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Messinian astrochronology of the Melilla Basin: Stepwise restriction of the Mediterranean–Atlantic connection through Morocco

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Abstract

The Melilla Basin (NE Morocco) formed the easternmost part of the Rifian Corridor, which was an important Mediterranean–Atlantic gateway during the Late Miocene. The sedimentary infill of the basin consists of a shallow marine, precession-related cyclic marl–diatomite succession, laterally grading into a marginal carbonate complex. Three bio-sedimentary events have been recorded within the marl succession: 1) onset of diatomite deposition, 2) major change in foraminiferal assemblages, and 3) transition to *Halimeda*-rich carbonates and *Porites* coral reef build-ups. Recent $^{40}Ar/^{39}Ar$ dating has provided a good age control for the Melilla carbonate sequences, but a high-resolution astronomical time frame is necessary to solve the climatic signature of the basin sediments.

This study focuses on the shallow marine marl succession of the Melilla Basin. Integrated magneto-, cyclo- and biostratigraphy allowed a detailed correlation to the astronomical target curve, resulting in a high-resolution time frame for the Late Miocene evolution of the basin. Comparison of the Melilla data with previous results from other Moroccan and Mediterranean basins indicates that the input of Atlantic waters through the Rifian Corridor became restricted after 6.84 Ma, and was minimized by 6.58 Ma. In the final period (6.58–5.96 Ma) towards the Messinian Salinity Crisis, the Melilla Basin can be considered as a marginal basin of the Mediterranean.

The astronomical time frame for the marl sequences of the Melilla Basin moreover enables a direct comparison between the independent isotopic and astrochronological dating techniques, as astronomical ages have also been assigned to intercalated volcanic tuffs for which $^{40}Ar/^{39}Ar$ ages were previously determined. We conclude that the isotopic ages are systematically younger than their astronomical equivalents.

Keywords: Mediterranean; Messinian; Morocco; Astronomical cyclicity; Diatomites

1. Introduction

During the Late Miocene, the Mediterranean was connected to the Atlantic Ocean through at least two marine gateways: the Betic and Rifian Corridors (e.g.

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Benson et al., 1991). The evolution of these corridors is of major importance to our understanding of the Late Neogene isolation of the Mediterranean Sea, which resulted in the Messinian Salinity Crisis. The recently developed Astronomical Time Scale (ATS) for the Messinian of the Mediterranean Realm (Hilgen et al., 1995; Krijgsman et al., 1999a) can now be used for detailed analysis of the paleogeographic evolution of these Neogene gateways.

The Melilla Basin in northeastern Morocco forms the easternmost part of the Rifian Corridor (Fig. 1). The sedimentary succession of this basin consists of an Upper Miocene carbonate platform, grading laterally into basinal marine clays, marls and laminites, which display repetitive lithological alternations (Choubert et al., 1966; Gaudant et al., 1994; Saint Martin and Cornée, 1996). The intercalation of volcano-clastic levels provides a correlation tool between the basinal sequences and the carbonate-platform (Cunningham et al., 1994; Cunningham et al., 1997; Roger et al., 2000). Isotopic dating of these volcanic ashes has provided a scenario in three stages of the pre-evaporitic Messinian basin-evolution (Roger et al., 2000; Münch et al., 2001); 1) the onset of a prograding bioclastic carbonate unit, coeval with the onset of diatomaceous marl deposition, 2) a transition to warm-water conditions, evidenced by the start of warm-water diatomites and prograding *Porites* coral reefs, and 3) the termination of the prograding carbonate complex.

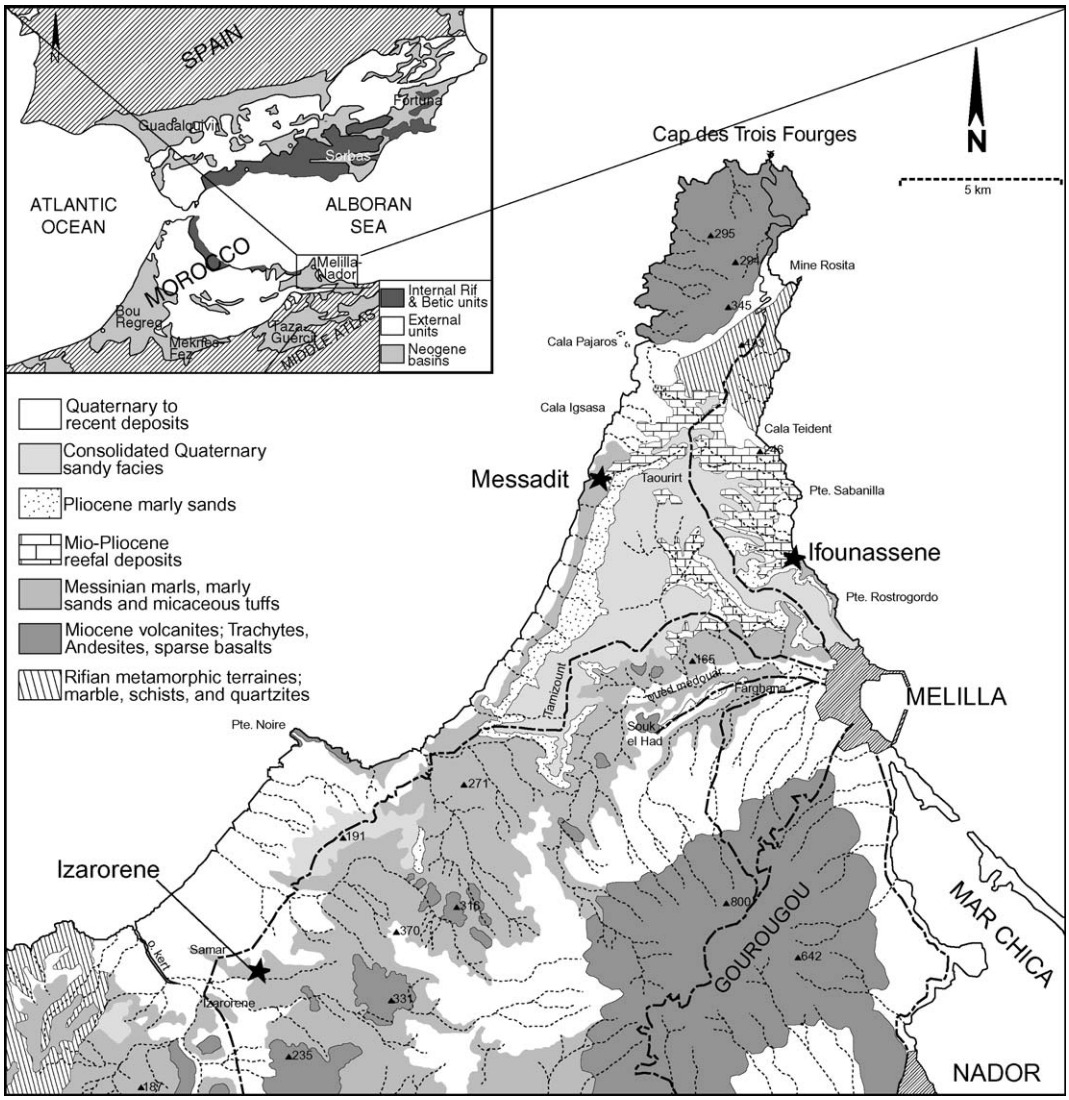

Fig. 1. Geographic location of the sampled sections in the Melilla Basin, Northeast Morocco. The main geologic units included in the figure are based on the work of Choubert et al. (1966).