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Post-Cimmerian (Jurassic–Cenozoic) paleogeography and vertical axis tectonic rotations of Central Iran and the Alborz Mountains

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ABSTRACT

According to previous paleomagnetic analyses, the northward latitudinal drift of Iran related to the closure of the Paleo-Tethys Ocean resulted in the Late Triassic collision of Iran with the Eurasian plate and Cimmerian orogeny. The post-Cimmerian paleogeographic and tectonic evolution of Iran is instead less well known. Here we present new paleomagnetic data from the Upper Jurassic Bidou Formation of Central Iran, which we used in conjunction with published paleomagnetic data to reconstruct the history of paleomagnetic rotations and latitudinal drift of Iran during the Mesozoic and Cenozoic. Paleomagnetic inclination values indicate that, during the Late Jurassic, the Central-East-Iranian Microcontinent (CEIM), consisting of the Yazd, Tabas, and Lut continental blocks, was located at low latitudes close to the Eurasian margin, in agreement with the position expected from apparent polar wander paths (APWP) incorporating the so-called Jurassic massive polar shift, a major event of plate motion occurring in the Late Jurassic from 160 Ma to 145–140 Ma. At these times, the CEIM was oriented WSW–ENE, with the Lut Block bordered to the south by the Neo-Tethys Ocean and to the southeast by the Neo-Sistan oceanic seaway. Subsequently, the CEIM underwent significant counter-clockwise (CCW) rotation during the Early Cretaceous. This rotation may have resulted from the northward propagation of the Sistan rifting-spreading axis during Late Jurassic–Early Cretaceous, or to the subsequent (late Early Cretaceous?) eastward subduction and closure of the Sistan oceanic seaway underneath the continental margin of the Afghan Block. No rotations of, or within, the CEIM occurred during the Late Cretaceous–Oligocene, whereas a second phase of CCW rotation occurred after the Middle-Late Miocene. Both the Late Jurassic–Early Cretaceous and post Miocene CCW rotations are confined to the CEIM and do not seem to extend to other tectonic regions of Iran. Finally, an oroclinal bending mechanism is proposed for the origin of the curved Alborz Mountains, which acquired most of its curvature in the last 8 Myr.

1. Introduction

The present-day structural configuration of Iran (Fig. 1) is the result of a complex history of geodynamic events. These include the collision of the Central-East-Iranian Microcontinent (CEIM *sensu* Takin, 1972), comprised of the Yazd, Tabas, and Lut blocks, with the southern margin of Eurasia during the Late Triassic Cimmerian orogeny (Sengör, 1984; Zanchi et al., 2006, 2009a,b; Muttoni et al., 2009a), the Late Jurassic–Cretaceous opening of small oceanic basins around the CEIM, and the closure of these basins during Late Cretaceous, in connection with the northward motion of the Arabian Plate and closure of the Neo-Tethys Ocean (Stöcklin, 1974; Dercourt et al., 1986; Sengör et al., 1988; McCall, 1997; Stampfli and Borel, 2002; Bagheri and Stampfli, 2008; Rossetti et al., 2010). Since the Cenozoic, shortening related to the Arabia–Eurasia convergence has been taken up mainly by tectonic displacements in the Zagros, Alborz, and Kopeh Dagh thrust-and-fold belts, whereas the intervening, fault-bounded crustal blocks of the CEIM seem to show little internal deformation (Fig. 1).

The Alborz and Kopeh Dagh Mountains in north Iran constitute a system of strongly curved, mostly double-verging orogens (Fig. 1). In particular, the Alborz range is a ca. 100-km-wide, sinuous orogenic belt that stretches E–W for ca. 600 km (e.g., Allen et al., 2003; Guest et al., 2006), and comprises Late Triassic Cimmerian structures (Zanchi et al., 2006) reactivated during the Late Cenozoic Arabia–Eurasia convergence and associated relative motion between the stable and rigid South Caspian Basin in the north and the CEIM in the south (e.g., Jackson et al., 2002; Allen et al., 2003).

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The most peculiar feature of the CEIM (to the south of the Alborz–Kopeh Dagh range) is the occurrence of an Upper Mesozoic ophiolitic 'ring', the so-called 'Coloured Mélange', which bounds its most internal part (Fig. 1). This ophiolitic ring is a remnant of Mesozoic peri-Tethyan oceanic basins that formed in the upper plate of the Neo-Tethyan subduction, and document a polyphase tectonic evolution during its Mesozoic–Cenozoic consumption along the Sanandaj–Sirjan Zone (Stöcklin, 1974; Sengör et al., 1988). The CEIM is affected by a complex system of N–S-trending dextral faults, which separate the Yazd, Tabas and Lut blocks causing intensive N–S dextral shearing in the whole area (Walker and Jackson, 2004) (Fig. 1). The left-lateral Great Kavir–Doruneh fault system, crossing the northern part of the CEIM, currently bounds this deformational system to the north.

Despite this complex tectonic history, paleomagnetic data from Iran are very sparse and have been mainly used to unravel its pre-Cimmerian tectonic evolution (Muttoni et al., 2009a,b; see also Besse et al., 1998). These data show that the Iranian block(s) was (were) located close to the Arabian margin of Gondwana in the Paleozoic, drifted off this margin attaining subequatorial palaeolatitudes in the Late Permian-early Early Triassic, and approached the Eurasian margin by the late Early Triassic. In contrast, several open issues regarding the tectonic and stratigraphic evolution of Iran have not been targeted by paleomagnetic research. These include discrepant views on the Mesozoic paleogeography of the CEIM in Central Iran (compare Stampfli and Borel, 2002; Barrier and Vrielynck, 2008; Wilmsen et al., 2009), the debated origin of the curved shape of the Alborz and Kopeh Dagh ranges (Hollingsworth et al., 2010; Alimohammadian et al., 2013), and the latitudinal drift of Iran and its relationships with the Turan plate after the Cimmerian collision (see Mattei et al., 2014 for a discussion).

In this paper, we revise previously published paleomagnetic data from CEIM (Conrad et al., 1981; Wensink, 1982; Bina et al., 1986; Soffel et al., 1989, 1996; Mattei et al., 2014) and Alborz Mts. (Wensink and Varenkamp, 1980; Cifelli et al., submitted to Tectonics) and present new paleomagnetic data from the Upper Jurassic Bidou Formation from Central Iran (CEIM). We anticipate that these paleomagnetic data are suitable to identify two main episodes of counter-clockwise (CCW) vertical axis rotations that occurred in Central Iran in the Late Jurassic–Early Cretaceous and after the Middle–Late Miocene, and to constrain the timing of Neogene oroclinal bending in the Alborz range. A brief summary of previous results (Muttoni et al., 2009a,b; Mattei et al., 2014) is also provided on the post Cimmerian latitudinal drift of Iran and the long-term evolution of climate-sensitive sedimentary facies deposition during the Late Paleozoic–Mesozoic.

2. Previous paleomagnetic results

2.1. Jurassic paleomagnetic data

2.1.1. CEIM

Mattei et al. (2014) report paleomagnetic results from Kimmeridgian–Tithonian red beds of the Garedu Red Bed Formation cropping out in the Garedu syncline of the western Shotori Mountains (#15 in Fig. 1 and Table 1) (see also Cifelli et al., 2013). A well-

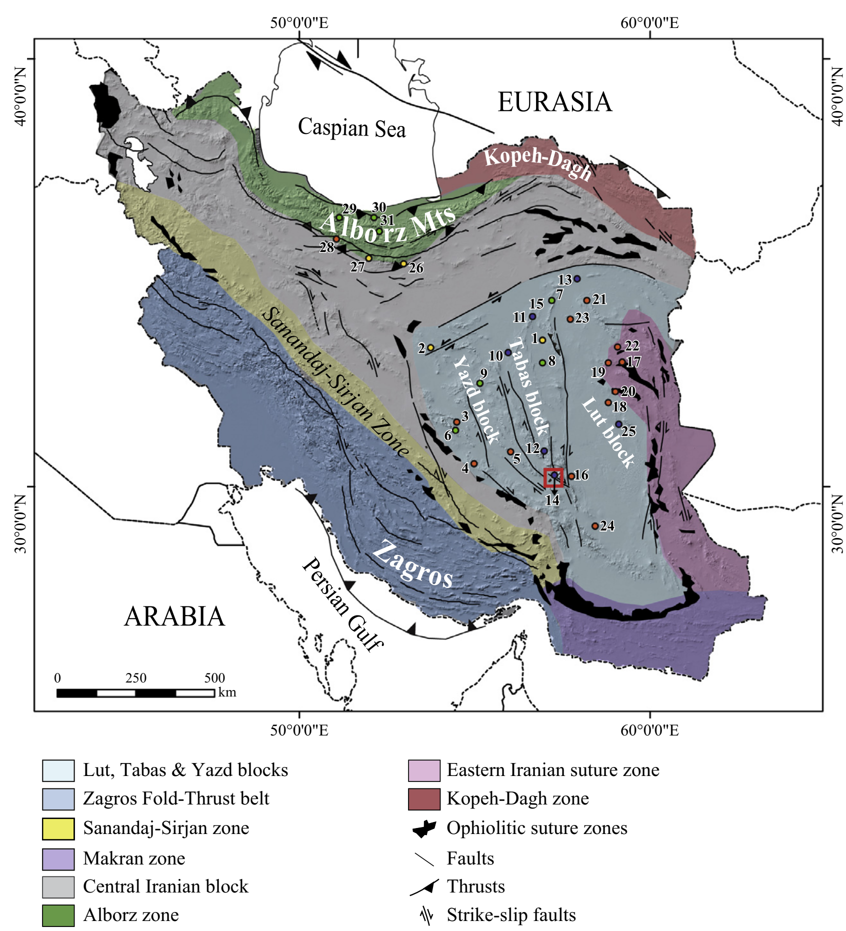

Fig. 1. Tectonic map of Iran showing the main tectonic provinces and the main active faults. Numbers represent sampling localities from the literature discussed in the text (see also Table 1). The red square represents the location of the paleomagnetic sites of this study from the siliciclastic member of the Bidou Formation from the Kerman area.