



Jurassic hydrocarbon seep-carbonates in the High Atlas Basin (Morocco)

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In the central High Atlas Basin of Morocco, the occurrence of Jurassic hydrocarbon seeps is observed in two distinct horizons: (1) the uppermost *Polymorphum* ammonite zone (Lower Toarcian) and (2) the Sauzei (eq. *Propinquans*) ammonite zone (Lower Bajocian).

The Toarcian seep-carbonates are made of 5 – 6cm in diameter, half-spherical concretions that surround two vertical and closely spaced tubes, parallel to each other. Each tube is less than 1cm in diameter and filled with late diagenetic cements. The tubes are interpreted as burrow trace fossil. The concretions are embedded within an organic-matter rich interval and resemble to the *Tisoa siphonalis* concretions described in the upper Pliensbachian of Western Europe. Carbon isotope values decrease from the rim to the center of the concretion (from 1 to -7 per mil) whereas oxygen isotope values remain stable around -7 per mil. The C-isotope values of the concretion rim are similar to the bulk carbon isotope values of the embedding rocks. The most negative C-isotope values indicate that the carbon source of the carbonate precipitated in the centre of the concretion is likely sourced from the organoclastic sulfate reduction zone.

The Bajocian seep-carbonates are observed within the dark calcareous mudstone of the Sauzei zone. One peculiarly well-exposed seep system shows the presence of a plumbing system leading to a 20cm thick carbonate crust showing the occasional occurrence of chimney structures on its upper part. The high abundance of serpulids clusters within the carbonate crust shows that it was precipitated at the water-sediment interface. The pipe structures of the plumbing system are composed of an external micritic rim enclosing a central tube that can be up to 12cm large. A complex, multi-phased infilling is observed in the inner part of the pipe and separated from the rim by a millimetric pyritized crust. Carbon isotope values are comprised between -20 per mil and -8 per mil for the micritic rim, whereas the infilling carbonate have values ranging from -12 per mil to 1 per mil. As for the Toarcian carbonate seep, the source of the carbon is therefore likely situated within the organoclastic sulfate reduction zone. Both seep-carbonate intervals are interpreted to be the consequence of early diagenetic processes affecting organic-rich sediments, and therefore a local signature of enhanced organic matter burial.