LATE QUATERNARY VERTICAL MOTIONS OF THE TYRRHENIAN COAST OF THE CALABRIA-BASILICATA BOUNDARY (ITALY)

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Introduction. The Tyrrhenian coast of Calabria-Lucania boundary has been investigated in depth combining geomorphological and stratigraphical approaches to get new quantitative data on its surface uplift history. In the study region, which spans from Maratea (Basilicata region) to Scalea (Calabria region), starting from Late Tortonian times back arc extension and opening of the Tyrrhenian Sea was coeval with the shortening in the chain (e.g., Butler *et al*., 2004, and references therein).

Surface uplift is referred to as "the displacement of the Earth's surface with respect the geoid" (England and Molnar, 1990) or, analogously, with respect to the mean sea level. Erosional indicators of fossil sea-level positions, e.g. abrasion platforms, marine notches and potholes, are well recorded on hard rocks (Evelpidou and Pirazzoli, 2015), as are those forming

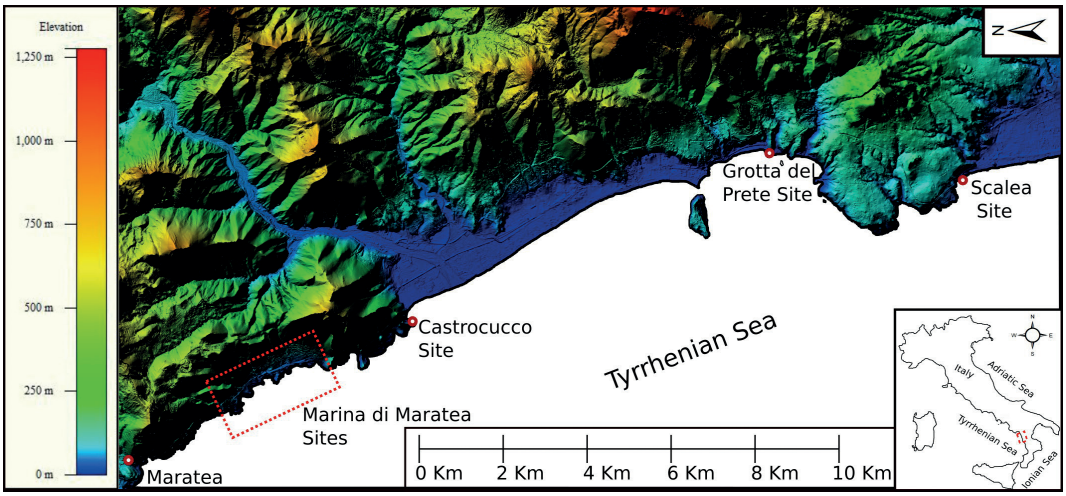

Fig. 1 - Location of the study sites shown on the5x5 m DEM.

the bedrock of the area investigated with our study. In the study area, Triassic to Miocene carbonates overlaid by ophiolitic unit (Iannace *et al*., 2005) form highly rocky coast alternated with bays, the main of which is the Noce River plain.

The costal sector that we have investigated is a key area placed between a northern sector (the Campania coastal belt), where indicators of the Last Interglacial period are located at elevations comparable to those of the correlative highstands (Ascione and Romano, 1999), and a southern sector (southern Calabria), which has recorded fast uplift in the Late Pleistocene (Damiani, 1970; Miyauchi *et al*., 1994; Westaway, 1993). However, the boundary between such sectors is not well defined (Ferranti *et al*., 2006).

The flight of marine terraces that in the study area stand in the elevation range between ~170 m and few m a.s.l. is already well known (Carobene and Dai Pra, 1991, 1990; Filocamo *et al*., 2009). However, poor age constrains are available and, for that reason, recent Quaternary uplift of the study area is still debated. In fact, while Westaway (1993) estimated an uplift rate around 1 mm/yr since the Last Interglacial, other authors (Filocamo *et al*., 2009) related the highest marine terraces to the Early Pleistocene and, in agreement with Carobene and Dai Pra (1991, 1990), assumed low Quaternary uplift rate.

Materials and Methods. The area spanning across the Calabria-Basilicata boundary has been investigated using geomorphological and stratigraphical approaches to the study of marine terraces standing in the 0-20 m a.s.l. elevation range. 1:5000 scale topographic maps and a 5x5 m DEM have been used for preliminary geomorphological analysis and to plan the field surveys. In the field, careful geomorphological-stratigraphical analyses have been carried out on both shallow marine and continental deposits correlated with wave-cut platform or tidal notches. A laser distance meter was helpful to measure the elevation of paleo sea-level markers.

The study has been integrated with mineralogical (X-ray powder diffraction, XRPD) and geochronological (U-series disequilibria dating) analyses on both *Cladocora caespitosa* corals and speleothems. A GE-Seifert ID 3003 and a PANalytical X'Pert with PIXcel detector diffractometres have been used for mineralogical characterization of each coral sample and some speleothem. U-series disequilibria dating has been performed by alpha-counting according to the chemical procedure described in Edwards *et al*. (1987).

Results and conclusion. Our work on paleo-shorelines has provided new quantitative data on both sea-level fluctuations and evidence of vertical motions in the Maratea-Scalea sector of the Tyrrhenian Sea eastern margin during the late Quaternary. Our attention has been focused

Fig. 2 - View of the wave-cut platforms in the Scalea site.

on sea level indicators in the 0-20 m elevation range, which are rather continuously exposed along the rocky headlands of the study region.

Field surveys have allowed us to: (1) identify and characterise different kinds of sea-level markers such as tidal notches, abrasion platforms and lithophaga holes bands, and (2) perform, at each study site (the main outcrops are shown in Fig.1), detailed relative chronology reconstructions of erosional/depositional events based on cross cut relationships between continental and marine landforms and deposits. Elevations of sea-level markers were accurately measured and both corals (*Cladocora caespitosa*) and calcite concretions associated with the paleo-shorelines were sampled in order to get new age constraints on the paleo-sea level markers.

In order to select corals with a calcite content<5% for uranium-thorium dating, XRPD qualitative vs. quantitative analyses were carried out. In fact, high calcite content means that the corals have lost their original aragonitic shells due to recrystallization processes. In the Grotta del Prete, Scalea (Fig.2) and Marina di Maratea sites (Fig.1) biocalcarenite deposits bearing *Cladocora caespitosa* present low calcite content (<3%). All of the parameters ($^{230}Th/^{232}Th$ activity ratios, total uranium content of corals, $^{234}U/^{238}U$) derived by the U-series analyses confirm the good quality of the results. Consistency of U-series data is indirectly confirmed by correlation of both dated corals with warm substages of the Late Pleistocene, and dated speleothems with cold stages of the late Quaternary.

The combined geomorphological and stratigraphical data have allowed both correlation of coral-bearing deposits with distinct shorelines and reconstruction of morphostratigraphical positions of speleothems. Based on relative chronology reconstructed, at each of the study site, among erosional sea-level markers (e.g., tidal notches, wave-cut platforms), shallow marine and continental deposits (e.g., marine pebbles and/or bioconstructions, and speleothems, respectively), on spatial correlations between paleoshorelines identified at each site, and on geochronological constraints, a relative sea-level curve has been reconstructed for the study region.

Notwithstanding some uncertainties on both vertical position of some sea-level markers and correlation between all the identified shorelines with eustatic peaks, our results suggest that sea level rises of the late substages of the Last Interglacial (namely MIS5c and MIS5a) reached paleo-elevation quite close to each other. Such a finding is consistent with evidence from stable areas in the western Mediterranean (e.g., Balearic island, Bardají *et al*., 2009). Moreover, at least two distinct sea-level peaksare identified during MIS5a, as already evidenced in southern Calabria by Dumas *et al*. (2005).

Assuming as reference values (with related uncertainties) eustatic sea level paleo-elevations of MIS5 and MIS3 inferred from stable areas of western Mediterranean (Balearic island; Bardají

et al., 2009) and Tyrrhenian coast of southern Italy (Iannace *et al*., 2003; Ferranti *et al*., 2006; Tuccimei *et al*., 2012), an uplift rate of at least one order greater than that previously estimated (Carobene and Dai Pra, 1991, 1990) for the study area is evaluated. This suggests that the study area, as well as southern Calabria, is subject to vertical motions, and rises the question of the possible occurrence of active faults –to date undetected- in the offshore, which may bear major implication on seismic hazard assessment for the study region.

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