Puglia 2003 - Final Conference
Project IGCP 437

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

Otranto / Taranto - Puglia (Italy) 22-28 September 2003
Quaternary coastal morphology and sea level changes

Project 437

Tuccimei P.[1], Fornós J. J. [2], Ginés À.[3], Ginés J.[2], Gràcia F. [4], Mucedda M.[5]

Sea level change at Capo Caccia (Sardinia) and Mallorca (Balearic Islands) during oxygen isotope substage 5e, based on Th/U datings of phreatic overgrowths on speleothems

[1]Dipartimento di Scienze Geologiche, Università "Roma Tre", Largo S. Leonardo Murialdo 1, 00146 Roma (Italy), fax +39-06-54888201, E-mail: tuccimei@uniroma3.it;
[2]Departament de Ciències de la Terra, Universitat de les Illes Balears, Palma de Mallorca, Spain, fax +34-971-173184, E-mail: joan.fornos@uib.es
[3]Museu Balear de Ciències Naturals, Sóller, Mallorca, Spain, E-mail: agines@sedusun3.caib.es
[4]Grup Nord de Mallorca, Pollença, Mallorca, Spain
[5]Gruppo Speleologico Sassarese, Via Pietro Canalis 10, 07100 Sassari, Italy

Keywords: *sea level, phreatic overgrowth, speleothem, Th/U dating, Western Mediterranean*

Abstract

Along the coasts of the Western Mediterranean, on the eastern part of Mallorca (Balearic Archipelago, Spain) and in Capo Caccia area (north-western coast of Sardinia, Italy), several coastal caves occur.

Inside the caves phreatic speleothems accrete around conventional vadose-zone speleothems in correspondence with the current sea level (Fig.1).

The main interest in these carbonate precipitates is that they have recorded past high and low sea stands, as indicated by means of strictly horizontal alignments of phreatic overgrowths on speleothems respectively located above and below present sea level (Ginés et al., 1981a; Pomar et al., 1987). In addition these speleothems can be dated using the Th/U method (Vesica et al., 2000) providing information on the timing and duration of past sea stands.

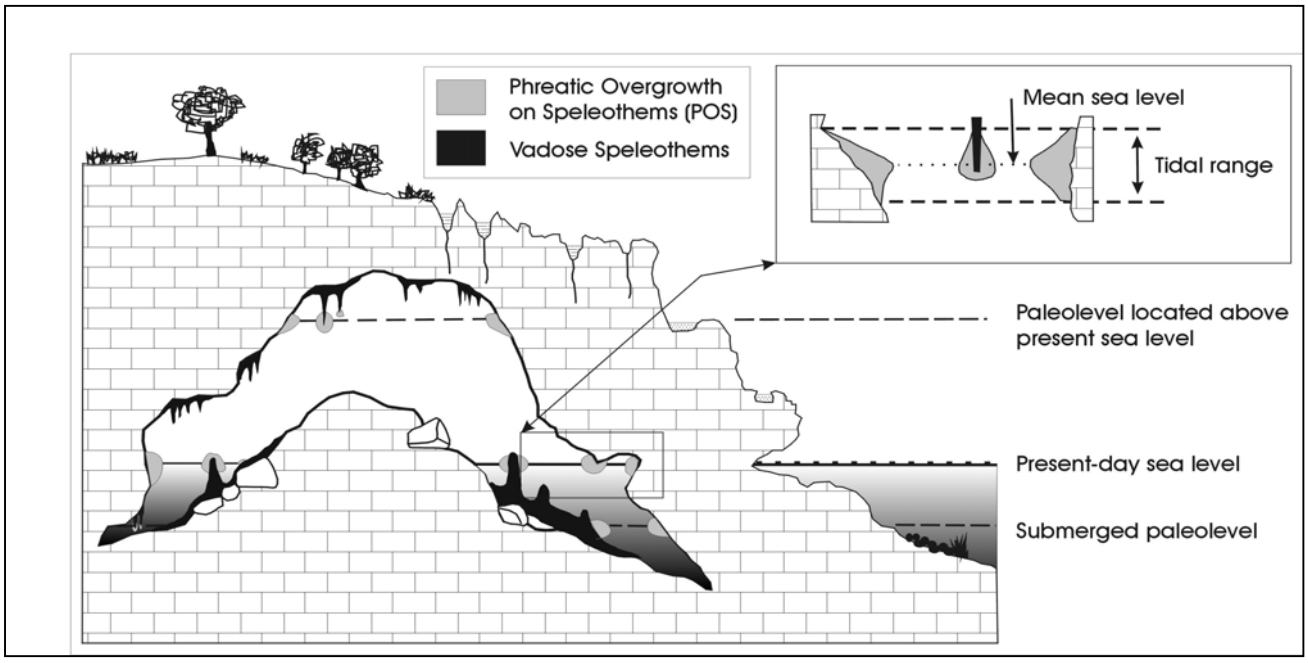

Figure 1. Schematic representation of littoral karst in Mallorca Island and Capo Caccia area (Sardinia) outlined in an ideal cross-section. Note the presence of phreatic overgrowths on speleothems related with past- and present sea levels.

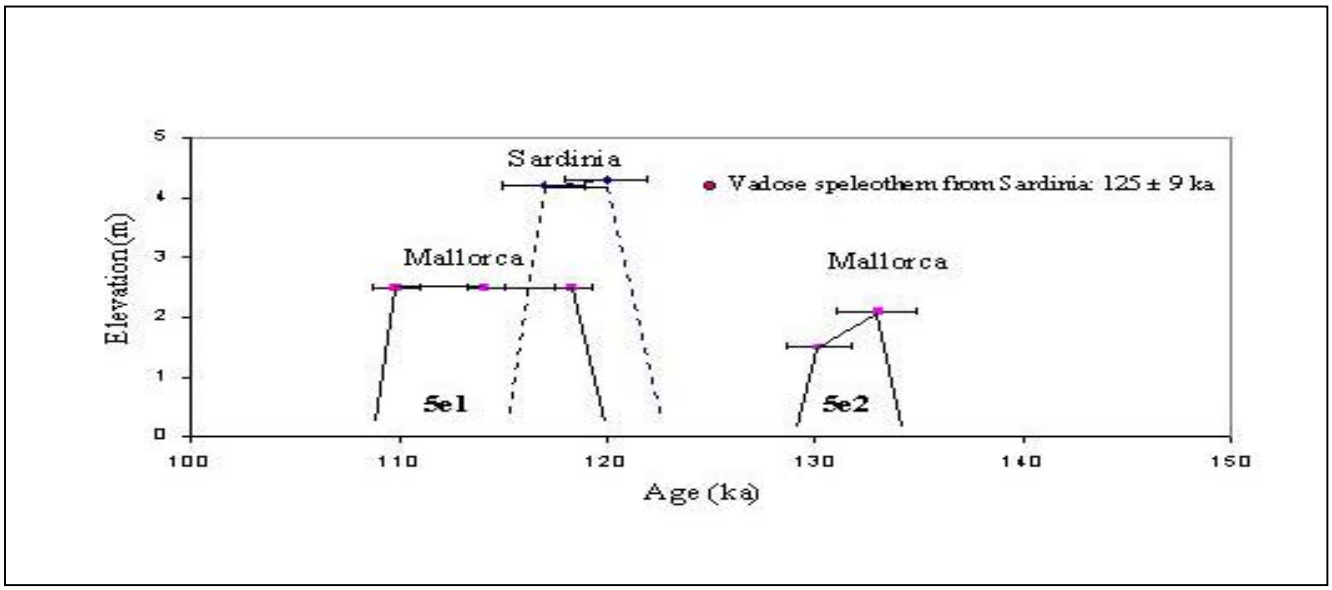

Figure 2. Last-interglacial high sea levels in Mallorca (Balearic Archipelago, Spain) and Capo Caccia area (Sardinia, Italy) based on Th/U datings of phreatic overgrowths on speleothems. Sea levels in Sardinia are indicated by a dashed line and levels in Mallorca by a continuous line. The closed circle represents a vadose speleothem from a cave in Capo Caccia area. Th/U datings have been carried out by TIMS and MC-ICPMS, except for the vadose speleothem from Capo Caccia (alfa counting). Quoted errors are always 2 sigma.

Here we present high-precision thermal ionisation mass spectrometry (TIMS) and multicollector inductively coupled plasma mass spectrometry (MC-ICPMS) U-series ages of Last Interglacial overgrowths on speleothems from Mallorca and Sardinia, locations situated at opposite sides of the central basin of the Western Mediterranean.

At Mallorca the data indicate two high sea stands during the Last interglacial that may have occurred from 135 to109 ka (Fig.2):

- a first stand (5e2 in Fig.2) at 1.5 - 2.1 metres above present sea level (a.p.s.l.), with an earlier possible beginning at 134.9 and a later start at 131.8 ka. The conclusion of this episode can be set from 131.1 to 128.6 ka resulting in a possible duration of a minimum of 0.7 and a maximum of 6.3 ka (average value = 2.8 ka)
- a second stand (5e1 in Fig.2) longer than the first, at 2.5 metres a.p.s.l., with an earlier possible beginning at 119.3 and a later start at 117.5 ka. The end of this stand seems to fall from 111.0 to 108.8 ka, lasting a minimum of 6.5 and a maximum of 10.5 ka (average value = 8.5 ka).

Two high sea stands during oxygen isotope substage 5e have been found in beach deposits from Mallorca Island also by Hillaire-Marcel et al. (1996). Th/U measurements by TIMS on mollusc shells from unconformably superimposed indurated littoral conglomerates and beach-rocks yielded ages of 135 and 117 ka.

It is worth noting that along the eastern coast of Mallorca, alignments of coeval phreatic speleothems, attributed to oxygen isotope substages 5a, 5c and 5e, are located at increasing elevations northwards (Fornós et al., 2002). This is an evidence of a significant tectonic tilting that took place, at least partially, after substage 5a because phreatic speleothems of this substage are now located at different altitudes. Considering that tectonic tilting has been continuous from post-substage 5a (approximately 85 ka) until now, and that normal displacement is approximately of 1.5 metres, the average minimum velocity of the tilting can be estimated as equal to about 0.02 mm/yr. The general tilting of the eastern coast of Mallorca is also demonstrated by stratigraphical, geomorphological and tectonic data, as well as by other microtectonic imprints.

In Sardinia (Capo Caccia area) three caves have been explored and studied. More than 25 phreatic overgrowths on speleothems have been sampled and dated by U/Th method. On the basis of these data, only an episode of high sea stand has been recorded inside the visited caves during the Last Interglacial at 4.3 m a.p.s.l. (Tuccimei et al., 2000). This sea stand can be correlated with the late substage 5e found at Mallorca (5e1 in Fig.2). Its earlier possible beginning can be set from 122.0 to 119.0 ka and its conclusion could range from 118.0 to115.0 ka, resulting in a possible duration of a minimum of 1.0 and a maximum of 7.0 ka (average value 3.0 ka). The age of 125 ka obtained for a vadose speleothems located at 4.3 m a.p.s.l. in a cave of Capo Caccia area (Grotta di Nettuno, Fig.2) supports the hypothesis that around that age the sea level had not reached the elevation of +4.3 m a.p.s.l. yet. The large error (+/- 9 ka) associated with this age does not allow any further consideration.

In the area of Capo Caccia there are no evidences of the early 5e high sea stand (5e2 in Fig.2) recorded at Mallorca, but it is not possible to exclude that this is due to a lack of sampling. Consequently only the data referred to the more

recent high stand will be discussed. It is important to stress that the promontory of Capo Caccia is cut at about 4-5 m a.p.s.l. by a wave-cut notch attributed to substage 5e. The notch is recorded at decreasing elevations northwards, from 5.40 to about 3.45 m a.p.s.l. This is an evidence of a descendent metric tilting from S to N (Antonioli et al., 1998) with an average rate of about 0.02 mm/yr.

On the basis of the data available so far (Fig.2) the high sea stand referred to late substage 5e is recorded at higher elevation on the north-western coast of Sardinia with respect to the eastern coast of Mallorca. The two sites can be considered substantially stable, even if minor post-120 ka tilting phenomena have affected similarly both sites (Fornós et al., 2002; Antonioli et al., 1998). In both cases, the sea level change can be considered to follow, in a first approximation, the eustatic sea level fluctuations in the Western Mediterranean, since Sardinia and Mallorca are located sufficiently far from former Penultimate Glacial Maximum ice sheets and are not significantly affected by glacial unloading. Further away from the ice sheets, the sea level changes are mainly controlled by the unloading and the loading of the seafloor as ocean volumes change (Lambeck and Bard, 2000). The small difference in elevation, from a maximum of 3.3 to a minimum of about 1 m (Fornós et al., 2002; Antonioli et al., 1998) recorded for the last interglacial sea stand at Mallorca and Capo Caccia could be due, besides to tectonics, to the different responses of the two sites to the uplift and subsidence processes induced by changes in the loading of the central basin of the Western Mediterranean seafloor during the last two glacial-interglacial cycles (Lambeck and Bard, 2000).

References

Antonioli F., Ferrant, L., Lo Schiavo F. (1998). *The submerged Neolithic burials of the Grotta Verde at Capo Caccia (Sardinia, Italy). Implication for the Holocene sea-level rise*. Memorie Descrittive del Servizio Geologico Nazionale, 52, 290-312.

Fornós J.J., Gelabert B., Ginés A., Ginés J., Tuccimei P., Vesica P.L. (2002). *Phreatic overgrowths on speleothems: a useful tool in structural geology in littoral karstic landscapes. The example of Eastern Mallorca (Balearic Islands)*. Geodinamica Acta, 15,113-125.

Ginés A., Ginés J., Pomar L. (1981a). *Phreatic speleothems in coastal caves of Majorca (Spain) as indicators of Mediterranean Pleistocene paleolevels*. Proceedings of 8th International Congress of Speleology 2, 533-536. Bowling Green.

Hillaire-Marcel C., Gariepy C., Ghaleb B., Goy J-L., Zazo C., Cuerda J. (1996). *U-series measurements in Tyrrhenian deposits from Mallorca. Further evidence for two last-interglacial high sea levels in the Balearic Islands*. Quaternary Science Reviews 15, 53-62.

Lambeck K., Bard E. (2000). *Sea-level change along the French Mediterranean coast for the past 30,000 years*. Earth and Planetary Science Letters, 175, 203-222.

Pomar L., Rodríguez-Perea A., Fornós J. J., Ginés A., Ginés J., Font A., Mora A. (1987). *Phreatic speleothems in coastal caves: a new method to determine sea-level fluctuations.* In: Zazo C. (eds.). *Late Quaternary sea-level changes in Spain*. Museo Nacional de Ciencias Naturales. C. S. I. C. Trabajos sobre Neógeno-Cuaternario 10, 197-224. Madrid.

Tuccimei P., Antonioli F., Delitala M.C., Fornós J.J., Ginés, A., Ginés J., Mucedda M., Orrù P., Taddeucci A. (2000). *Sea level changes during Oxygen Isotope Stage 5 at Capo Caccia (Alghero, Sardinia), based on U/Th datings of phreatic overgrowths on speleothems and geomorphological evidences*. Convegno: "L'Eemiano e il Tirreniano in Italia", 12-13 settembre 2000, Verona, Italy., 24-26.

Vesica P.L., Tuccimei P., Turi B., Fornós J.J., Ginés A., Ginés, J. (2000). *Late Pleistocene paleoclimates and sea-level change in the Mediterranean as inferred from stable isotope and U-series studies of overgrowths on speleothems, Mallorca, Spain*. Quaternary Science Reviews, 19, 865-879.