

Original article

# Nannoplankton biostratigraphic calibration of the evaporitic events in the Neogene Fortuna Basin (SE Spain)<sup>☆</sup>

*Calibration biostratigraphique des événements évaporitiques du bassin néogène de Fortuna fondée sur les nannofossiles calcaires (SE Espagne)*

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## Abstract

The Fortuna Basin is an example of a marginal Mediterranean basin with evaporitic sedimentation during the Late Tortonian and Messinian. This basin shows an early restriction event before the main Messinian Salinity Crisis (MSC) that allows the Tortonian Salinity Crisis (TSC) to be proposed as a tectonic uplift event isolating the eastern Betic basins. Four evaporitic events are present in the central part of the Fortuna Basin, from bottom to top: Los Baños Marls Formation (composed by Fenazar Conglomerate Bed, Lower Gypsum Member [Mb] and Sanel Mb), Tale Gypsum Formation (Fm), Chicamo Diatomites and Gypsum Cycles Fm, and Rambla Salada Gypsum Fm. The present work documents the first biostratigraphic dating based on calcareous nannoplankton of these events. The lowest occurrence (LO) of *Amaurolithus primus* is registered at the upper part of the Sanel Mb, below the Tale Gypsum Fm. The LOs of *Amaurolithus delicatus* and *Reticulofenestra rotaria*, which mark the base of the Messinian, occur in the lower part of the Chicamo Cycles Fm, above the Tale Gypsum Fm, the *Triquetrorhabdulus rugosus-Nicklithus amplificus* integrate form and the LO of *Nicklithus cf. amplificus* in the upper part of the Chicamo Cycles Fm. Taking into account these results, a new calibration of the available magnetostratigraphic data is presented: the Chicamo Cycles Fm were formed during the reverse chron C3Ar and the Tortonian-Messinian boundary should be found within the Tale Gypsum Fm or near the top of the Sanel Mb. The onset of the TSC, the first restriction phase of the Fortuna Basin, is represented by the Fenazar Conglomerate Bed, bottom of the Los Baños Fm, and not by the Tale Gypsum Fm, as previously considered.

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**Keywords:** Betic Cordillera; Tortonian Salinity Crisis; Calcareous nannoplankton; Messinian; Fortuna Basin

## Résumé

Le bassin de Fortuna est un exemple de bassin méditerranéen marginal avec sédimentation évaporitique pendant le Tortonien supérieur et le Messinien. Il présente l'enregistrement d'événements de restriction avant la Crise de Salinité Messinienne (CSM), ce qui a permis de mettre en évidence une Crise de Salinité Tortonienne (CST) induite par un soulèvement tectonique qui a isolé le bassin. Dans la partie centrale du bassin, on peut reconnaître quatre ensembles évaporitiques, avec de bas en haut, la Formation Los Baños (Couche Conglomératique de Fenazar, Membre [Mb] du Gypse Inférieur, Mb des Marnes de Sanel), la Formation (Fm) Gypse de Tale, la Fm Cycles de Diatomites et Gypse de Chicamo et la Fm Gypse de Rambla Salada. Ici, pour la première fois, nous datons ces ensembles sur la base d'une analyse biostratigraphique du nannoplancton calcaire. La première occurrence d'*Amaurolithus primus* est enregistrée dans la partie supérieure du Mb Sanel, au-dessous de la Fm Gypse de Tale. Les premières occurrences d'*Amaurolithus delicatus* et de *Reticulofenestra rotaria*, qui marquent la base du Messinien, sont localisées dans la partie inférieure de la Fm Cycles de Chicamo, au-dessus de la Fm Gypse de Tale. Finalement, la transition *Triquetrorhabdulus rugosus-Nicklithus amplificus* et la première occurrence de *Nicklithus cf. amplificus* sont enregistrées dans la partie supérieure de la Fm Cycles de Chicamo. Sur la base

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<sup>1</sup> Professor Jesús Caracuel passed away in the course of this work. We dedicate it to his memory.

de ces résultats, nous proposons un nouveau calibrage des données magnétostratigraphiques disponibles. La Fm Cycles de Chicamo s'est déposée durant le Chrono C3Ar. La limite tortonienne/messinienne est localisée près du toit du Mb Sanel ou dans la partie inférieure de la Fm Gypse de Tale. L'initiation de la CST, la première phase de restriction du bassin de Fortuna, est représentée par le Conglomérat de Fenazar, au bas de la Fm Los Baños et non pas par la Fm Gypse de Tale comme préalablement suggéré dans la littérature.

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*Mots clés* : Cordillère Bétique ; Bassin de Fortuna ; Crise de Salinité tortonienne ; Messinien ; Nannofossiles calcaires

## 1. Introduction

During the Late Miocene, the sedimentary basins of the Eastern Betic Cordillera have registered two of the most singular events in the recent evolution of the Mediterranean. The most striking was the Messinian Salinity Crisis (MSC), manifested by the evaporitic sedimentation in the Mediterranean basins. In the Betics, the MSC is well-documented in the Nijar Basin (Fortuin and Krijgsman, 2003; Aguirre and Sánchez-Almazo, 2004), Sorbas Basin (Martín and Braga, 1994; Riding et al., 1998, 1999, 2000; Fortuin et al., 2000; Krijgsman et al., 2001; Sierro et al., 2001; Flores et al., 2005), Vera Basin (Fortuin et al., 1995), Bajo Segura Basin (Feldmann and McKenzie, 1997; Lancis, 1998; Soria et al., 2003, 2008; Caracuel et al., 2004), and Fortuna Basin (Garcés et al., 1998; Tent-Manclús et al., 2007, 2008).

The other singular event was the recently documented Tortonian Salinity Crisis (TSC) named after Krijgsman et al. (2000). The TSC is prior to the MSC and has been defined by evaporite precipitation in the centre of the Lorca and Fortuna basins. The evaporites are related to a restriction phase due to tectonics (Garcés et al., 1998; Dinarès-Turell et al., 1999; Garcés et al., 2001; Krijgsman et al., 2006; Tent-Manclús et al., 2008). The TSC was originally proposed as an important event in the evolution of the Betic basins, because it marks the closure of the foreland North betic strait (Viseras et al., 2004). Recently, Tent-Manclús et al. (2008) related the TSC with the onset of the activity of the Trans-Alboran Shear Zone (De Larouzière et al., 1988), thus affecting only the eastern portion of the cordillera; consequently this activity would not have an expression in the western basins. Likewise, during the Late Miocene, many Betic basins as Granada, Guadix-Baza, Lorca, and Fortuna undergo emergence, indicating a regional tectonic uplift of the whole cordillera (Viseras et al., 2004).

The Fortuna Basin is an intramontane basin developed in the eastern Betic Cordillera (southern Spain, Fig. 1). It is located along the suture zone between the South-Iberian Palaeomargin (External Zone) and the Alboran Block (Internal Zone). Its sedimentary history started in the Early Tortonian as a pull-apart basin associated to the Puerto de Barinas strike-slip Fault (Tent-Manclús, 2003). Two infill periods can be distinguished in the Fortuna Basin: the first one, during the Tortonian, was mainly a marine basin where at least 600 m thick Fortuna Marls accumulated; and the second one, during the latest Tortonian-Pliocene, continental and restricted marine sedimentation of shale, marl, gypsum, and conglomerate took place. These two periods are associated with different tectonic settings; the first one was dominated by the transtensive activity of the right-

lateral Puerto de Barinas Fault, while the second one started when the movement of this fault stopped and a new tectonic stress field, related to the Trans-Alborán Shear Zone, started (Tent-Manclús et al., 2008).

The Fortuna Basin has received much attention due to its evaporitic sediments (Montenat, 1977; Santistebán Bové, 1981; Santistebán and Taberner, 1983; Lukowski, 1987; Müller and Hsü, 1987; Lukowski and Poisson, 1990; Montenat et al., 1990; Garcés et al., 1998; Dinarès-Turell et al., 1999; Krijgsman et al., 2000; Playà et al., 2000; Garcés et al., 2001; Tent-Manclús, 2003; Soria et al., 2005; Kuiper et al., 2006; Tent-Manclús et al., 2008), thought to be related to the MSC. Initially, the evaporites were considered to be Messinian (Santistebán Bové, 1981; Santistebán and Taberner, 1983; Lukowski, 1987; Müller and Hsü, 1987; Lukowski and Poisson, 1990). However, as pointed out early by Montenat (1977), palaeomagnetic studies concluded that the evaporites were older (Garcés et al., 1998, 2001; Dinarès-Turell et al., 1999; Krijgsman et al., 2000). Three temporal calibration options have been proposed for the palaeomagnetic data obtained in the Rio Chicamo section, two due to Dinarès-Turell et al. (1999) and one to Krijgsman et al. (2000). None of these three alternative calibrations were directly supported by the biostratigraphic data obtained from the section.

Due to the relevance of the TSC in the palaeogeographic evolution of the Betic Cordillera, it has been considered important to establish the precise stratigraphy and age of this event in the Fortuna Basin, with well-exposed outcrops of the Late Tortonian-Early Messinian sediments. Our technique of centrifugation before production of smear slides offers the first calcareous nannoplankton biostratigraphic ages for the Fortuna Basin evaporitic events, and the calibration of the previously published magnetostratigraphy for the Rio Chicamo section (Dinarès-Turell et al., 1999; Krijgsman et al., 2000).

## 2. Methods

The central basin sediments of the Fortuna Basin are well-exposed in three sections distributed along the Tale ENE-WSW hill (Fig. 1(B)). The Rio Chicamo section is located 4 km south of the Abanilla village in the centre of the Fortuna Basin. The lower part outcrops at the Chicamo River right margin and the upper part can be followed along the Abanilla-Santomera road (MU-414). The Canal section is located 3 km to the East of the previous one, following an access road from the Abanilla-Albatera road to a waterway. The Sebos section runs along a secondary road to an industrial suet factory, 2 km west of the

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