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ORIGINAL PAPER

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Coalification history of the Stephanian Ciñera-Matallana pull-apart basin, NW Spain: Combining anisotropy of vitrinite reflectance and thermal modelling

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Abstract The Stephanian Ciñera-Matallana Basin of NW Spain comprises 1,500 m of alluvial to lacustrine coal-bearing sediments, which were deposited in a late Variscan transtensional/transpressional pull-apart setting. The relationship between coalification pattern and rock deformation was evaluated by measurements of the anisotropy of vitrinite reflectance (AVR). The AVR ellipsoids reveal both pre-tectonic elements related to the bedding fabric and syn-tectonic elements related to folding, producing biaxial ellipsoid shapes with the maximum reflectance parallel to fold axes. The mean coalification gradient for the Stephanian succession is about 0.62 %Rr/km. Calculations of the mean palaeo-geothermal gradient are presented on the basis of three different empirical equations. A palaeo-geothermal gradient of 85 °C/km is considered the most realistic, with an overburden of about 1,000 m. 1-D numerical modelling of the burial history results in two possible scenarios, the most preferable involving a palaeo-heat flow of 150 mW/m^2 and an overburden of ca. 1,050 m. These results indicate that maximum coalification was related to a localised but high palaeo-heat flow/-geothermal gradient. The anisotropy of vitrinite reflectance highlights the interactive and transitional nature of sedimentary compaction and rock deformation on the maturation of organic material within strike-slip fault zones.

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Introduction

The Stephanian Ciñera-Matallana Basin (CMB), located in the Cantabrian Zone of NW Spain (Fig. 1A), is one of the most important coal mining districts of the Iberian Peninsula with more than 100 years of mining tradition. Despite this, no published study has attempted a quantitative characterisation of the overall coalification and thermal history of this small, fault-related pull-apart basin. The CMB is one of several Stephanian coal basins positioned along the southern border of the Cantabrian Zone, all of which have complex depositional and tectonic histories. These strike-slip fault related basins, especially the CMB, are positioned in key sites for unravelling the geological and thermal development of the Cantabrian Zone during the late stages of the Variscan orogeny (Garcia-Lopez et al. 1999), and the transition to Permian crustal extension and volcanism (Fernandez-Suarez et al. 2000).

There is a long tradition in using the patterns of coalification to reconstruct the thermal history of sedimentary basins (Teichmüller 1987a; Yalcin et al. 1997; Taylor et al. 1998, and references herein). The distribution of coalification grade, measured by the random vitrinite reflectance (%Rr), enables construction of surface maps and cross sections that incorporate isoreflectance lines (e.g. Kalkreuth et al. 1989; Hertle and Littke 2000). The geometric relationship between isoreflectance lines and bedding planes allows differentiation between pre-, syn- and post-tectonic coalification at a regional scale (Teichmüller and Teichmüller 1966). To evaluate the relationship between coalification and tectonic deformation in greater detail, the anisotropy of vitrinite reflectance (AVR) can also be measured. During the process of coalification the inner aromatic structure of the organic material responds to directional stress