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Tsunami-related deposits in temperate carbonate ramps, Sorbas Basin, southern Spain

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Abstract

Tsunami-related deposits occur in Upper Miocene (uppermost Tortonian–lowermost Messinian) temperate carbonates in the Sorbas Basin, SE Spain. These carbonates exhibit two distinct depositional models. At the northern margin, small, locally steepened ramps developed on an irregular palaeotopography. These ramps displayed bryozoan accumulations at the toe of submarine cliffs changing laterally to coralline algal rudstones to floatstones. A gentle homoclinal ramp extended along the southern margin of the basin. Bivalve (brachiopod/bryozoan)-rich carbonates formed in the mid-ramp, whereas coralline algal-rudstones spread over the outer-ramp, changing basinwards to packstones with planktonic foraminifers.

During the tsunami event large amounts of sediment were eroded from the carbonate ramps and redeposited. Two types of tsunami deposits are intercalated in outer-ramp sediments at both margins of the basin. In the steep outer-ramps of the northern margin, some folded layers are eroded and overlain by convex upward, stratified megahummocks. In the southern ramp, an abnormal thick shell-debris bed (TSB) occurs. Distinctive sedimentary features of these tsunamites and the inferred inflow and backflow effects were controlled by different palaeotopographic profiles. At the northern margin, inflow tsunami wave(s) struck the steep ramps, causing folding of underlying beds and excavating a large, irregular erosive surface. Backflow surges filled the inflow scours with the removed sediment, producing the megahummocky sets. At the southern margin, incoming tsunami surge(s) crossed the gentle ramp and eroded the sediments, especially in the inner-ramp settings. Backwash transported part of the previously removed sediments basinwards, depositing them as a thick bioclastic bed on the outer-ramp.

The triggering mechanism of the tsunamis was probably related to seismic events recorded in the adjacent Tabernas Basin as several coeval seismites.

Keywords: Tsunami; Temperate carbonates; Megahummocks; *Maerl*; Sorbas Basin; SE Spain

1. Introduction

Tsunamis, among the most powerful events on Earth's surface, have a very high recurrence interval (Schnyder et al., 2005). These "harbour waves" can be earthquake, volcanic, slide, or bolide impact-induced (Bondevik et al., 1997; Carey et al., 2001; Kelsey et al., 2005; Lawton et al., 2005). They erode and rework huge amounts of sediments from shallow marine and coastal settings and deposit them in either marine or continental environments. Tsunami-related deposits (tsunamites)

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have been referred to in numerous papers dealing with both Present and ancient examples (e.g. Clague and Bobrowsky, 1994; Dawson et al., 1996; Hindson and Andrade, 1999; Dawson and Shi, 2000; Rossetti et al., 2000; Cantalamessa and Di Celma, 2005; Schnyder et al., 2005; Goff et al., 2006).

Tsunami waves produce major effects on the sea-floor in nearshore settings, but resulting deposits (scour-and-fill structures) are normally later eroded due to reworking by currents and waves (Einsele et al., 1996). However, the effects of tsunami train waves (inflow and backflow surges) can also affect the platform in deeper positions (Pickering et al., 1991), below the fair and storm wave base. In these areas, preservation potential is higher as, after the tsunami event, normal sedimentation in calm-water conditions returns and the tsunami-generated deposits are buried and preserved.

In recent studies about tsunami deposits, one of the main concerns has been to determine significant sedimentary features of the tsunamites and their connection with landward flow and backflow (e.g. Massari and D'Alessandro, 2000; Rossetti et al., 2000; Bussert and Aberhan, 2004; Cantalamessa and Di Celma, 2005). Only minor importance has been given, however, to the type of source-sediment (i.e. carbonate versus terrigenous). In the case of siliciclastic systems, sediments are always unlithified on the sea floor and, under tsunami conditions, particles of different sizes (silt to large boulders) are easily mobilized. Carbonate tsunamites in warm-water (tropical) settings, where sea floor cementation is very high, consist of large reef blocks swept by tsunami waves (e.g. Nott, 1997; Scheffers and Kelletat, 2004), or shell debris (van den Bergh et al., 2003; Schnyder et al., 2005). However, little attention has been paid up to now to tsunamites in non-tropical carbonate environments. Only a few examples, such as Mid-Pliocene carbonate deposits in South Italy studied by Massari and D'Alessandro (2000) and the "calcareous sandstones" referred to by Mastronuzzi and Sansò (2004) are presumably related to temperate carbonates. In shallow-marine, non-tropical

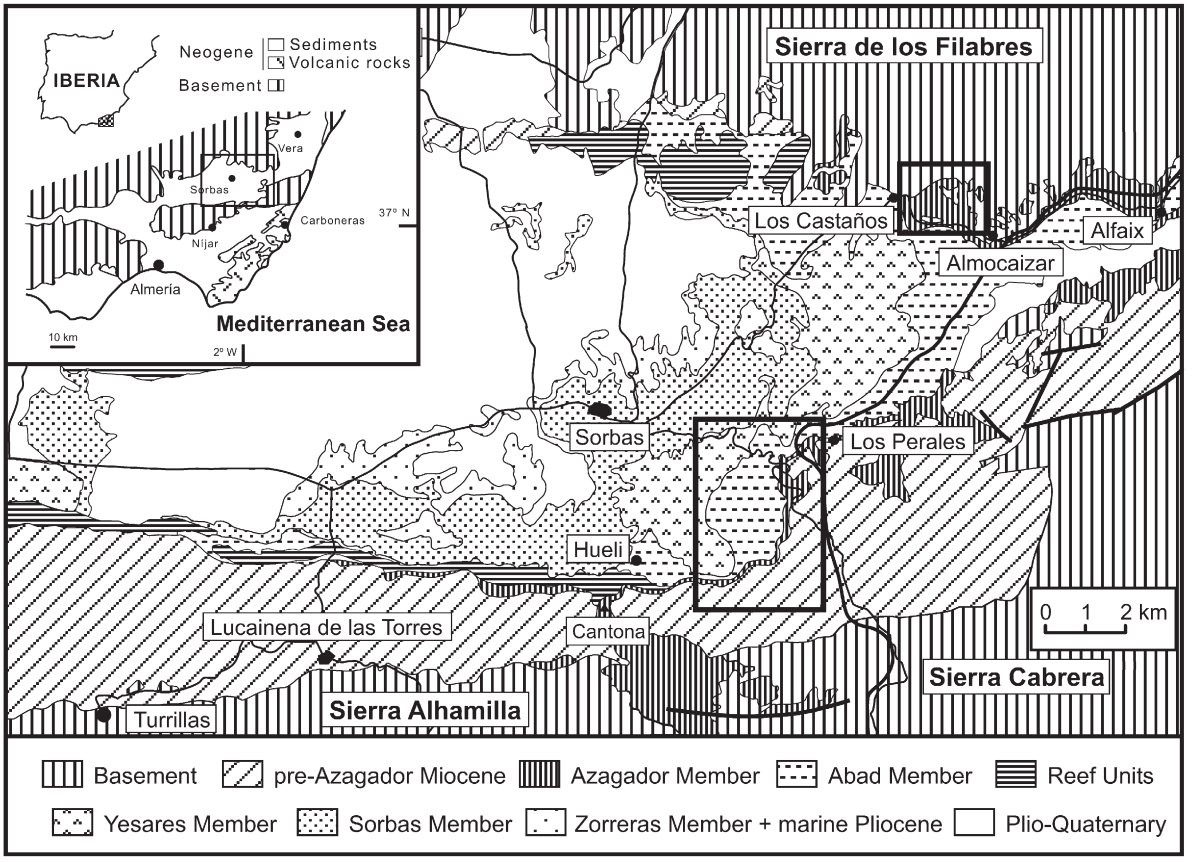

Fig. 1. Neogene basins in southeastern Spain and detailed geological map of the Sorbas Basin (modified from Montenat, 1990). Insets show location of the study areas.