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Lower Aptian Subbetic organic-rich facies, radiolarites, and associated deposits: the local expression of Oceanic Anoxic Event 1a (Carbonero Formation, southern Spain)

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ABSTRACT

The Carbonero Formation represents a scarce, well documented example of Aptian anoxic facies in the Betic Cordillera. Generally, the Aptian record in the pelagic Subbetic basin is both very discontinuous and affected by frequent hiatuses, but in some subsident areas controlled by extensional faults (as in the Carbonero trough) an interesting record is preserved. The Carbonero Formation is characterised by a thick pelagic succession composed of marls with intercalations of calcareous turbidites and a thick interval of anoxic facies. This interval, dated as early Aptian, most likely represents the local expression of Ocean Anoxic Event 1a in the Subbetic basin. A multidisciplinary study including lithostratigraphy, biostratigraphy, and sedimentology has been carried out in the Carbonero Formation, with special attention to the anoxic interval. A collection of facies and sedimentary features has been characterised and interpreted, including barite concretions, calcareous concretions, black shales, siliceous marls and radiolarites, and calcareous turbidites. All these facies seem to have been deposited under oxygen-depleted conditions on a fault-bounded depression with a high subsidence rate. The accumulation and burial of sediments and the preservation of organic matter were controlled by both local and regional factors, such as the physiography of the basin and tectonic setting, as well as by global factors, such as palaeoceanographic and climatic changes.

1. Introduction

In recent years, numerous research groups have focussed their attention on Aptian marine formations, since this stage records notable geological events. One of the more interesting and extensively studied events is the widespread deposition of organic matter and black shale that took place in the early Aptian. This episode has been interpreted as the sedimentary record of Oceanic Anoxic Event 1a (OAE1a) (Schlanger and Jenkyns, 1976; Jenkyns, 1980), known in the Tethys domain as the "Selli event" (Coccioni et al., 1989, 1992; Erba, 1994; Erba et al., 1999). In order to explain the mechanisms involved in the black-shale formation, several palaeoceanographic models have been proposed, based ultimately on the relative importance of two main controlling factors: primary productivity and organic matter preservation.

The productivity model points out that the origin of black shales is related to episodes of increased primary productivity within surface waters (Pedersen and Calvert, 1990; Weissert and Lini, 1991; Hochuli et al., 1999; Jenkyns, 1999; among others). The second model proposes that organic carbon accumulates in sediments as a consequence of its preservation under anoxic conditions (e.g., Bralower and Thierstein, 1984; Wignall, 1991; Tyson, 1995).

These organic-rich deposits or black shales are usually associated with other facies and sedimentary features, including concretions and radiolarites (Wignall, 1994; Bréhéret, 1997). These features are valuable indicators when interpreting the depositional environment and, in addition, they can give clues to recognizing the origin of the organic matter.

This work focuses on a study of Lower Aptian rocks in the Carbonero Formation, which includes black shales and radiolarites plus certain other specific facies such as barite and calcareous concretions, cinerite layers, and calcareous turbidites, which represent the sedimentary record of OAE1a in this part of the Subbetic basin (Betic Cordillera). Analysis of facies and sedimentary features of the black shales are characterised and interpreted. Finally,

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a sedimentary model is proposed to interpret the facies association, taking into account both local and global oceanographic, climatic, and tectonic factors that led to the formation of these deposits.

2. Geographical and geological setting

The External Zones of the Betic Cordillera comprise by sedimentary rocks deposited on the South Iberian Continental Palaeomargin (SICP) (Fig. 1A) during the Alpine tectonic cycle (from the Triassic to the early Miocene). The SICP crops out at present in the External Zones of the Betic Cordillera (Fig. 1A, B), and was affected by transtensional tectonics during the Late Jurassic and Early Cretaceous (Vera, 2001, 2004; Martín-Chivelet et al., 2002). Two tectonostratigraphic domains are differentiated: the Prebetic Zone (para-autochthonous), characterised by shallow-marine facies with intercalations of continental facies, and the Subbetic Zone (allochthonous), with pelagic facies predominating. The allochthonous Subbetic units thrust over the Prebetic units in a northward direction. The current palaeogeographic model considers the existence of highs and basins corresponding to areas with

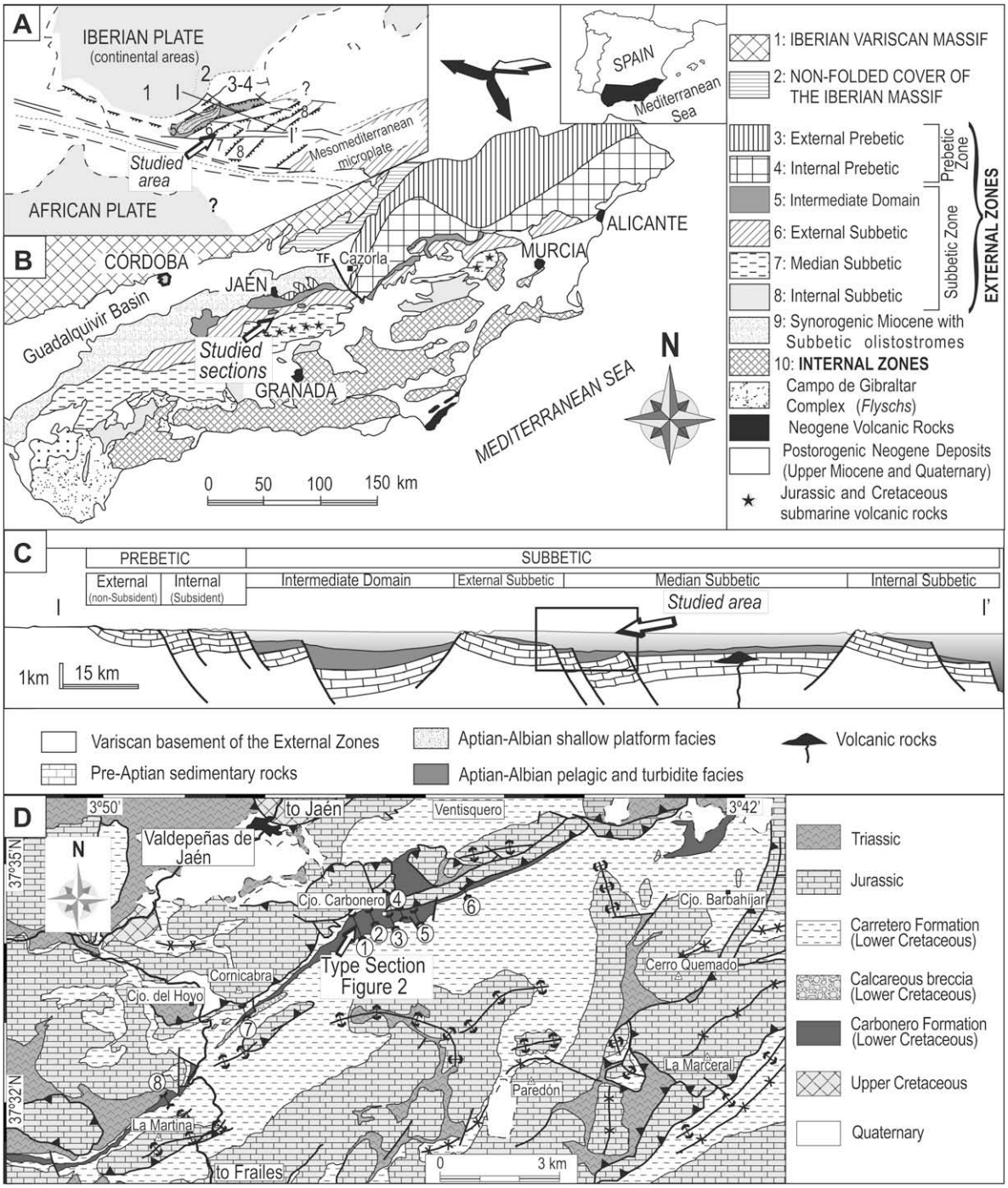

Fig. 1. A, Palaeogeographic reconstruction of the Southern Iberian Continental Margin (SICM) during the Early Cretaceous. Numbers in Fig. 1A are explained in the key. The location of section I-I' in Fig. 1C is shown. B, Geological map of the Betic Cordillera with the location of the studied outcrops (modified from García-Hernandez et al., 1980). C, Schematic section with the palaeogeography of the SICM during the Aptian-Albian (modified from Vera, 1983). D, Geological map of the area located south of Valdepeñas de Jaén, showing the outcrops of the Carbonero Formation and the position of the study sections.