

# XI



# CONGRESSO NACIONAL DE GEOLOGIA

GEOCIÊNCIAS E DESAFIOS GLOBAIS

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*Coordenadores da Edição*

*F. C. Lopes, P. A. Dinis, L. V. Duarte, P. P. Cunha*

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**Universidade de Coimbra**

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## Organic petrography applied to the study of thermal maturation of black shales and implications to Cu mineralization in Ossa Morena Zone

### Petrografia orgânica aplicada ao estudo da maturação térmica de xistos negros e implicações nas mineralizações de Cu da Zona Ossa-Morena

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**Sumário:** A refletância da matéria orgânica é um parâmetro petrográfico robusto na determinação da maturação térmica de rochas permitindo estimar paleotemperaturas e avaliar a evolução térmica associada aos processos que afetaram estas rochas. Este trabalho tem como objetivo determinar a maturação térmica de xistos negros especialmente associados a mineralizações de Cu na Faixa Metalogénica de Sousel-Barrancos (Zona Ossa Morena). Os resultados da refletância da matéria orgânica destas rochas permitiram estimar paleotemperaturas de até cerca de 350°C e identificar um padrão irregular de maturação associado à circulação de fluidos hidrotermais característicos da instalação de veios mineralizados de Cu em Miguel Vacas.

**Palavras-chave:** Miguel Vacas, xistos negros, matéria orgânica, refletância, paleotemperatura, fluidos hidrotermais.

**Key words:** Miguel Vacas, black shales, organic matter, reflectance, paleotemperature, hydrothermal fluids.

The maturation of dispersed organic matter in rocks, such as black shales, developed after its deposition, resulting from the burial history, controlled by the increase and duration of heat and pressure (Suárez-Ruiz et al., 2012), and other geological processes such as magma installation, burial, metamorphism, and circulation of hydrothermal fluids. The maturation of organic matter (OM) in rocks can be determined based on the measurement of their reflectance, which can be used to estimate the paleotemperature (Barker & Pawlewicz, 1994).

The detailed characterization of organic matter in black shales and the evaluation of the time-temperature history in ores or host rocks can be used to identify and understand ore deposits genesis and/or other processes affecting these deposits.

This work aims to estimate the thermal maturation and paleotemperatures of black shales spatially associated with Cu deposits in Ossa-Morena Zone (OMZ), and identify implications related to the deposit formation.

In OMZ, specifically in Sousel-Barrancos metallogenic belt, several Cu-Fe ( $\pm$ Zn  $\pm$ Pb  $\pm$ Au) vein-type occurrences and deposits are known. The Cu-Fe veins are composed of quartz-carbonate and sulphides, hosted in Paleozoic metasedimentary series (e.g., Mateus et al., 2013). There are two important clusters of Cu occurrences: (1) Alandroal cluster, (Bugalho, Mociços, Zambujeira and Miguel Vacas), and (2) Barrancos cluster (Minancos, Aparis, Botefa and Defesa das Mercês) (Mateus et al., 2013). Most of the veins are hosted in black and grey shales, sometimes with interbedded lydites and black quartzites of Silurian to Lower Devonian ages. With respect to the genesis of these veins, it is considered that the mineralized structures are related to the hydrothermal activity contemporaneous of late Variscan brittle deformation stages (Mateus et al., 2013).

A total of 29 samples of black shales were collected in 5 exploration drill-cores of the Miguel Vacas deposit. Samples were collected at different depths and the proximity to mineralized veins were controlled during

sampling. The samples were dried and crushed to 1 mm size-grains, mounted in polished blocks for petrographic analysis, in accordance with ISO 7404-2 (2009) standard. The random and maximum reflectance ( $R_r$  and  $R_{max}$ , respectively) were measured following the ASTM D7708-14 (2014) standard. To evaluate the maturation of the OM, the classification proposed by Kwiecinska & Petersen (2004) based on the  $R_{max}$  values was considered. The paleotemperature was estimated using Barker & Pawlewicz (1994):  $T_{max} = (\ln R_r + 1.19)/0.00782$ . Reflectance measurements were carried out in vitrinite-like particles and graptolites since vitrinite is absent in rocks dated from Silurian. The equivalent vitrinite reflectance for the studied samples was calculated according to Petersen et al. (2013) with the equation:  $VR_{eq} = 0.73 \times R_{grap} + 0.16$ . The maturation of OM varies between the range of anthracite and semigraphite, although most of samples show a thermal maturation of anthracite

rank. The estimated paleotemperatures for the studied samples range from 223°C to 351°C. Samples from drill-cores 2, 3, and 5 do not exhibit variable maturation of OM with depth, evidencing a heterogeneous pattern. On the other hand, in drill-cores 1 and 4, the maturation seems to show an increasing trend with depth. The irregular distribution of maturation with depth in the Miguel Vacas drill-cores, sometimes with lower  $R_r$  underlying higher values, is attributed to the circulation of hydrothermal fluids. Irregular profiles are characteristic of OM matured by fast heating due to irregular heat distribution in hydrothermal-geothermal systems (Glikson et al., 2000). The results also reveal a lateral variation of OM maturation, supporting the effect of circulation of hydrothermal fluids related with Cu-ore deposit genesis. The values higher paleotemperatures may indicate the proximity to the mineralized vein or local veining.

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## References

- ASTM D 7708-14 (2014). Standard Test Method for Microscopical Determination of the Reflectance of Vitrinite Dispersed in Sedimentary Rocks. ASTM International.
- Barker, C.E. & Pawlewicz, M.J. (1994). Calculation of vitrinite reflectance from thermal histories and peak temperatures - a comparison of methods. In: P.K. Mukhopadhyay & W.G. Dow (eds.). *Vitrinite reflectance as a Maturity Parameter. Applications and Limitations*. ACS Symposium Series, 216-229.
- Glikson, M. & Mastalerz, M. (2000). Organic Matter and Mineralisation: Thermal Alteration, Hydrocarbon Generation and Role in Metallogenesis. Springer Dordrecht.
- ISO 7404-2 (2009). Methods for the petrographic analysis of coals -- Part 2: Methods of preparing coal samples. International Organization for Standardization.
- Kwiecinska, B. & Petersen, H.I. (2004). Graphite, semi-graphite, natural coke, and natural char classification-ICCP system. *International Journal of Coal Geology* 57, 99-116.
- Mateus, A., Munhá, J., Inverno, C., Matos, J., Martins, L., Oliveira, D., Jesus, A. & Salgueiro, R. (2013). Mineralizações no sector português da Zona de Ossa-Morena. In: R. Dias, A. Araújo, P. Terrinha, J. C. Kullberg (eds.). *Geologia de Portugal, Volume I - Geologia Pré-mesozóica de Portugal*. Escolar Editora, 577-615.
- Petersen, H.I., Schovsbo, N.H. & Nielsen, A.T. (2013). Reflectance measurements of zooclasts and solid bitumen in Lower Paleozoic shales, southern Scandinavia: Correlation to vitrinite reflectance. *International Journal of Coal Geology* 114, 1-18. <http://dx.doi.org/10.1016/j.coal.2013.03.013>.
- Suárez-Ruiz, I., Flores, D., Mendonça Filho, J.G. & Hackley, P.C. (2012). Review and update of the applications of organic petrology: Part 2, Geological and Multidisciplinary Applications. *International Journal of Coal Geology* 98, 73-94.