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The Silurian graptolitic black shales of the Tassili n'Ajjer plateau (Algeria): Thermal maturity evolution and origin-timing of late diagenetic illite

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Abstract

The study area is located in the Tassili n'Ajjer plateau in the south-eastern part of the Algerian Saharan Platform near the Hoggar Massif. Outcrops along the Tassili n'Ajjer plateau offer exceptional exposure of Silurian sections and more specifically the Oued Imihrou 'graptolite-rich black shales' Formation (Djouder et al., 2018). Furthermore, the Tassili n'Ajjer plateau is the southern margin of the largest petroliferous Berkine – Ghadames and Illizi basins (BGI) that provides a critical insight to understand the diagenesis- and thermal maturity-evolution mainly of the lower Silurian shales, which are the major source rock of Paleozoic sourced hydrocarbons in North Africa and the Middle East (MacGregor, 1998; Lüning et al., 2000).

On the basis of sixty-five representative samples from the eastern- and western-Tassili n'Ajjer plateau, the black 'hot' shales, mudstones, siltstones and sandstones in the Oued Imihrou Formation and the Atafaïtafa Formation contain high amounts of graptolite organic matter, clay minerals and non-clay minerals such as quartz, muscovite and minor phases such as pyrite, iron oxides and K-feldspar. The clay assemblages show important differences depending on the stratigraphical level, the paleogeographical location and the lithology.

Clay mineralogy characterization and the measurements of illite crystallinity (*IC*) on the clay fraction (<2µm) were determined from each samples. The identified clay minerals include kaolinite (20–100%), mica-illite (0–20%), and chlorite (0–5%) from the total clay content.

The extreme western Tassili n'Ajjer succession yielded the lowest of all the measured calibrated *IC* values, around or less than 0.53 with median of 0.6 $\Delta°2\theta$ (n= 22). These lowest values point to abnormally high temperature conditions of the advanced grade diagenesis. Alternatively, these samples may have attained during the illite crystallization the high anchi-metamorphic degree (e.g. Kübler, 1967; Ferreiro Mählmann et al., 2012).

The observations and interpretations reached during this study, both on the inorganic and organic evolution (authigenic clay minerals and graptolites-derived organic matter) are good evidence of heating events. Thus, influencing later on the hydrocarbon generation/migration notably along N-S lineaments mega-shear-zones in the Hoggar Shield. The K–Ar illite age data of the extreme western Tassili n'Ajjer suggest fault reactivation at least at two different periods during the Mesozoic (i.e. Middle-Late Triassic and Lias). Our result is the first documentation of the reactivation of Pan-African fault zones in south-eastern Algeria on the basis of illite crystallinity and graptolite reflectance. These reactivation may represent significant transtensional tectonic events coupled with subsequent igneous activity during the opening of the Tethys (Triassic) and the Central Atlantic (Jurassic) oceans in extensive areas of the Saharan Platform (Djouder et al., in prep).

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