cu distribution was very much influenced by the mining activity whereas Zn seems to have less influence of that kind, see Fig. 3. To characterize the Cu, Zn and Pb distribution a ternary map was built (Fig. 4) showing areas where concentrations were preferential to each element and altogether.

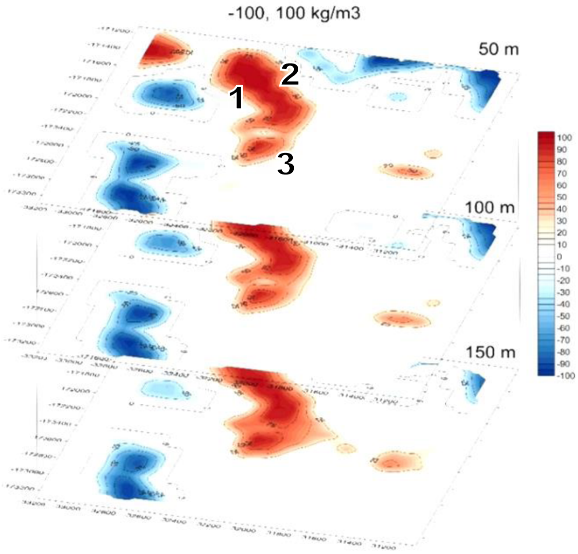

Fig. 2 - Density contrast model resulting from the 3D inversion of gravity data (50 m, 100 m and 150 m slices). Sulphide mineralizations: 1 - Helena/Salvador, 2 - Luísa, 3 - Caveira East. HG D73 coordinates in meters.

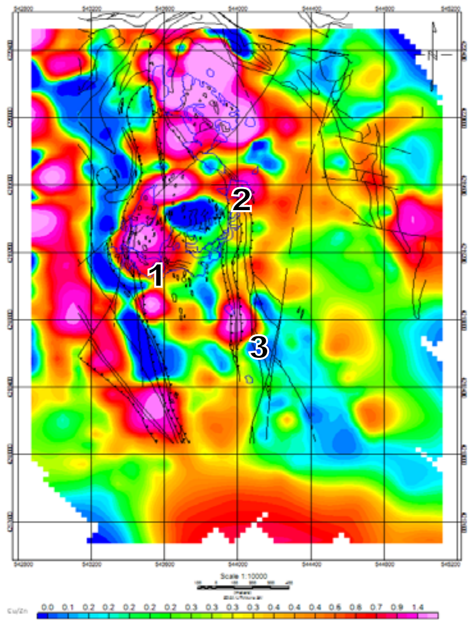

Fig. 3 - Soil geochemistry Cu/Zn relation map, overlayed by geological contacts (black lines) and tailings contour (blue lines). Explanatory geological legend is represented in Fig. 1. Sulphide mineralizations: 1 – Helena/Salvador, 2 – Luísa, 3 – Caveira East. Grid 400m, UTM ED50 coordinates in meters.

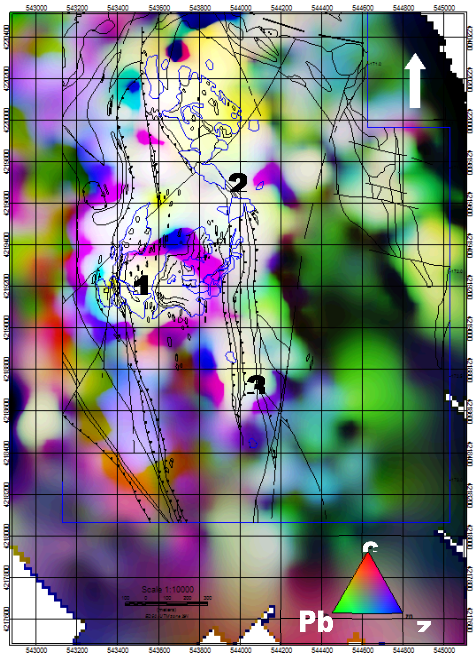

Fig. 4 - Geochemical ternary map (RGB colour) of Cu-Pb-Zn overlayed by geological contacts (black lines) and mine waste limits (blue lines). See geology in Fig. 1. Sulphide mineralizations: 1 – Helena/ Salvador, 2 – Luísa, 3 – Caveira East. Grid 400m, UTM ED50 coordinates in meters.

Discussion and exploration guides

The Caveira massive sulphide deposit presents the same Strunian age of important IPB deposits as Neves Corvo, Tharsis, Aznalcollar and Lousal (Matos et al. 2011b, Matos et al. 2014) and similar ore mineralogy (Mateus et al. 2008). The complexity of the Caveira antiform, dominated by structural corridors between the PQG and VSC units, demands a careful interpretation of the geophysical and geochemical data. However, the density contrast model resulting from the 3D inversion of gravity data shows positive scenarios, linked to the probable presence of sulphide mineralizations in depth in the northeastern and eastern Caveira sectors. The Cu/Zn soil geochemistry map (Fig. 4) shows the enrichment of Cu in the upper VSC units, represented by volcanic sediments, shales with nodules, purple shales, cherts and jaspers, black shales and important basic intrusive and extrusive volcanics whereas Zn indicates supergene enrichment with high concentration in gossan samples, represented by a NNW-SSE negative anomaly in this ratio map. It is possible to observe the structural NW-SE alignment also observed in the gravity map, although geochemical anomalies may be displaced due to the topography even though, basic volcanics, in the eastern sector of the area, shows high Cu concentrations. It is not possible to draw any conclusions about the central mined area in Caveira, where the presence of a large amount of mining wastes is reflected in all Cu-Pb-Zn anomalies as shown in the ternary map, Fig. 4. Besides this, the influence of the referred NW-SE structural alignment is observed. The less evident NNE-SSW anomalies, related with vertical strike slip faults, can be observed in the Pb component of Fig. 4. These data were also confirmed by Pb soil geochemistry mapping. The geology-gravity-geochemistry data combination used in this study seems to point that it is a successful tool in predictive studies. To future success an interactive methodology must be followed, considering the presence of the Lousal-Caveira Formation of Strunian age, a key geological guide in the exploration of the IPB NW region.

References

Castelo Branco, J.M., 1994 Grândola-Alcácer do Sal Area SMRA Report, LNEG Archive ID12989 doc, 297p.

Camacho, A.G., Montesinos, F.G., Vieira, R., 2002. A 3-D gravity inversion tool based on exploration of model possibilities. Computers & Geosciences, 28, 191–204. doi:10.1016/S0098-3004(01)00039-5.

Mateus, A., Figueiras, J., Matos, J.X., Gonçalves, M.A., Lopes, R., Labaredas, J., Beleque, A., 2008. Condicionantes impostas à dispersão de metais acumulados em escombreiras: o exemplo de Caveira (FPI). MCoimbra ISBN: 978-989-95994-0-6: 373-382.

Matos, J.X., 2006. Carta geológico-mineira da Caveira, escala 1/5000, INETI.

Matos, J.X., Pereira, Z., Rosa, C.J.P., Rosa, D.R.N., Oliveira, J.T., Relvas, J.M.R.S., 2011. Late Strunian age: a key time frame for VMS deposit exploration in the IPB. 11th SGAmeeting, Antofagasta, 790-792p.

Matos, J.X., Pereira, Z., Rosa, C., Oliveira, J.T., 2014. High resolution stratigraphy of the Phyllite-Quartzite Group in the northwest region of the IPB, Portugal Com. LNEG T. 101, ISSN: 0873-948X, 489-493

Matzke, K, 1974. Unpublished Report Mine Et Industrie, SA, Caveira Area, LNEG Archive ID12658 doc, 23pp.

Pereira, Z., Matos, J.X., Fernandes, P., Oliveira, J.T., 2008. Palynostratigraphy and Systematic Palynology of the Devonian and Carboniferous Successions of the South Port. Zone. Mem 34 INETI: 1-176p.