Combining noble gas tracing and thermodynamic approaches to unravel complex fluid history in a sub-salt petroleum reservoir

MAGALI PUJOL[1], HONGGANG ZHOU[1], FRANCOIS MONTEL[1], STUART GILFILLAN[2]

[1]TOTAL EP, CSTJF, Avenue Larribau, 64000 Pau, France (magali.pujol@total.com)

[2] School of GeoSciences, Univ. of Edinburgh, EH9 3FE, UK

Sub-salt hydrocarbon (HC) reservoirs in the Atlantic Ocean passive margins are one of the new key targets for frontier oil and gas exploration. However, several structures have been found to contain uneconomic CO_2-rich fluids. Understanding the origin of these fluids, their relative charging chronology and their impact on fluid properties will help to decrease the exploration risk linked to this CO_2.

To tackle this issue, we focus on interpreting the origin of fluids in a number of bottom hole gas (85% mol CO_2) samples, obtained vertically from a single well whilst drilling within the same reservoir structure. In order to resolve the origins of the fluids, we combine thermodynamic and organic approaches, based on HC fluid composition, and chariterisation of asphaltene deposits [1], with noble gas tracing. The HC molar distribution illustrates that there are two HC fluids within the reservoir: one is of low maturity oil and one of more mature gas. Characterisation of the asphaltene deposits indicates that low maturity oil was the first fluid charge into the reservoir.

The inertness and ubiquity of noble gases make them powerful tools to trace physical processes affecting fluids in the shallow crust [2]. We show that the noble gas isotopic and elemental signatures provide an insight into fluid source influences at each reservoir depth. Three main end-members are apparent: one derived from water due to aquifer recharge, a radiogenic-rich component from the HC fluids, and MORB-type input which we show to be linked to the CO_2 charge.

A greater water influence with depth illustrates a connection with an active aquifer. Significantly, the noble gas composition linked to the HC fluid can be solely linked to an oil phase, complicating the origin of the gas phase. In-situ generation of gas from the cracking of asphaltene deposits (so called pyrobitumen phase) could solve this issue. Hence, we show that noble gas tracing provides additional information on the origin of fluids, which is not possible to obtain by using more established HC fluid composition methods alone.

[1] Porte et al. (2003) *Langmuir* **19**, 40-47 [2] Ballentine & Burnard (2002) *Rev. Min. Geochem.* **47**, 481-538