

ISOTOPIC ANOMALIES OBSERVED AT THE VICINITY OF FRACTURES IN POREWATER OF TOURNEMIRE SHALES: EXPERIMENTAL ARTEFACTS OR LOCAL PALAEO-CIRCULATIONS?

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Introduction

Patriarche et al. (2004) acquired in the Toarcian argillaceous formation of Tournemire a vertical profile of stable isotope content of interstitial water. They found a good agreement between these experimental data and calculated values obtained from a pure diffusion model except for samples collected less than one meter from fractures. Samples closely located to fractures displayed a systematic increase of their water stable isotope contents. Two types of hypotheses were proposed for accounting for these discrepancies: (i) some local circulations could have occurred around the fractures and may have affected stable isotope concentrations and (ii) the vacuum distillation technique used for determining the isotope contents may have induced experimental artefacts on these particular samples.

In the present study, the influence of fractures on the stable isotope contents was addressed by acquiring an isotopic profile along a fracture by means of several techniques (extraction and equilibration approaches) coupled with mineralogical and petrophysical characterisations of rock samples.

Experimental concept

Core samples were collected from an horizontal air-drilled borehole intercepting a sub-vertical fracture. Two methods were applied for determining the water stable isotope contents in pore water (see Altinier et al., 2007, for details). The vapour exchange method consists in equilibrating by diffusion the pore-water of crushed sample with a spiked solution in water-tight container. In the other hand, we performed vacuum distillation technique at two extraction temperatures (at 50°C, as Patriarche et al. did and at 150°C). At last, several petrophysical determinations were carried out: water contents by oven-drying at 105°C and 150°C, bulk densities by kerosene immersion and grain densities by helium pycnometry. Mineralogical characterisations were performed by means of XRD analyses and total chemistry.

Results and interpretations

Fig. 1 shows the oxygen-18 content of pore water as a function of the distance to the fracture. Data obtained from vapour exchange experiments display a slight scattering, which is not linked to the presence of the fracture. The same trend can be highlighted from data obtained from distillation at 150°C. Inversely, the profile derived from distillation at 50°C displays a clear increase of oxygen-18 contents at less than one meter from the fracture. These results suggest that the discrepancies observed by Patriarche et al. (2004) would be due to artefacts induced by vacuum distillation technique at 50°C and not to natural phenomena associated to the presence of the fracture.

In order to try answering the question of the artefact origin, the variation of several mineralogical and petrophysical parameters was studied. Neither the mineralogy of the bulk rock nor the composition of the clay fraction display any change as a function of the distance to fracture.

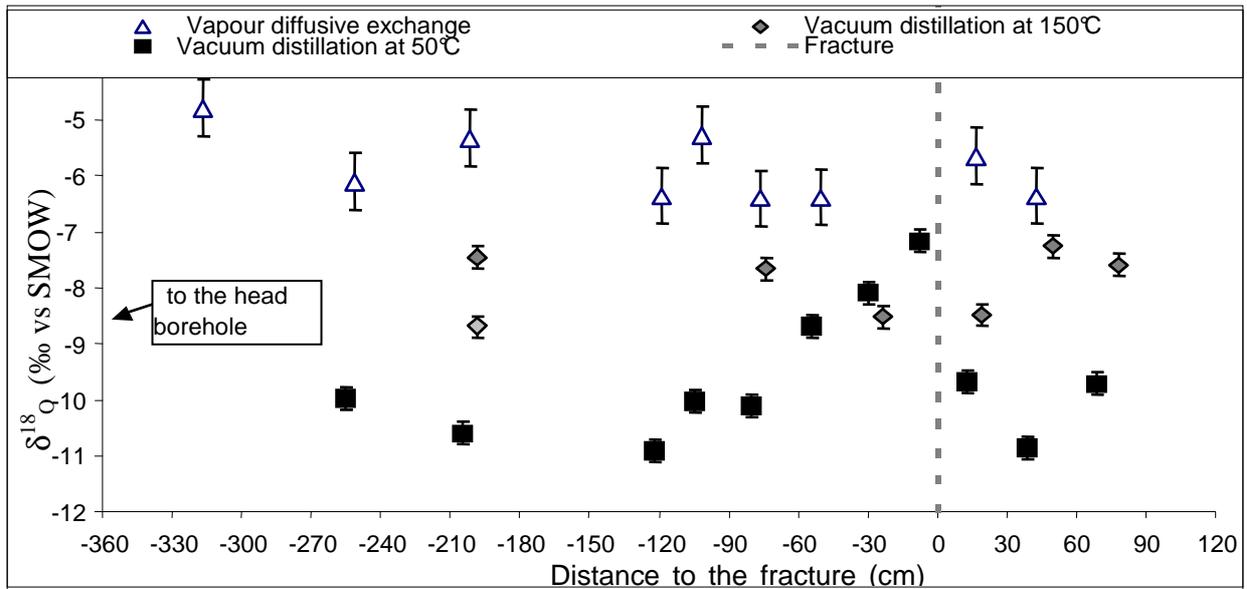


Figure 1: Profile of $\delta^{18}\text{O}$ as a function of the distance to the fracture

In fact, the increase of water content at the vicinity of fracture (Fig. 2), which is also associated with an increase of the proportion of large pores in samples (from 10 nm to 180 nm, BET- N_2 analyses) could account for the isotopic anomaly observed on data derived from vacuum distillation at 50°C. This higher proportion of large pores at the vicinity of the fracture could indeed make the water extraction easier, limiting the effects of incomplete distillation. This would lead to obtain water isotope contents close to those derived from both vacuum distillation at high temperature and vapour exchange method.

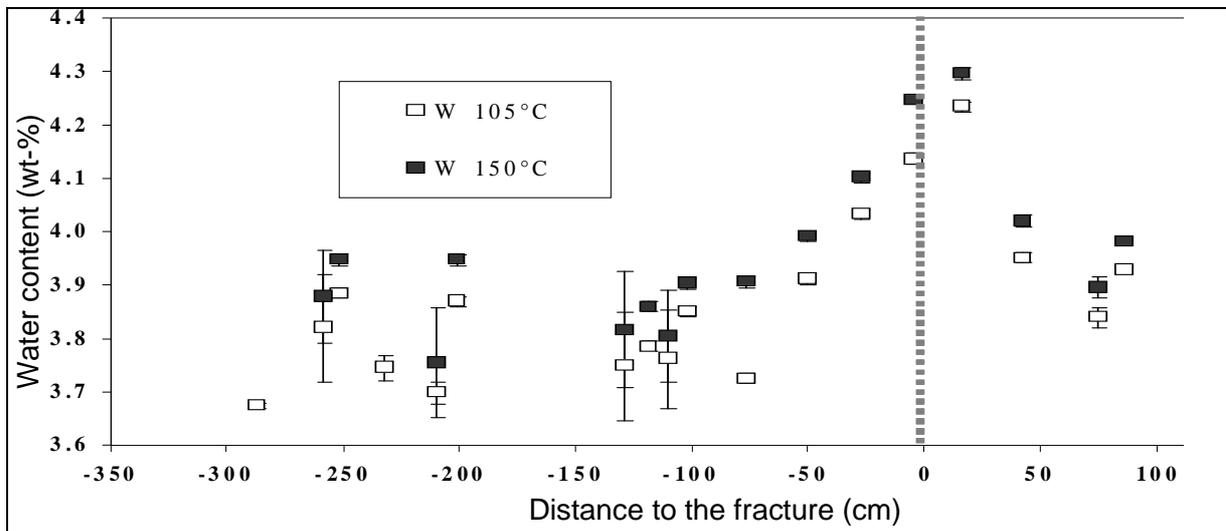


Figure 2 Profile of water content as a function of the distance to the fracture

References

- Altinier, M.V., Savoye, S., Michelot, J.L., Beaucaire, C., Massault, M., Tessier, D. & Waber, H.N. (2007): The isotopic composition of argillaceous-rocks pore water: an intercomparison study on the Tournemire argillite (France). *Physics and Chemistry of the Earth*, 32, 209-218.
- Patriarche, D., Ledoux, E., Michelot, J.L., Simon-Coincon, R. & Savoye, S. (2004): Diffusion as the main process for mass transport in very low water content argillites Part 2. Fluid flow and mass transport modeling. *Water Resources Res.*, 40, W01517, 2004.