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Petrographic organic matter characterization for calibrating 1D thermal models of an inverted extensional basin (Cameros Basin, North of Spain)

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Introduction

1D thermal models can be very helpful to reconstruct the geological and thermal history at one or more points in a sedimentary basin (Higley et al., 2006). In fact burial histories can be constructed using geological data from wells, outcrops, seismic sections, etc., In addition 1D thermal models can calculate the effect on thermal maturation of sedimentological and tectonic processes as burial, uplift, erosion (Higley et al., 2006). Fundamental for the interpretation of the obtained results is the calibration of the thermal models with precise and reliable paleothermometers.
Organic matter characterization and particularly vitrinite reflectance measurement represent an excellent tool for defining the thermal maturity of the sediments from a stratigraphic succession (Suárez-Ruiz et al., 2012).
This work demonstrates how petrographic analyses of organic matter can validate and integrate the results of 1D thermal models of an inverted extensional basin, the Cameros Basin (North of Spain).

Geological context

The Cameros Basin is an extensional basin, formed during the second stage of the Mesozoic Iberian rift system (Late Jurassic-Eearly Cretaceous), relative to the opening of the Western Thetis. It records more than 9000 m of sediments (approx. 40 My) of mainly continental fluvio-lacustrine nature with some marine incursions. Its depocenter contains more than 6000 m of vertical thickness of sediments. The basin was inverted during the Alpine orogeny (Eocene to Early Miocene).
The Cameros Basin is characterized by a very peculiar thermal history. Anomalous high temperatures have been recorded in the rift deposits of some sectors of the basin. Despite of the high sedimentation rate that characterizes the basin rift stage, burial process is not big enough to explain such high temperatures. Several authors attribute these anomalies to hydrothermal metamorphic events that took place during the post rift stage.

Metodology and work flow

To clarify some aspects of the Cameros Basin thermal history several 1D thermal models of the rift and post-rift basin infill have been built. PetroMod software has been used for the modeling. The proposed 1D models refer to virtual wells built on a NE-SW basinal balanced cross-section (Omodeo-Salé et al., 2011).
For each virtual well, lithologies, thickness, and depositional/erosional ages have been defined for every stratigraphic unit. A simply combination of these data allow us to obtain a burial history diagram for each well.
A necessary boundary assignment for carrying out 1D thermal models is the estimation of the heat flow trend during the rifting stages. These data have been obtained from the previous subsidence curves by means the method of Royden (1986).
Thermal models have been calibrated with geothermometer data indicating whether the temperatures calculated by the models fit the temperatures recorded the sediments. Calibration has been performed using vitrinite reflectance values (%Ro).

Results

The obtained 1D thermal model represents the temperature variation in depth and in time for a specific basin point, as a result of the overburden and the regional and local variations of syn-rift heat flow effects.
The calibration of the thermal model with vitrinite reflectance values permitted an evaluation of the temperature raised by (1) overburden and the effect of the heat flow, and by (2) additional heat flow processes.

Discussion

The thermal models obtained are well calibrated in the southern and central sectors of the basin. Moving northward the vitrinite reflectance data analyses demonstrate that:
1) %Ro measured are higher than the theoretic proposed by the obtained thermal models;
2) %Ro measured values are higher in the samples located in the uppermost stratigraphic levels than the ones located in the lower ones, inverting the theoretic typical rift basin trend (Sweeney and Burnham, 1990).

Conclusions

Burial explains the thermal history in the southern and central sectors of the basin. To explain the thermal anomalies in the northern sector it is necessary to evocate the circulation of a hot flow that: 1) heats the sediment up to anomalous temperature respect the theoretic ones; 2) inverts the %Ro trend recording highs values even in the upper stratigraphic levels.
This hot flow circulation could be related to the hydromthermal metamorphic event (during the post-rift stage) recognized in the Upper Cretaceous (Mas et al., 2011 and references therein).

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