On the Late Miocene continentalization of the Guadix Basin: More evidence for a major Messinian hiatus

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Abstract

The chronology of the Late Miocene Mediterranean-Atlantic gateways through southern Iberia is a key issue to better understand the geodynamic processes that lead to the Messinian salinity crisis. The timing of the North Betic corridor continentalization has recently been constrained by integrated magnetobiostratigraphic dating of the La Lancha section in the Guadix basin (Hüsing et al., 2010: Palaeogeography Palaeoclimatology Palaeoecology 291, 167–179). This work showed that the continentalization of the Guadix basin encompasses an approximately 2 myr hiatus, with the interval between ~7.7 to ~5.5 (or 5.0) Ma missing in the stratigraphic record. Minwer-Barakat and colleagues comment that this hiatus could be slightly shorter, but they base their hypotheses solely on an interval without any reliable magnetobiostratigraphic data. Their key localities Negratín 1 and Rambla de Chimeneas 3 (MN13), however, confirm that the oldest faunas found at La Lancha section correlate with the upper part of chron C3r (~5.5 Ma). These continental faunas thus provide more evidence on the presence of a major Messinian hiatus in the Guadix record.

1. Introduction

The significance of the North Betic Corridor in the process of marine restriction that leads to the Messinian Salinity Crisis (MSC) of the Mediterranean has remained elusive for years. A detailed reconstruction of the paleogeography of this corridor prior to its closure turns to be a difficult task because of the lack of a reliable, high resolution chronology of the marine sediments that filled the intramontane basins of the Internal Betics. Early studies suggested that an Atlantic-Mediterranean marine connection existed through the Guadix-Baza, Fortuna and Lorca basins during the Messinian (Müller and Hsu, 1987). More recent studies, however, provided revised magnetobiostratigraphic-based chronologies of the sedimentary fill of the Fortuna (Garcés et al., 1998, 2001) and Lorca Basins (Krijgsman et al., 2000). These studies revealed that the marine-continental transition in the Fortuna and Lorca basins occurred in the late Tortonian, thus ruling out the existence of a marine corridor flowing across these basins during Messinian times. These results, combined with apparent evidences of a late Tortonian continentalization of the Granada and Guadix Basins, supported the conclusions that a North Betic corridor did not exist in the course of the MSC. This was first proposed by Soria and Ruiz Bustos (1992) and was further used in several works (Soria, 1994; Fernández et al., 1996; Soria et al., 1998; Betzler et al., 2006).

The conclusions of Hüsing et al. (2010) are most significant in this respect. Our magnetobiostratigraphic results confirmed the correlation of the Lower Marine Unit to the late Tortonian, more precisely we place it between 8.1 and 7.85 Ma. However, in contrast to Soria et al. (1998) and Soria et al. (1999), our paleobathymetric results do not indicate a shallowing trend towards the continental unit. Moreover, our magnetostatigraphic results from the continental unit, in combination with the presence of the murid Paraethomys meini at the base of the Continental Unit, suggest a correlation to the latest Messinian or Zanclean. This implies that a significant hiatus of ~2 myr is present between the Lower Marine Unit and the Continental Unit. For the first time, we showed:

- The lack of shallowing in the Lower Marine Unit;
- An age of ~7.85 Ma for the top of the Lower Marine Unit;
- A much longer hiatus between the Lower Marine Unit and the continental unit than previously thought;
- A latest Messinian to Zanclean age for the continental unit.
Fig. 1. Correlation of the Guadix basin continentalization (La Lancha section) after several authors. Labels A to H are typed in order to better follow the text explanations. In any case, the time involved in the Messinian hiatus (indicated by stripped polygons) is important in both Hüsing et al. (2010) and Minwer-Barakat et al. (2012).
We thus concluded that most (if not all) of the Messinian is missing in the La Lancha section.

2. On the oldest continental sedimentation in the Guadix basin

The magnetostratigraphic data from the La Lancha section (Hüsing et al., 2010) allows dating of the oldest continental sediments, lying unconformably on the marine units of the Guadix Basin, as late Messinian to early Pliocene. These results were largely inconsistent with earlier biostratigraphic data from the Salinas fossil mammal locality (Soria and Ruiz Bustos, 1992), where mammal assemblages indicated a MN12 age (latest Tortonian–early Messinian age following Agustí et al., 2001, 2006). This inconsistency, pointed out in Hüsing et al. (2010), had been resolved earlier in the study of Minwer-Barakat et al. (2009), who questioned the age of the Salinas locality because the species present are not restricted to MN12, but are also found in MN13. At the time of submission of our paper, we were unfortunately unaware of these findings. We are of course, very excited to know that these results are in full agreement with our conclusions, resolving the inconsistencies with older results of Soria and Ruiz Bustos (1992).

In Fig. 1, we attempt to summarize how the correlation of the La Lancha section (Fig. 1(C)) with the standard scales (Fig. 1(A, F)) changed over the years. Column B represents the original correlation by Soria and Ruiz Bustos (1992) with the age for the continentalization at 7.6 Ma (latest Tortonian), mainly based on the attribution of the Salinas fossil mammal site to the MN12 mammal biostratigraphic unit (Fig. 1(B, C)). Minwer-Barakat et al. (2012), in contrast, claimed that Salinas faunas better correlate to the MN 13 unit. In our paper (Hüsing et al., 2010), the new magnetostratigraphic results allowed to reject Soria and Ruiz Bustos (1992) correlation as well, since we found MN13 faunas at the very base of the continental succession of the La Lancha section. Based on presence of Paraethomys meini, we assigned a maximum age to this succession of ~6.1 Ma, following the magnetostratigraphic data of Garcés et al. (1998). The observed polarity pattern (R1, N1, R2, N2) in the Continental Unit then most logically correlates to the chron C3r, C3n.4n, C3n.3r, and C3n.3n (~6.0 to ~4.8 Ma) of the Geomagnetic Polarity Time Scale (GPTS; Fig. 1(D)), although an alternative correlation to C3n.3r, C3n.3n, C3.2r, and C3n.2n (~4.9 to ~4.5 Ma) cannot be completely ruled out (Fig. 1(E)). Both magnetostratigraphic correlations yield a latest Messinian to Zanclean age for the continental deposits. There is no paleomagnetic evidence that the interval with uncertain polarity at the base of the continental unit might contain the entire normal Chron C3An.1n as suggested by Minwer-Barakat et al.’s (2012) hypothesis 1 (Fig. 1(G)). We disagree with their hypothesis 2 (Fig. 1(H)), i.e., that all of chron C3r is present in the R1 interval. Their arbitrary correlation lines are unclear to us, but we can agree on the uppermost dashed correlation line to the upper part of C3r as we will point out below.

The results by Minwer-Barakat et al. (2012), and especially the reconsideration of the site Salinas to be of MN 13, and the observation that the Rambla de Chimeneas 3 and Negratín 1 sites also should be attributed to MN 13, help to distinguish between our preferred and alternative correlation (Fig. 1(D vs. E)). These fossil mammal results indicate that the basal part of the Continental Unit correlates to MN 13, implying that the reversed interval R1 must correspond to C3r (Fig. 1(D)). In Hüsing et al. (2010), we state that the La Lancha Continental Unit comprises the latest Miocene and early Pliocene, which is in agreement with the evidence from the Negratín 1 and Rambla de Chimeneas 3 sites. However, Minwer-Barakat et al. (2012) misinterpreted this conclusion (see asterisk in Fig. 1(H)) by arguing that we propose a maximum age of La Lancha at the base of the Pliocene, which is not the case (this misinterpretation is clearly seen in their Fig. 1). At the end, we conclude that all the evidence points to their midpoint “hypothesis 2”, which does not differ from our preferred correlation (Hüsing et al., 2010; Fig. 1(D)).

From a magnetostratigraphic as well as from a sedimentological point of view, we still consider assuming relatively constant sedimentation rates as the most appropriate tool to estimate the age of the continental base. We had interpolated the sedimentation rate over the 50 m of continental deposits below the R1-N1 reversal boundary to the base of the continental deposits – using a similar sedimentation rate as for the upper part – and had consequently estimated an age of ~5.5 Ma for the base of the continental unit. We agree that this age is not an accurate one, but we think that a position in the upper part of C3r is rather straightforward and that the error will probably be not larger than 0.2 myr.

3. Conclusions

Recent magnetostratigraphic data on the continentalization age of the Guadix basin in the North Betic corridor showed that a significant hiatus of ~2 myr is present between the Lower Marine Unit and the Continental Unit (Hüsing et al., 2010). This is based on the biostratigraphic age of ~7.85 Ma for the top of the Lower Marine Unit and the presence of the murid Paraethomys meini (~6.1 Ma) at the base of the continental unit. The observed polarity pattern (R1, N1, R2, N2) in the Continental Unit thus most logically correlates to the chron C3r, C3n.4n, C3n.3r, and C3n.3n (~6.0 to ~4.8 Ma) of the Geomagnetic Polarity Time Scale. The work by Minwer-Barakat et al. (2012) provides further evidence for a Messinian hiatus in the continentalization of the Guadix basin and contributes with the integration of two micromammal sites. We conclude that the Hüsing et al. (2010) and Minwer-Barakat et al. (2012) results are in very good agreement and that they together better constrain the major hiatus in the Guadix basin, showing that this comprises the interval between 7.85 and 5.5 Ma, i.e., part of the upper Tortonian and most of the Messinian.

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References


