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Geological 3D Modelling and Soils: functions and threats

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3D POTENTIAL FIELD MODELLING OF RÍO TINTO AREA. NEW INSIGHTS INTO ITS GEOLOGICAL STRUCTURE

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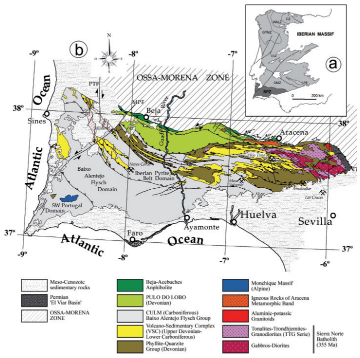
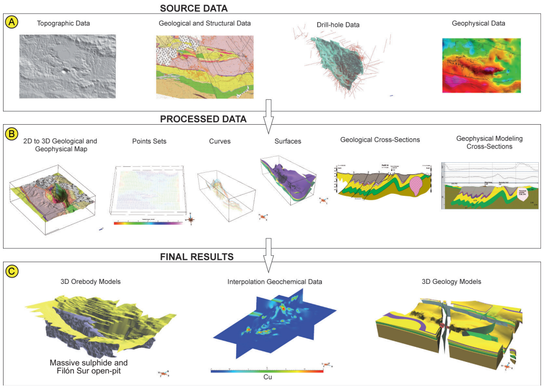
INTRODUCTION



The **Iberian Pyrite Belt** (IPB) is a Variscan metallogenic province in SW Iberia hosting the largest concentration of massive sulphide deposits worldwide. The IPB has a relatively simple stratigraphic column that consists of three major lithostratigraphic units.

The lowermost stratigraphic unit is the early Givetian to late Famennian **Phyllite-Quartzite Group** (PQG), with shales, quartz-sandstones, quartzwacke, minor conglomerate and limestones at top. Over them, the **Volcano-Sedimentary Complex** (VSC), that comprises a submarine volcanic succession, with VHMS deposits. At the top there is thousands of meters thick **Baixo Alentejo Flysch-Culm-Group** (CG) of late Visean to Moscovian age. To the East of the IPB, there are subvolcanic-plutonic rocks, the **Sierra Norte Batholith** (SBN), which represents the continuation of the VSC. The SNB includes geochemical associations of mafic rocks (gabbro-diorite) and granitoids with TTG affinities. Tectonically, variscan NW-SE/W-E-trending and SW/S-verging folds and thrusts occur in western/central and eastern IPB, respectively. In late to post-Variscan time strike-slip oblique faults formed, either N-S to NNW-SSE or NE-SW to ENE-WSW, dextral or sinistral (both extensional), respectively.

WORKFLOW



Schematic flow-chart for 3D modelling through data integration between source data, GIS and gOcad.

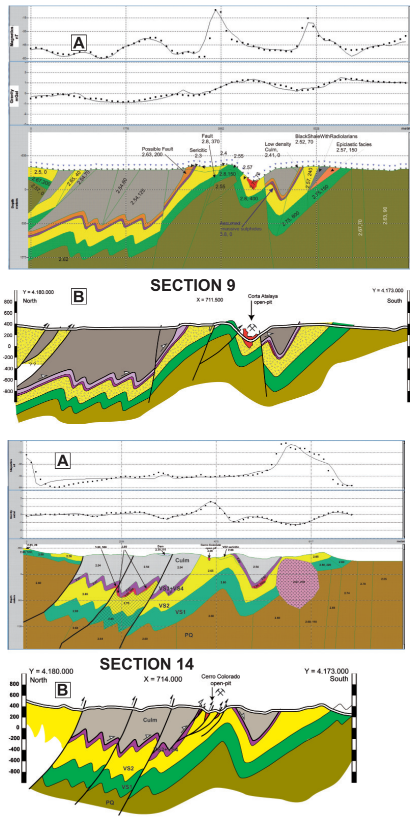
A/ The input-source data used in this study are the topographic reference, new geological map, structural data and samples for petrological and petrophysical characterization, geophysical data with corresponding interpretations and models, and borehole data.

B/ The first step of the proposed methodology refers to the creation of a geological database, which includes all the information needed for 3D modelling. Six main typologies of geometric features and related attributes are exported from an ArcGIS-geodatabase.

C/ All these layers are processed within the gOcad environment with adequate interpolators to generate 3D layers of curves and surfaces, and finally voxets of the modelled bodies.

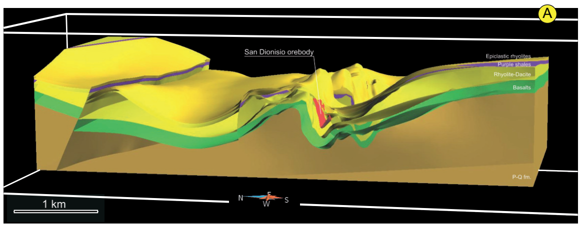
Documents from mining activities have been made available, which has allowed the reconstruction of historical ore bodies (left).

PROCESSED DATA

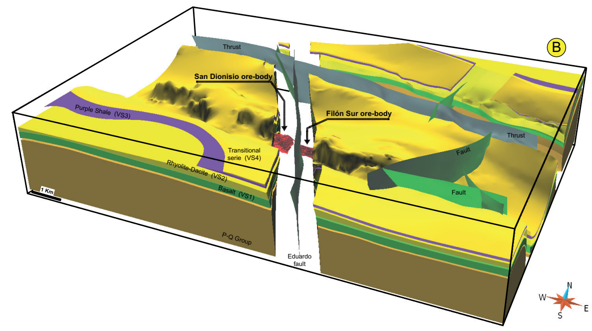


Section 9 and 14. A) Fitted to **gravity and magnetic anomalies cross-section model**. Note the adjustment between measured (dotted line) and calculated (solid line) responses (magnetic above, gravimetric below). **B**) **Geological cross-section**. Density in g/cm³. Red- assumed massive sulphides with a density of 3.8 g/cm³. RMS of the gravity anomaly differences between observed and calculated is 0.18 mGal. (2.54, 125= first number, density in g/cm³; second number, magnetic susceptibility in cgs).

MODEL

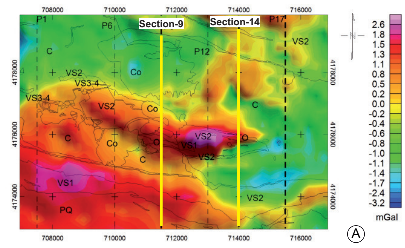


The 3D model obtained shows the general structure in the area, a wide syncline with an anticline in the middle with the Culm formation above. The contact with the VSC is a detachment, eroding some parts of the underlying units. In order to make the figure easier to understand, this layer is not present in the figure, or the eroded upper part, so it becomes clear the folding at the central part and how it affects the sulphides. The sulphide massive ore-body is also shown, revealing their relationships with the acid volcanism and how they have been affected by the tectonics.

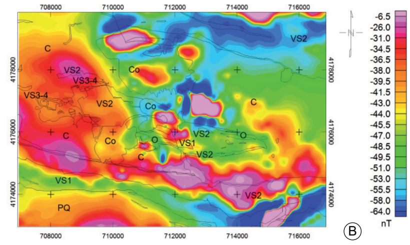


The 3D modelling of the Río Tinto geological structure and of the relationships between the thrusts and faults has greatly improved the understanding of this complex structure. 3D modelling takes into consideration the strong lateral variations of the tectonic features and the thickness of each volcanic unit. Folded surfaces have been finally constructed in gOcad using cross-sections, fold axes and surface stratigraphic boundaries as constraints.

GEOPHYSICS



The **residual Bouguer anomaly map** displays three zones that vary between 0 and -3.2 mGal in the north (Culm facies and acid VSC facies), more than +3.5 mGal in the Rio Tinto ore mine and +2.6mGal in the South coinciding with the P-Q Group and basic VSC facies.



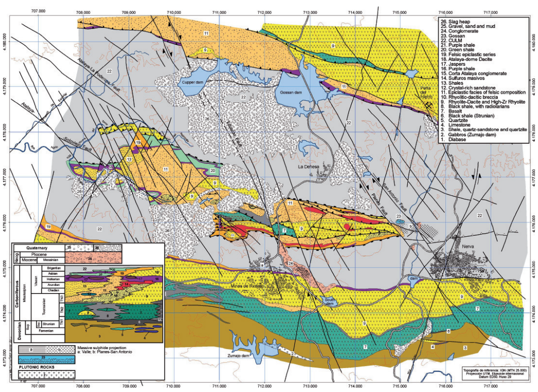
Regarding discrete anomalies, **total field reduced to the pole aeromagnetic map** two zones can be established. One of them it is a low field areas (below -45 nT, green-blue colours) in the north (also low density) and other one with high field of intensity (over -45 nT, yellow-red colours) in the south.

This bimodal magnetic response does not coincide with a bimodal density since homogeneous high values are showed in this area. A few shortwavelength high magnetic anomalies are depicted in the centre of the area probably related to some dumpling materials from the mine working.

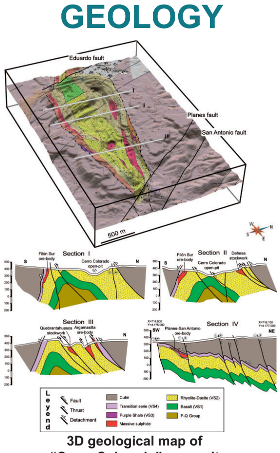
	Measured Density d (g/cm³)			Measured Susceptibility k (*10-6 ucgs)		
Sampled units	Nº	range	avg	range	avg	Main ferromagnetic mode
P-Q	12	2.92-2.27	2.60	117.00-8.00	35.51	-
VS1-Basalts	55	3.00-2.34	2.80	2115.00-3.00	118.11	-
VS2-Rhyolites-Dacites	77	2.96-2.32	2.65	630.00-0.00	61.86	-
VS2-Rhyolites hight Zr	7	2.77-2.42	2.64	31.83-0.00	9.78	-
Green slates	2	2.56-2.21	2.38	21.49-0.00	10.74	-
ORE	10	4.86-3.45	4.30	86.00-1.59	44.79	-
VS3-Purple slates	37	3.00-2.07	2.57	100.00-4.00	33.35	-
VS4-Acid Epiclastic serie	27	2.84-2.31	2.63	655.00-2.00	66.63	-
Culm	7	2.70-2.24	2.41	60.00-0.00	24.57	-
Total	234	4.30-2.38	2.78	2115.0-21.5	45.04	

In this work we have also realized a new gravimetric survey (2 points per km²) and petrophysical data, totalizing 327 gravity stations and 234 petrophysical samples.

GEOLOGY

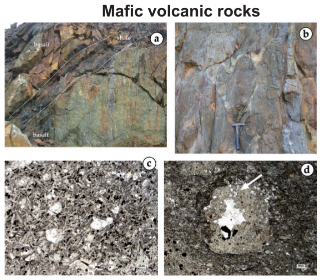


In the project we realized a new **geological map** of the area at 1:10,000 scales. At the same time, 44 cross sections have been interpreted from the map, as input for the potential fields modelling, with special focus on the Río Tinto anticline.



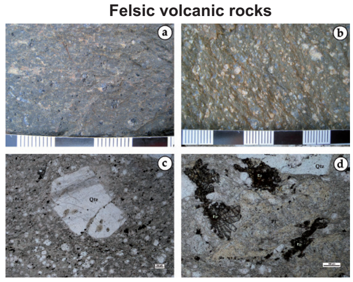
3D geological map of "Cerro Colorado" open-pit

Mafic volcanic rocks



Volcanic facies and mineralization of the basalts. **a**) Black shale layer between two basalt flows. At the bottom right, basalt is affected by the 'Corta Atalaya' stockwork. **b**) Pillow-lavas of Cerro Colorado. **c**) Textural microscopic appearance of basaltic lava. **d**) Photomicrograph of a vacuole (v) filled with chlorite, quartz and pyrite core, basalt with chloritic alteration.

Felsic volcanic rocks



a) Fresh rhyolite with quartz phenocrystals. **b**) Fresh dacite with quartz and plagioclase phenocrystals. **c**) Microscopic textural aspect of a rhyolite. **d**) Microscopic textural aspect of a dacite; in the central part, we see a plagioclase crystal altered to mica (muscovite). (Qtz=quartz; Pl=plagioclase; Ep=epidote; Ms=muscovite)

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