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Correlation between magnetic susceptibility and mineral species along NWA-1 well, southern Tunisia: An overlap of the depositional environment, the climate, and the diagenesis

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ABSTRACT

In order to distinguish the effects of diagenesis, the climate and the depositional environment, the magnetic properties were correlated with some minerals along the NWA-1 well, which crosses the southern subsurface from Cretaceous to Silurian successions. The MS along NWA-1 well shows major picks probably indicating a dramatic change of geochemical and mineralogical composition. Minor picks may be attributed to diagenetic transformations affecting some minerals. The mineralogical analysis shows the presence of illite, kaolinite with some traces of chlorite and smectite. Quartz, calcite, white feldspar, anorthite, dolomite, gypsum and pyrite are identified as associated minerals. The PCA of the different minerals and the magnetic susceptibility shows three different heterogeneous populations. In these populations, the traditional classification of magnetic minerals is not respected. For instance, diamagnetic minerals are positively correlated with MS. This correlation is through indirect causal relation extrapolating the temperature caused by the burial diagenesis. The aim is not totally reached because the handicap is twofold. The XRD diffraction is not able to identify the low amounts of magnetic minerals and the primary mineralogy and magnetic properties are radically modified by post-depositional processes. At the productive well of NWA-1, this overlap is further complicated by hydrocarbons, low grade metamorphism and remagnetization modifying the original magnetic signal.

1. Introduction

Some clayey minerals may give an idea about the depositional environment (Freed, 1980; Ingles and Anadón, 1991) as well as the climatic conditions (Myers et al., 2011). Nonetheless, the diagenesis may cause the transformation of some minerals, especially the clayey ones, to other mineralogical species (Mefteh et al., 2014). Consequently, the interpretation of the depositional environment becomes the hard task to do because the primary mineralogical composition overlaps with diagenetic byproducts.

Similarly to minerals modifications, compared to recent sediments, rocks affected by diagenesis have some additional potential complexities that should be considered when interpreting magnetic susceptibility (MS) records (e.g., Da Silva et al., 2012, 2013). From the early diagenesis, to burial, remagnetization and metamorphism (e.g. McCabe and Elmore, 1989; Elmore et al., 1993, 2012; Font et al., 2006, 2012; Rowan et al., 2009), post-depositional transformations can be relatively strong. In such a case, the magnetic susceptibility signal becomes a convolved expression of detrital, diagenetic and later remagnetization processes. Thus, for a meaningful interpretation in terms of paleoenvironment and paleoclimate, the origin of the magnetic susceptibility signal must be fully understood. In this vein, few are the studies addressing the question of the potential influence of diagenesis and metamorphism on the magnetic signal (Schneider et al., 2004; Devleeschouwer et al., 2010; Riquier et al., 2010; Da Silva et al., 2012, 2013).

In this work, the magnetic properties were correlated with some minerals along the NWA-1 well, which crosses the southern subsurface from Cretaceous to Silurian successions. Along the record of this well, the climate, the depositional environment, and the diagenesis interplay to give a final magnetic signal.

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2. Study area and geological settings

The Tunisian subsurface represents a serious promise for academic and applied purposes. On the one hand, the tectonic evolution of the region is a key point to infer the geodynamic evolution of North Africa (Bouaziz et al., 2002; Bodin et al., 2010; Raulin et al., 2011). Also, the outcropping (Fanti et al., 2012) and subsurface (Mefteh, 2009; Mefteh et al., 2014) sediments were the subject of sedimentological, paleontological and mineralogical studies. On the other hand, the Tunisian subsurface hosts considerable groundwater (e.g., Gabtni et al., 2012) and petroleum (e.g., Mefteh et al., 2014) recourses, giving to this region a specific interest. In addition, clays of the Tejera-Sghira (Mednine) (Eloussaief et al., 2009; Eloussaief and Benzina, 2010) and El Haria (Gafsa) (Eloussaief et al., 2014) Formations were proven useful for heavy metals removal from aqueous solutions.

In southern Tunisia, the Pre-Carboniferous Paleozoic marine clastic sequences unconformably overly the metamorphic Precambrian basement (Bishop, 1975). In this domain, several major sedimentary basins were developed during the Paleozoic age (Bishop, 1975; Memmi et al., 1986), extending in northwestern Libya and Eastern Algeria. The major regional feature is an E–W oriented anticlinorium resulting from a Mid-Late Paleozoic deposit uplift and erosion (Busson, 1972; Bishop, 1975; Memmi et al., 1986). The Late Carboniferous and Permian thick marine sequences are mainly recognized through subsurface data such as those of the productive well of NWA-1 (Mefteh et al., 2014). The only Paleozoic rocks exposed belong to the Late Permian neritic sequence of the Jebel Tebaga of Medenine (Newell et al., 1976).

Previous geological studies (Busson, 1967; Mello and Bouaziz, 1987; Bouaziz et al., 1989, 2002) showed that the Mesozoic sequence consists of three sedimentary cycles separated by Norian and Early Albian major unconformities. The Early–Middle Triassic sequences are mainly constituted of continental sandstone, conglomerate, and clay, whereas the Late Triassic outcrops exhibit shallow marine carbonates extending over the major part of the Saharan Platform in southern Tunisia, Algeria and western Libya (Busson, 1972). The upper part of the sequence, including dolomite, clay and gypsum, is partly eroded beneath the Norian

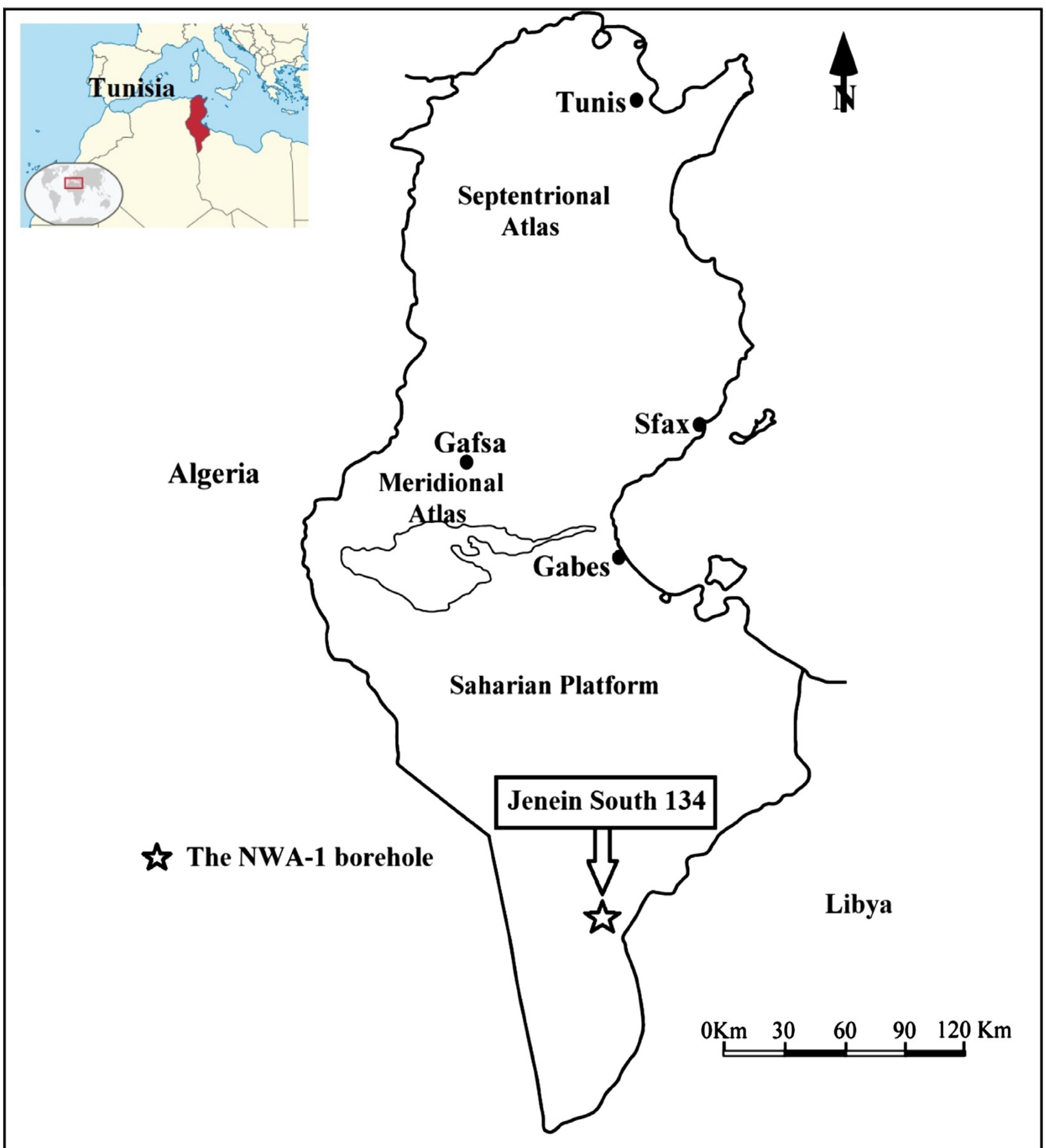

Fig. 1. Geographical location of NWA-1 well.