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# **FLUIDS EVOLUTION, HYDROCARBON GENERATION AND DESTRUCTION IN FORELAND BASINS: EXAMPLE OF THE PETROLEUM SYSTEMS OF SOUTHERN AQUITAINE (FRANCE).**

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## **Introduction**

Sedimentary basins in compressive settings have often complex geological histories and features. Therefore, they present a real challenge in oil and gas exploration. Recent revision of the geodynamic evolution of the North Pyrenees mountain range (France) within the frame of the research project “Convergence” lead to consider the effects of intense heat flow during the rifting phase prior to compression. We investigated the consequences of this previously unrecognized heating episode on the evolution of the fluids within the petroleum systems in the northern Pyrenees and Aquitaine foreland basin (France). Results permit to reconsider dolomitization phases of reservoirs, maturation history of source rocks, conditions and impact of TSR, secondary migration and reservoir filling, distribution of Gas vs Oil as well as sourness of fields.

## **Geological settings**

The Aquitaine basin with 35000km<sup>2</sup> is one of the largest sedimentary basins of Western Europe. It is located in South Western France and subdivided into six geological provinces which lead to major petroleum discoveries [1]. On the most southern rim, at the limit with the North Pyrenean Frontal Thrust, the Adour, Arzacq and Comminges sub-basins contain petroleum systems of major importance: the giant Lacq hydrocarbons field (with the Upper Lacq oil and the Lower Lacq sour gas – 18 vol% H<sub>2</sub>S- bearing reservoirs), the sour gas reservoirs of St Faust, Cassourat (with 6 vol% H<sub>2</sub>S), the dry gas fields of Meillon, Ucha-Lacommande, Rousse (with H<sub>2</sub>S<1%).

Resting on a Palaeozoic basement influenced by an inherited Hercynian tectonic framework, the sedimentary filling of the sub-basins ranges from Triassic to Quaternary. Major events include: thick evaporites deposits during Triassic, the formation of a carbonate platform with source-rocks during Jurassic, a major aborted rifting stage during lower Cretaceous with a hyperextension and mantle exhumation below a dragged pre-rift cover and a synrift infill of rifted basins [2]. This mantle exhumation implied intense heating [2, 3, 4]. The highest temperatures are related to rifting and hyperextension phases of the lower Cretaceous (350-450°C in the Pyrenees Central Domain, up to 550°C near mantle cores [2, 4]) with temperatures varying from 350°C in the extant foothills [5] to 150°C in the foreland basin [6, 7]. Then followed thermal subsidence allowing the deposition of the Cretaceous carbonate platforms (with source-rock), the beginning of convergence from upper Cretaceous leading to maximum compression during Paleocene responsible for flysch and then molasses deposits. Then from 20My to present, the whole system evolved in a post Orogenic situation with vertical motions due to isostatic rebound of the thickened orogenic crust.

## Results

Taking into account the geodynamic frame, fluids geochemistry was investigated using fluid inclusions from major reservoirs, gas and oils geochemistry, evolution of the source-rocks through basin modelling and artificial maturation, multiple sulfur isotopes analysis.

The ultra-thinning of the crust during the aborted rifting stage (Hyper-Extension) leads to very intense heating of the major source-rocks of Kimmeridgian and Barremian age along the southern rim of the Aquitaine basin. Maturation modelling indicates that the oil window stage was very brief while source-rocks experienced mostly dry gas generation during Cretaceous. High pressure regimes allowed hydraulic fracturing of Jurassic carbonate deposits allowing fluid circulation and dolomitization [5]. A mantle contribution is evidenced with abiogenic methane and trace elements in some dolomite occurrences [8], while dissolution of Triassic evaporites contributed to high salinity [9].

Study of the paleo-fluids trapped within fluid inclusions of the Deep Lacq reservoir indicates a first filling stage with light oil during Cretaceous. At the beginning of Tertiary during maximal compression, rapid evolution to dry gas saturation (+ up to 20 vol% H<sub>2</sub>S) is achieved.

High H<sub>2</sub>S contents of reservoir gas are attributed to TSR. Yet, reservoir rock petrography and fluid inclusions indicate that TSR did not occur within reservoirs while multiple sulfur isotopes investigations on H<sub>2</sub>S indicate a fully complete reaction (consumption of all available sulfate). Dry gas generation and TSR must have happened in the petroleum kitchen prior to gas migration. Nevertheless, such conditions are not compatible with the evolution of the source-rock/reservoir system where Deep Lacq is located, leading us to conclude that the petroleum kitchen is positioned deeper in the Arzacq basin.

## Conclusions

Advances in the understanding of the structural evolution of the Pyrenees and its impact on the structural and thermal evolution of the southern Aquitaine basin, together with new geochemical investigations lead to revise the history of the petroleum system, especially the identification of a very late dry sour gas filling of the Deep Lacq structure. The consequences on the timing and conditions of TSR, hydrocarbons destruction as well as on gas migration will be discussed.

## Literature

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