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Coastal Environmental Change During Sea-Level Highstands: A Global Synthesis with implications for management of future coastal change



Project 437

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U-series ages of coral-bearing littoral deposits with Strombus bubonious of OIS 7 from La Marina (Alicante, SE Spain). A reappraisal of the Tyrrhenian chronostratigraphy in the Mediterranean Sea.

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Abstract

The Tyrrhenian marine deposits, defined by the presence of a warm water "Senegalese" fauna, are widely distributed around Mediterranean coastlines. They are often

associated with the Last Interglacial *stricto sensu*, *i.e.*, the isotopic substage (ISS) 5e interval. However, the status of the Tyrrhenian as an chronostratigraphic unit and the spreading pathway of its marker fauna are still unclear.



Figure 1. Spanish localities with S. bubonius in pre-last Interglacial deposits.

The Tyrrhenian cycle was defined by Issel (1914) in order to describe the "Strombus bearing layers" mentioned by Gignoux (1913) that came to the Mediterranean from Equatorial Africa. This warm fauna, the most representative of which was the Strombus bubonius, included other species also extinct in the present Mediterranean sea, which was called the "Senegalese fauna". These "Strombus bearing layers" appeared between the Sicilian cold fauna deposits and the Holocene temperate ones, meaning that the chronological amplitude of these Tyrrhenian cycle was wider in its original sense that it has been afterwards (~ISS Nevertheless, considered 5e). detailed geomorphological mapping together with the application of different dating methods such as fission track (Bonadonna and Bigazzi, 1970); U-series measurements on mollusc shells (Hillaire-Marcel et al., 1986; Goy et al., 1986; Causse et al., 1993; Goy et al., 1993; Zazo & Goy, 1989) suggested the presence of Strombus bubonius in the Mediterranean during OIS 7. The marine sequence of El Pinet Quarry (Fig. 1) is known long before now, and different authors have dated these S. bubonius bearing deposits. Bernat et al., (1982) carried out 12 U-series measurements on Strombus shells assigned all the units, oolitic or not, to the ISS 5c. Using the same technique, Causse et al., (1993) suggested an open geochemical system for these deposits; however sedimentological and geomorphological data made by the same authors (Goy et al., 1993), suggested the occurrence of two superposed units, the earlier one of oolitic nature, assimilating them to the ISS 5e and 5c respectively. Hearty et al., (1987) analysed the aminoacid racemization in both units, concluding that both two belonged to the aminozone E (ISS 5e). Recent work carried out in the surroundings of El Pinet Quarry, allowed to study and describe the sediments underlying the units outcropping in the quarry, being the first time that the presence of Cladocora caespitosa has been cited in this area (Zazo et al., 2003) coexisting with Strombus bubonius.

The preliminary results of one U-series dating carried out on this coral, suggested an OIS 7 age for this deposit.

The main aim of this paper is, therefore, to present the results obtained in the area of La Marina - El Pinet Quarry (Alicante, SE Spain) by means of different studies such as U-series measurements corals. detailed on geomorphological mapping (Sc. 1:5000), and neotectonic, palaeontological and sedimentological data, in order to contribute to the understanding of the palaeoecological changes of the western Mediterranean littorals during the Quaternary, as a key area of faunal interchange between an open ocean and a semi-closed sea. The area of La Marina, where El Pinet Quarry is sited, is located in the Elche Basin (Alicante), within the northern terminal splay of the Eastern Betics left lateral shear corridor. The present morphology of this tectonic corridor was reached during the Early-Middle Pleistocene, when an important tectonic phase gave place to a significant palaeogeographic change in this area. N-S faults and E-W folds and faults determined the outline of the palaeocliffs in the marine terraces (Goy and Zazo, 1988, 1989). A N100°E normal fault system with certain dextral characteristic triggered the spatial distribution of deposits which in turn are affected by N15-20°E and N150°E joint systems.

The marine and transitional deposits found at La Marina – El Pinet area developed within this tectonic realm Prograding sandy and conglomeratic beaches develop cut into a +8.5-9m marine terrace. These prograding beaches present colonies of *Cladocora caespitosa*, a constructional scleractinian coral (Morri et. al., 2000) endemic in the present Mediterranean, where it lives between the surface and 20-30 meters deep waters, bearing important temperature oscillations (Mean annual SST 13°C in winter and above 20°C in summer).

Many molluscs appear associated to the colonies, such as *S.bubonius, Arca noae, Gastrana fragilis* (articulated),



Figure 2. Activity ratios (by TIMS measurements) and age of samples from La Marina – El Pinet. Error bars represent $\pm 2\sigma$ values.

Bittium risoa, Cantharus viverratus, and Vermetids, pointing to very littoral facies. The maximum height of these beaches does not exceed 4-5 m asl. These corallittoral deposits constitute the substratum of the Strombus bubonius- bearing marine sediments outcropping at El Pinet Quarry, attributed in age to the OIS 5 (Goy et al., 1993; Zazo et al., 2003) and presenting oolitic facies in the most ancient unit, typical of the OIS 5e in the Spanish littoral. The maximum height of these units is 5 m asl. TIMS measurements on fossil C. caespitosa in 8 samples from two distinct sections at La Marina, yielded U-series ages ranging from $ca.178\pm10$ to 208 ± 11 ($\pm2\sigma$) ka (Fig. 2) and one outlier at 240±18 ka. All samples depict δ^{234} U values at the origin exceeding slightly that of modern specimens $(1.148\pm0.005; n = 4)$, a feature often observed in raised marine deposits from the Mediterranean (Hillaire-Marcel et al., 1996). This indicate some diagenetic mobility of Uranium However, the tight cluster of ²³⁰Th-ages at La Marina and the U-contents of its fossil C. caespitosa within the range observed in modern specimens (2.56 to 3.10 ppm; n = 4), suggest that this mobility should not have been important. An assignment of the embedding unit to the isotopic substage 7a seems thus reasonable, leading to infer the presence of S. bubonius in the Mediterranean at least as early as the ISS 7a (possibly 7c, if the outlier age is confirmed). Several other sites (Fig.1), notably in SE Spain and the Balearic Islands, also suggest S.bubonius occurrence during the penultimate interglacial, and possibly during older ones (Hi Zazo et al., 2003). In addition, S. bubonius seems to have still been present during the ISS 5c, possibly the ISS 5a (Hillaire-Marcel et al., 1986; Bernat et al., 1978). It is concluded that the chronological boundaries of the Tyrrhenian cycle are loosely constrained, except in the fact that S.bubonius and the accompanying "Senegalese fauna" did not survive the Würm glacial stage in the Mediterranean Sea, and that oceanographic conditions during the Holocene did not permit its re-entry from potential source areas (i.e., from the Guinean Gulf, the Cabo Verde archipelago). Consequently the term Tyrrhenian should be restricted to its original definition, i.e., to Strombus bubonius bearing marine units, without any chronostratigraphic implication.

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