# INTEGRATED THERMAL MODEL, DIAGENETIC HISTORY AND OIL CORRELATION IN WESTERN MEDITERRANEAN, SPAIN

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## Introduction

During the seventies the Maestrat Basin as well as adjacent offshore areas were explored for hydrocarbons. In the Maestrat Basin located in the eastern part of Iberian Chain, exploration results were negative except for oils shows in Maestrazgo-1 well. The offshore Amposta oil field was discovered 22 km offshore south of the Ebro delta, with 55 million bbl ultimate recoverable reserves. Oil production was stopped some years ago and nowadays producing wells are abandoned.

The late Jurassic Mas d'Ascla Fm (Salas, 1989) outcropping in the adjacent Maestrat Basin has been proposed as a candidate source rock (Seifert et al., 1983; Albaigés et al. 1986; Seemann et al., 1990). This formation was deposited in a deep-outer ramp zone in transition to basin of a carbonate platform similar to a distally steepened ramp type with anoxic episodes, tempestites and slumps.

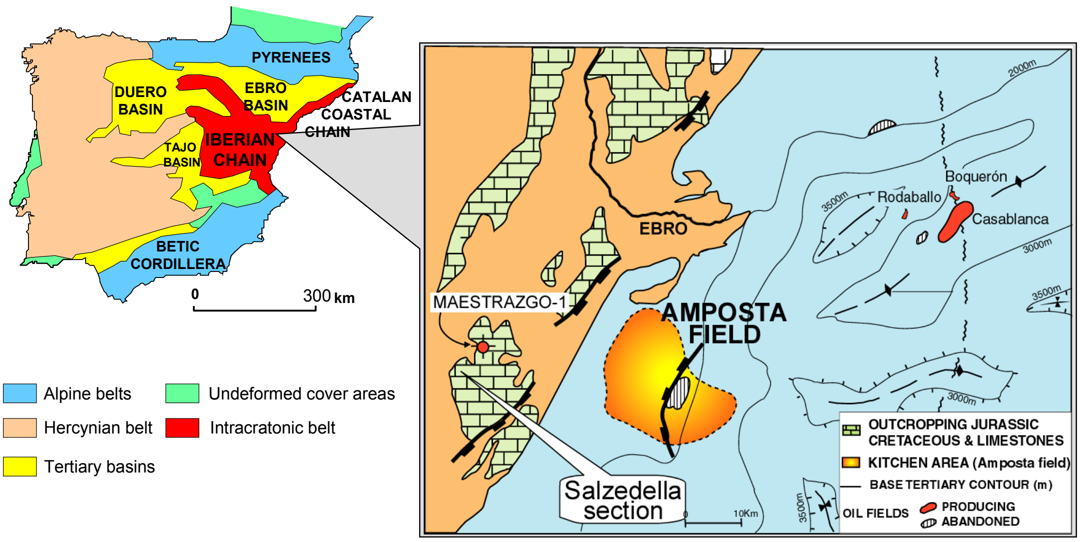


Figure 1. Location map of studied area. *(Offshore map modified from Seeman et al, 1990)*

In the Salzedella section the highest values (up to 1.26 %.) of TOC are found along the 50 lowermost meters of the TST (Permanyer et al., 2000; Permanyer & Salas, 2003). The spatial trend of TOC across the Salzedella sub-basin displays a significant increase from the marginal areas in the west to more open areas of the basin in the east.

In order to prove the contribution of the Ascla Fm to oil generation, thermal modelling was applied to the Salzedella sub-basin and Amposta field, as well as diagenetic history and oil-source rock correlation. Results of this study are presented hereafter.

## Thermal modelling

The one-dimensional BasinMod™ software was applied, based on the assumptions given by Lopatin (1971) and Waples (1980). Due to the geological evolution of the basin, two periods with different geothermal gradients were considered. For the initial rifting period during late Jurassic-early Cretaceous, a gradient of 27ºC/km was used. During the syn-rift/post-rift stage a slightly elevated gradient with 30ºC/km was assumed. The surface temperature was set to 15ºC. The vitrinite reflectance of 0.73% measured in the lower part of the Ascla Fm has been used to constrain the model. Additionally, the equivalent reflectivity was calculated from steranes isomerisation at base and top of the Ascla Fm. Equivalent reflectivities were converted to temperatures using empirical calibrations (Barker & Pawlewicz, 1994) giving 111ºC for the lower part of the section and 97-104ºC for the upper part. A mean TOC value of 1.26% and type II kerogen has been used (Fig. 2).

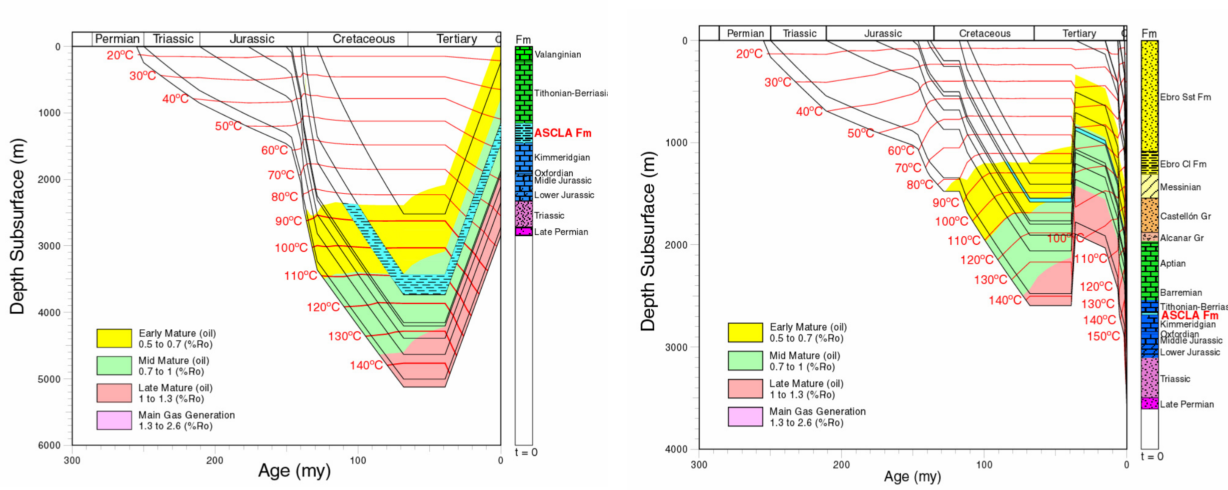


Figure 2. Thermal models for Salzedella sub-basin (left) and Amposta Marino C3 well (right).

It has been argued that the Ascla Formation cannot be the source for the Amposta oil, because it was already overmature for oil generation in the Amposta area during the Miocene (Albaigés et al., 1986). The results of modelling indicate that oil generation and migration from the Ascla Formation in the Salzedella sub-basin took place when the formation reached its maximum burial depth (3-3.7 km), very likely during the Late Cretaceous to earliest Tertiary and before the Eocene. The Ascla Fm entered the oil window at 90 Ma (Turonian). This places oil migration in this area just before Alpine tectonics, which created the most obvious traps and probably destroyed previous ones. Thus, the potential for oil accumulation in this particular part of the basin is probably low.

As mentioned before the possible contribution of oils generated in the Ascla Formation to the nearby Amposta oil field has been a matter of debate. This field is located offshore, 40 km to the west of Salzedella (Fig. 1), and oils are reservoired in Paleogene-aged karst developed in Lower Cretaceous carbonates (Seemann et al., 1990). The age of trap and seal is Miocene, when the area experienced an important rifting phase. Burial and thermal model of the Amposta Marino C-3 well suggest that Miocene subsidence could have caused a second phase of oil generation from the Ascla Fm.

**Diagenetic and oil migration history**

A petrographic, geochemical and fluid-inclusion (FIs) study of the cements of the Ascla Fm in the Maestrat Basin was performed in order to unravel the diagenetic and thermal evolution, with emphasis on possible evidence of oil migration and timing (Rossi *et al*. 2001).

Three cementation phases were distinguished. The first one occurs from late Kimmeridgian to late Berriasian during a burial stage. Primary porosity was filled by shallow depth (low Ferroan calcite, and Mg and Sr rich calcite) and burial Fe-rich calcite and dolomite cements. A second burial stage occurs during Valanginian to Paleocene. Fracture-filling calcites contain aqueous and oil fluid inclusions (FIs). Homogenisation temperatures are 117ºC. Oil FIs in phase 2 evidence that the Ascla generated oil and migrated via fractures.

The last cementation phase corresponds to Eocene to Oligocene and Neogene, during uplift and then erosion. Cross-cutting relationships with compressional microstructures indicate that last phase formed after the Eocene-Oligocene tectonic inversion of the basin.

**Correlation of the Ascla Fm with Amposta oil**

The Amposta oil has unique geochemical characteristics and is not correlated with the other oils in the Tarragona offshore basin, which have their source in Miocene rocks deposited in the Tarragona Trough (Albaigés *et al*., 1986).

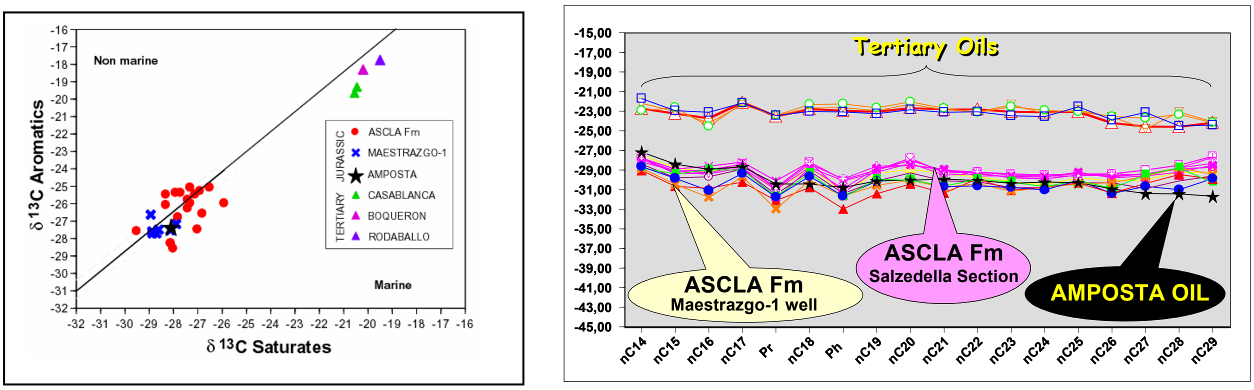


Figure 3. Isotopic correlation between extracts from Ascla Fm and oil shows from Maestrazgo-1 well (onshore) and Amposta oil and Tertiary oils (offshore).

The isotopic signature of saturate and aromatic hydrocarbons from source-rock extracts of the Ascla Fm in the Salzedella section bears a close resemblance with those from the Amposta oil and Maestrazgo-1 source-rock extracts. Values are consistent with the data provided by Seemann *et al.* (1990) for Amposta crude. A comparison of Jurassic (Kimmeridgian) samples and Tertiary oils from the Tarragona offshore basin (Casablanca, Boquerón and Rodaballo oil fields) (Fig. 1), currently in production, shows that the isotopic features differ drastically (Fig. 3).

GC-C-IRMS-$\delta^{13}C$ analyses show a good correlation between samples from the Tertiary or Kimmeridgian families. In particular, the correlation between source rock samples from the Ascla Formation, Maestrazgo-1 well and Amposta oil, lends support to the hypothesis that the Amposta oil generated from the Ascla formation source rock (Fig.4).

## Conclusions

The paragenetic sequence and burial history are consistent with oil generation when the Ascla Fm was at or close to maximum burial depth. Results from mineral and organic geochemical study from Ascla Fm samples, oil shows from Maestrazgo-1 well and Amposta oil demonstrate that Ascla Fm constitute the source rock at the origin of Amposta oil.

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