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Larger foraminifera distribution and strontium isotope stratigraphy of the La Cova limestones (Coniacian–Santonian, "Serra del Montsec", Pyrenees, NE Spain)

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ABSTRACT

The Upper Cretaceous La Cova limestones (southern Pyrenees, Spain) host a rich and diverse larger foraminiferal fauna, which represents the first diversification of K-strategists after the mass extinction at the Cenomanian–Turonian boundary.

The stratigraphic distribution of the main taxa of larger foraminifera defines two assemblages. The first assemblage is characterised by the first appearance of lacazinids (*Pseudolacazina loeblichi*) and meandropsinids (*Eofallotia simplex*), by the large agglutinated *Montsechiana montsechiensis*, and by several species of complex rotalids (*Rotorbinella campaniola*, *Iberorotalia reicheli*, *Orbitokhatina wondersmitti* and *Calcarinella schaubi*). The second assemblage is defined by the appearance of *Lacazina pyrenaica*, *Palandrosina taxyae* and *Martiguesia cyclamminiformis*.

A late Coniacian-early Santonian age was so far accepted for the La Cova limestones, based on indirect correlation with deep-water facies bearing planktic foraminifers of the *Dicarinella concavata* zone. Strontium isotope stratigraphy, based on many samples of pristine biotic calcite of rudists and ostreids, indicates that the La Cova limestones span from the early Coniacian to the early-middle Santonian boundary. The first assemblage of larger foraminifera appears very close to the early-middle Coniacian boundary and reaches its full diversity by the middle Coniacian. The originations defining the second assemblage are dated as earliest Santonian: they represent important bioevents to define the Coniacian-Santonian boundary in the shallow-water facies of the South Pyrenean province.

By means of the calibration of strontium isotope stratigraphy to the Geological Time Scale, the larger foraminiferal assemblages of the La Cova limestones can be correlated to the standard biozonal scheme of ammonites, planktonic foraminifers and calcareous nannoplankton. This correlation is a first step toward a larger foraminifera standard biozonation for Upper Cretaceous carbonate platform facies.

1. Introduction

The "Serra del Montsec" is a continuous mountain ridge extending east-west for more than 50 km south of the Pyrenees, between the Tremp and Ager basins (Fig. 1). It is mainly made of Upper Cretaceous shallow-water carbonates covering with no interruption the Cenomanian to Maastrichtian time interval. These shallow-water carbonates contain a very rich and diverse fauna of larger foraminifera that has long attracted the attention of micropaleontologists (Aubert et al., 1963; Hottinger, 1966; Caus and Cornella, 1981a,b; Hottinger and Caus, 1982, 1993; Hottinger et al., 1989; Cherchi and Schroeder, 1999 among them). The larger foraminifera of the La Cova limestones represent in the Pyrenean Basin the first great diversification of the K-strategists in the Late Cretaceous Global Community Maturation cycle (Hottinger, 2001) after the Cenomanian–Turonian mass extinction (Caus et al., 1993, 1997; Parente et al., 2008). During this interval of time, the Pyrenean fossil record documents the "explosive" development of two groups of porcelaneous larger foraminifera, the lacazinids (larger milioliform foraminifera with a trematophorate aperture) and the meandropsinids (a group of Late Cretaceous foraminifera with Ophtalmidiid origin), and of a group of lamellar-perforate, the

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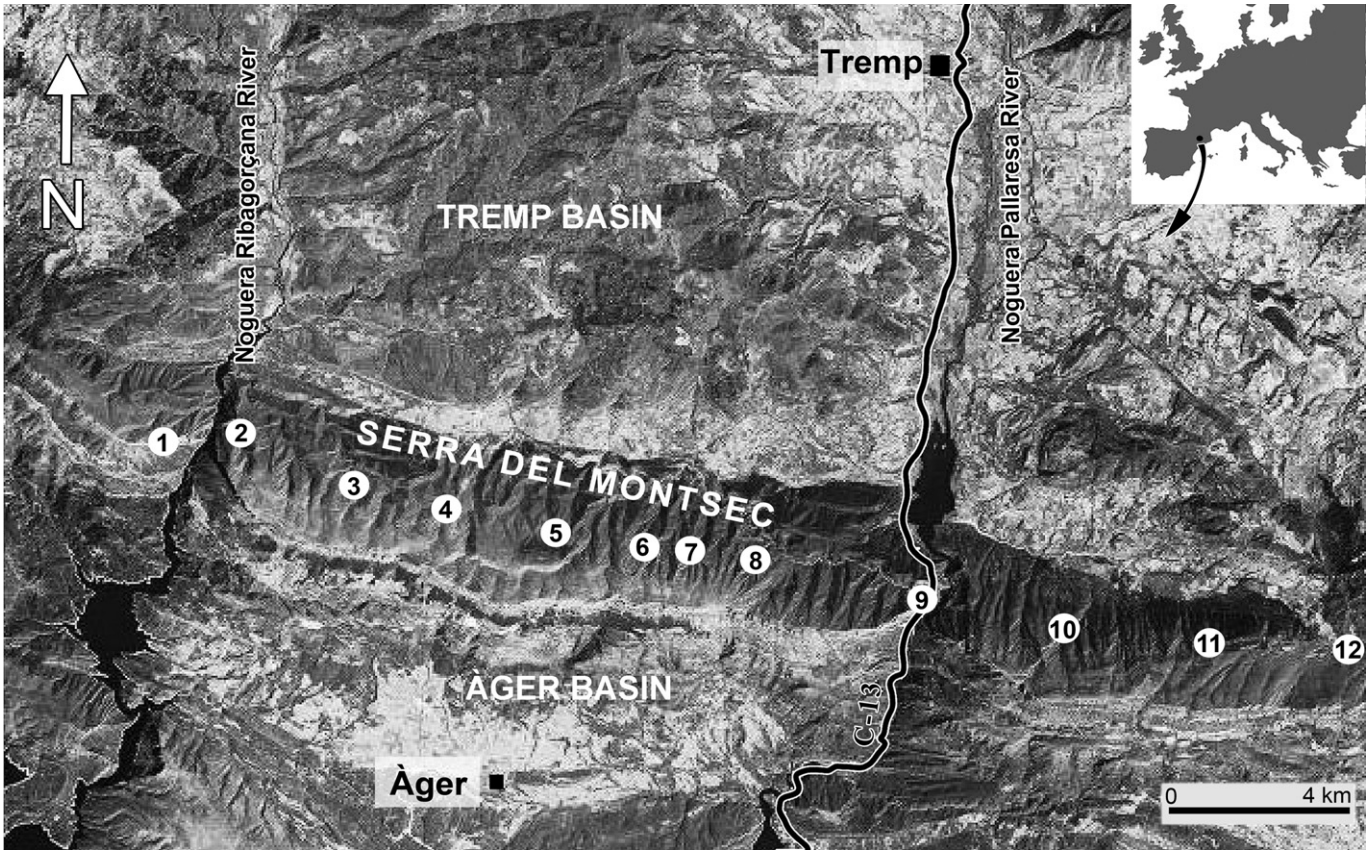

Fig. 1. Location of the "Serra del Montsec" and of the measured Sections (1–12).

rotaliids. Moreover, new genera of agglutinated foraminifera, such as *Ramirezella* and *Martiguesia*, appear, while a few survivors from the Cenomanian (such as *Cuneolina*, *Dicyclina* or *Cyclolina*) are still present.

Recently, several taxonomic studies have been carried out on the larger foraminifera of the La Cova limestones (Boix, 2004; Boix, 2009; Albrich, 2008; Villalonga, 2009; Boix et al., 2009; Hottinger and Caus, 2009). However, the stratigraphic ranges of many taxa are still not known in detail and their chronostratigraphic age is not well constrained.

The La Cova limestones have been classically attributed to the late Coniacian–early Santonian time interval (Hottinger and Rosell, 1973; Pons, 1977) and their larger foraminiferal assemblages have been correlated with the *Dicarinella concavata* planktic foraminiferal zone (Caus and Gómez-Garrido, 1989). However, this correlation is based exclusively on indirect lithostratigraphic correlation with deep-water facies exposed more to the north (Bòixols Thrust Sheet). No direct evidence is available as ammonites, calcareous plankton and nannoplankton have never been found in the La Cova limestones.

The lack of precise correlation with deep-water facies and of accurate chronostratigraphic dating is often a severe drawback in the study of Cretaceous carbonate platforms which has in some cases generated harsh controversies (Föllmi, 2008). During the last decades, chemostratigraphy has been successfully applied to tackle these problems. Carbon isotope stratigraphy proved particularly successful for high resolution dating and correlation of middle Cretaceous carbonate platforms (Parente et al., 2007 and references therein) while strontium isotope stratigraphy (SIS) has proven particularly suitable for Upper Cretaceous rudist limestones (Steuber, 2003, 2003a; Steuber et al., 2005; Frijia and Parente, 2008a; Schlüter et al., 2008).

The potential of SIS as a high resolution tool of chronostratigraphic dating and correlation of marine sedimentary rocks has been widely demonstrated (see Veizer et al., 1997 and McArthur and Howarth, 2004 for recent reviews). The curve describing the secular variation of marine Sr isotope ratio during the Cretaceous is known in considerable detail. In particular, the late Turonian-Maastrichtian segment of the reference curve is characterised by a narrow error band and by a fairly high gradient. As a result, a maximum resolution of $\leq$0.5–1 My can be attained over this time interval with SIS (McArthur and Howarth, 2004).

The aim of this work is to supply new data on the stratigraphic distribution of the main taxa of larger foraminifera in the La Cova limestones and to constrain their chronostratigraphic age by SIS. We propose two larger foraminiferal assemblage zones and correlate them to standard ammonite, planktic foraminiferal and calcareous nannoplankton zones. Finally, we use SIS to define the position of the Coniacian-Santonian boundary within the La Cova limestones and propose a biostratigraphic criterion, based on larger foraminifera, for the definition of the boundary in shallow-water carbonate facies of the Pyrenean basin.

2. Geological setting

During the Late Cretaceous the "Serra del Montsec" was part of the southern margin of the Pyrenean Basin, which was a narrow and deep gulf open to the Atlantic Ocean and extending approximately east-west between the Iberian and European plates, from the Galician offshore to the "Bassin of Beausset" near Marseille.

Nowadays, the "Serra del Montsec" forms part of the Montsec Thrust Sheet that, together with the Bòixols Thrust Sheet to the north and the Serres Marginals Thrust Sheet to the south,