New Palaeomagnetic Data from the Betic Cordillera: 
Constraints on the Timing and the Geographical Distribution 
of Tectonic Rotations in Southern Spain

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Abstract — A palaeomagnetic investigation has been carried out at 14 sites on Jurassic red nodular limestones from the central and eastern part of the External Zones of the Betic Cordillera (Subbetic and Prebetic Zones). Progressive thermal demagnetisation of samples from the Subbetic Zone reveals the presence of two stable magnetic components of the natural remanent magnetisation: 1) a secondary Neogene syn-folding component and 2) the original Jurassic magnetisation. As similar characteristics have been reported in Jurassic limestones from the western Subbetic Zone, a widespread remagnetisation event took place within $<10^6$ years in the entire Subbetic region during Neogene times. In contrast, in the Prebetic region, no evidence for a secondary overprint has been detected. Palaeomagnetic Jurassic declinations indicate variable and locally very large clockwise rotations (35°–140°), but the two sites in the north-westernmost part of the investigated region are not rotated. The use of both components of magnetisation and the incremental fold-test results allowed the timing of block rotations in the Subbetic Zone to be constrained. Rotations in the western Subbetic occurred after the acquisition of the secondary overprint, whereas in the central part of the Subbetic Zone they were completed by the time of the remagnetisation event.

Key words: Palaeomagnetism, Betic Cordillera, remagnetisation, rotation, Jurassic, Neogene.

Introduction

Palaeomagnetism is a very useful tool for studying the rotational component of the kinematics of a deformed region. Most commonly, palaeomagnetic declination is used to determine the component of vertical axis rotation, which is generally undetectable using conventional structural analysis. The Betic Cordillera is the
northern branch of the Betic-Rifean orogen, an arc-shaped mountain belt bordering the Alboran Sea, that constitutes the westernmost segment of the Mediterranean Alpine orogenic system. The entire chain developed in response to the collision between Africa and Eurasia since the late Mesozoic. The Betic-Rifean orogen can be divided into four tectonic domains (Balanyà and García-Dueñas, 1987): the Alboran domain (Internal Zones), the Southiberian and Maghebrian domains (External Zones) and the allochthonous Flysch trough. The Alboran domain is made up of several thrusts that have been grouped into three main tectonic complexes (the Nevada-Filabride, Alpujarride and Malagueña complexes) and mainly consist of metamorphic rocks of Paleozoic and Triassic age. The Southiberian and Maghebrian domains represent the palaeomargins of the Iberian and African plates respectively, and comprise mostly unmetamorphosed Mesozoic and Tertiary sediments. The External Betic Zones are divided into the Prebetic Zone (the most external) and the Subbetic Zone (itself being differentiated into External, Middle and Internal Subbetic).

Over the last 15 years, the Betic Cordillera has been the subject of several palaeomagnetic studies. Early tectonic studies were performed in Jurassic volcanic and sedimentary rocks from the Subbetic Zone (Osete et al., 1988, 1989). They showed that systematic dextral block rotations took place in the central part of the Subbetic (to the north of Granada) and a very large rotation was found at one site in the eastern Betics. Platzman and Lowrie (1992), Platzman (1992) and Platt et al. (1994) carried out extensive palaeomagnetic studies in sedimentary rocks of Jurassic and Cretaceous age around the Gibraltar Arc. They observed clockwise block rotations in the western Subbetic and counterclockwise rotations in the Rif Mountains of Morocco. A systematic palaeomagnetic study of mostly Jurassic sedimentary rocks from the eastern External Betic Zone was conducted by Allerton et al. (1993, 1994). They observed a more heterogeneous behavior with mainly clockwise rotations, sometimes very large, along with some regions that had experienced no rotation at all. Villalain et al. (1994) carried out a palaeomagnetic study in grey oolitic limestones and grey and red nodular limestones of upper Jurassic age from the western Subbetic. This revealed that the natural remanent magnetisation (NRM) of these rocks is dominated by a widespread and pervasive remagnetisation of Neogene age. This work also demonstrated that the remagnetisation is coeval with the deformation by folding in the Betics. Later, Villalain et al. (1996) presented an evaluation of the consequences of an incorrect interpretation of the nature (primary or secondary) of the NRM. They found that heterogeneous rotational patterns could be observed if the secondary magnetisation is erroneously interpreted as a primary magnetisation. The palaeomagnetic study carried out by Kirker and McClelland (1996) on upper Jurassic grey micrites from the western Subbetic also revealed a multicomponent remanence, including a syn-deformational component of magnetisation.