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Magnetic fabrics in the Jurassic–Cretaceous continental basins of the northern part of the Central High Atlas (Morocco): Geodynamic implications

B. Moussaid [a,*], H. El Ouardi [a], A. Casas-Sainz [b], J.J. Villalaín [c], T. Román-Berdiel [b], B. Oliva-Urcia [d], R. Soto [e], S. Torres-López [c]

[a] Dép. de Géologie, Faculté des Sciences, Université Moulay Ismail, BP 11201 Zitoune, Meknès, Morocco
[b] Dpto. de Ciencias de la Tierra, Facultad de Ciencias, Universidad de Zaragoza, 50009 Zaragoza, Spain
[c] Dpto. de Física, Escuela Politécnica Superior, Universidad de Burgos, Avd Cantabria S/N, 09006 Burgos, Spain
[d] IPE-CSIC, Avda. Montañana 1005, 50059 Zaragoza, Spain
[e] Instituto Geológico y Minero de España, Unidad de Zaragoza, C/Manuel Lasala 44, 9B, 50006 Zaragoza, Spain

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ABSTRACT

The aim of this work is to study the Anisotropy of the Magnetic Susceptibility (AMS) in two Jurassic–Cretaceous synclines located in the northern border of the Central High Atlas (Morocco): the Aït Attab and Ouaouizaght basins. AMS is used in order to obtain the magnetic fabric and its relationship with the kinematic evolution of both basins. The tectonic evolution of the basins, still under discussion, is mostly considered as the result of inversion during Tertiary and perhaps since Bathonian, of extensional and/or strike-slip Jurassic basins. Both basins are filled with Upper Jurassic to Lower Cretaceous silts and sandstones, with less frequent marine marly limestones.

The bulk magnetic susceptibility (km) generally shows higher values in the red facies (163.2 E−6 in AT and 168.6 E−6 in WZ) than in the yellowish marly limestones (97.88 E−6 in AT and 132 E−6 in WZ). Most sites show an oblate magnetic fabric. The rock magnetic analyses indicate that the main carrier of the magnetic susceptibility for the red facies is hematite, whereas in the yellowish facies there is a dominance of paramagnetic minerals. In both basins, the magnetic lineation (long axis of the ellipsoid, k_{max} axes) shows a predominant E–W direction. The overlapping of the stress fields during the Atlasic basins evolution, in both compressional and extensional regimes and hinder the straightforward interpretation of the magnetic fabrics. However, a coeval N–S compression during the times of sedimentation with an E–W transtension can explain the magnetic lineation found in many of the sites analyzed in the present work. There are also other less frequent directions of k_{max} axes (NE–SW and NW–SE) are interpreted as the result of local change of the stress field during the early extensional stage of basin formation.

1. Introduction

Anisotropy of Magnetic Susceptibility (AMS) is, since the first works of Graham (1954, 1966), a technique able to give information about the petrofabric of a rock, and hence, it provides information related to the deformation the rock underwent. It is one of the most frequently used magnetic tools in geology, which can replace the lack of conventional strain markers at the mesoscopic scale in weakly deformed rocks (e.g. Kissel et al., 1986; Tarling and Hrouda, 1993; Borradaile and Henry, 1997; Parés et al., 1999). AMS is applicable to sedimentary, magmatic and metamorphic rocks (e.g. Hrouda, 1982; Tarling and Hrouda, 1993; Arbaret et al., 1993; Borradaile and Henry, 1997; Talbot et al., 2005) and in deformation analysis, it can be used in structures related to compressional events, as well as in extensional regimes (e.g. Soto et al., 2007, 2009; Oliva-Urcia et al., 2010). In a simple compressional case, magnetic lineation (k_{max} axes) is parallel to the folds axes in weakly deformed rocks (Borradaile and Tarling, 1981; Hrouda, 1982; Sagnotti et al., 1998; Larrasoaña et al., 2004), whereas in an extensional case, the orientation of the k_{max} axes indicates the regional stretching direction perpendicular to the main normal faults or following the bedding dip (Mattei et al., 1997; Cifelli et al., 2005).

In this work AMS is applied to study two basins filled with Jurassic–Cretaceous terrigenous sediments and located near the northern border of the intra-continental alpine chain of the Central High Atlas where conventional deformational markers are

* Corresponding author.
E-mail addresses: bnmous@hotmail.fr (B. Moussaid), hmidouelouardi@yahoo.fr (H. El Ouardi), acasas@unizar.es (A. Casas-Sainz), villa@ubu.es (J.J. Villalaín), boliva@ipe.csic.es (B. Oliva-Urcia), r.soto@igme.es (R. Soto).

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scarce. (Choubert and Faure-Muret, 1962; Michard, 1976; Mattauer et al., 1977; Laville, 1985; Fig. 1). In addition, the continental nature of the filling of these basins precludes the formation of synsedimentary structures that could contribute to solve their origin and evolution. Our study involves the analyses of magnetic fabrics and their interpretation in relation to the structural and geodynamic history of the Aït Attab and Ouaouizaght basins, whose kinematic evolution is controversial and still not well understood, since they have been alternatively interpreted as (i) extensional basins, (ii) strike-slip basins, as pull-apart between two major E–W faults (Laville, 1985; Charrière et al., 2011), the North fault of Central High Atlas and the North Jebilet fault, or (iii) linked to compressional regimes (e.g. Souhel, 1996; Löwner, 2009). These basins collect sediments, which are continental at the bottom (silts and sandstones), and marine towards the top of the sequence (marly limestones). Marls and clays are the preferred materials to sample for AMS analysis, since the magnetic fabric in these rock types will frequently reflect the orientation of paramagnetic minerals (mainly phyllosilicates, Rochette and Vialon, 1984; Aubourg et al., 1991; Cifelli et al., 2005). In our case, ferromagnetic minerals such as hematite are also present in the red beds. The characterization of the internal arrangement of particles within sediments by means of AMS can shed light on the definition of the tectonic regime linked to the formation of these basins and their kinematic evolution, in addition to the study of the two NE–SW and E–W branches of the Aït Attab syncline and the change of stress field during the period of sedimentation (Bathonian to Early Cretaceous).

2. Geological setting

The Aït Attab and Ouaouizaght basins are located in the northern boundary of the Central High Atlas (Fig. 1). This chain is

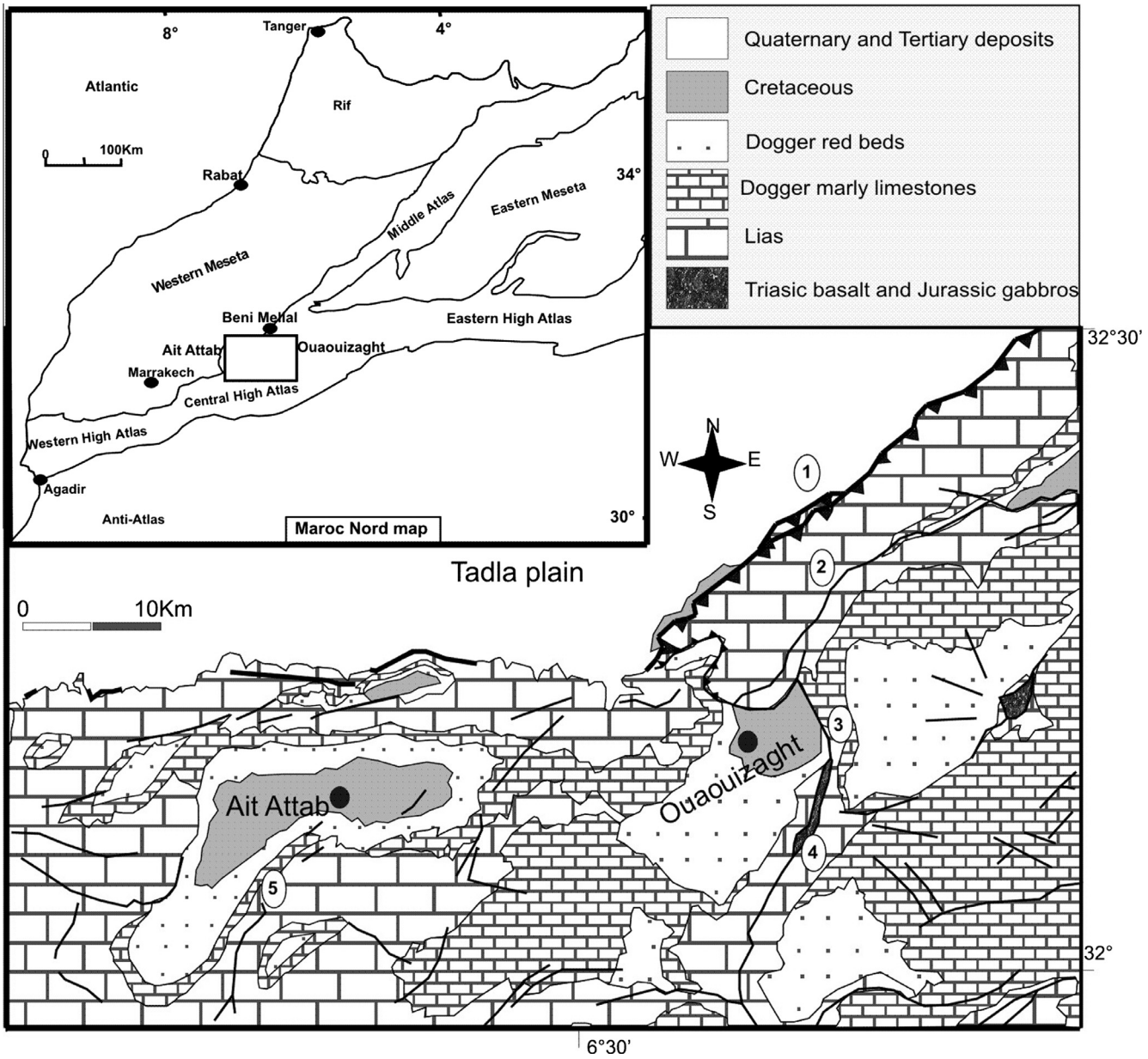

Fig. 1. Sketch showing the structural setting of the studied basins with the main faults; 1: Major North High Atlasic Fault (MNHAF); 2: Aghbala–Afourer fault; 3: Tasrift fault; 4: Jbel Abbadine fault; 5: Ait Sri fault. Excerpt from geological map of Beni Mellal 1/100,000 (Monbaron, 1985).