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THE CONTRIBUTION OF COSEISMIC DEFORMATION TO HOLOCENE RELATIVE SEA LEVEL CHANGE: NEW DATA FROM THE COASTAL AREAS OF NORTH-EASTERN SICILY AND SOUTHERN CALABRIA

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ABSTRACT: Monaco C. *et al*., *The contribution of coseismic deformation to Holocene relative sea level change: new data from the coastal areas of north-eastern Sicily and southern Calabria.* (IT ISSN 0394-3356, 2011)
A new geomorphologic survey *has been carried out along coastal sectors of southern Calabria (Capo dell'Armi) and north-eastern Sicily (Capo Milazzo e Capo Schisò), Here, the occurrence of raised Holocene shorelines has been confirmed. In order to reconstruct the history of vertical deformation of the analyzed areas, the elevation of all the morphologic, biological and archaeological palaeo-sea level markers has been measured. These data, accompanied by absolute and archaeological dating, allowed us to assess a contribution of coseismic deformation, related to active faulting, to Holocene relative sea level change.*

RIASSUNTO: Monaco C. *et al*., Il contributo della deformazione cosismica alle variazioni relative del mare durante l'Olocene: nuovi dati dalle aree costiere della Sicilia nord-orientale e della Calabria meridionale. *(IT ISSN 0394-3356, 2011)*
Una nuova campagna di rilevamento è stata eseguita lungo settori costieri della Calabria meridionale (Capo dell'Armi) e della Sicilia nord-orientale (Capo Milazzo e Capo Schisò), dove è stata confermata la presenza di linee di costa oloceniche sollevate. Al fine di ricostruire la storia della deformazione verticale delle aree analizzate, sono state misurate le quote di tutti gli indicatori morfologici, biologici e archeologici del paleo- livello del mare. I dati ottenuti, accompagnati da datazioni assolute e archeologiche, hanno consentito di accertare un contributo di deformazione cosismica,correlato ad attività di faglie, alla variazione relativa del mare durante l'Olocene.

Key words: *coseismic deformation, relative sea level, tectonic uplift,. southern Italy*

Parole chiave: deformazione cosismica, livello relativo del mare, sollevamento tettonico, Italia meridionale

1 INTRODUCTION

Sea level is the general reference for detecting ongoing vertical crustal movement and assessing short- and long-term tectonic instability in coastal areas (LAJOIE, 1986). Vertical crustal movements can be deduced by archeological markers indicating apparent sea-level changes or by mapping and dating palaeoshorelines and separating the tectonic component from the eustatic and hydro-glacio-isostatic components of the relative sea level change (LAMBECK *et al.,* 2011).
Data on relative sea level change occurred during the Holocene along the coast of north-eastern Sicily and south-eastern Calabria (Fig. 1) have been obtained using precise measures and radiometric dating of raised shorelines in the Milazzo peninsula (see also RUST & KERSHAW, 2000; SCICCHITANO *et al.*, 2011a), Messina Straits (see also FERRANTI *et al*., 2007; SCICCHITANO *et al.*, 2011b) and Taormina area (see also STEWART *et al.*, 1997; ANTONIOLI *et al.*, 2003; DE GUIDI *et al.*, 2003), the fastest uplifting sectors of the central Mediterranean region. These strongly uplifted coastal regions are located along a main seismogenic system which affects the Tyrrhenian side of southern Calabria and the Ionian coast of eastern Sicily (see inset in Fig. 1).

2. DATA ANALYSIS

The detailed survey of Capo Milazzo (Tyrrhenian coast of north-eastern Sicily) confirmed the occurrence of raised Late Holocene shorelines and provided evidences of contribution of episodic motions to a steady regional tectonic uplifting. Two palaeoshorelines have been measured at distinct elevations. The upper shoreline is represented by: i) a barnacle band at 2.0-3.0 m elevation; ii) a notch with a roof at ~2.10 m; iii) a marine deposit at 1.4-2.4 m elevation. The lower shoreline is characterized by a wave-cut platform extending from ~1 m down to the present coastline and by a barnacle band reaching a maximum elevation of 1.1 m. Relationships between age and elevation suggest that the upper shoreline formed between 6200 and 1600 years ago and that a coseismic uplift (1.4-1.5 m) occurred between 1600 and 1400 years ago. Similarly, a more recent coseismic uplift

(0.8-0.9 m) should be occured in the last 1400 years. An average uplift rate of 1.5 mm/yr has been estimated for the cumulative uplift. This could be related to the activity of a transpressive structure that is clearly evident in the offshore (e.g. the Capo Milazzo fold; Fig. 1; ARGNANI *et al*., 2007).

In the Taormina area (Ionian coast of north-eastern Sicily) a detailed survey of the Capo Schisò promontory has been carried out. Here, a lava flow (6 ka old) is encrusted by calcarenitic marine deposits containing mollusk fossils and by algal and barnacle bands, forming three palaeoshorelines at elevation of 1.6-1.8, ~2.9 and 3.0-5.0 m a.s.l. New radiocarbon dating results, compared with published data (ANTONIOLI *et al*., 2003; BRANCA, 2003, DE GUIDI *et al*., 2003) suggest an average uplift rate of 1.7-1.8 mm/yr and the occurrence of three co-seismic uplift events in the last 5 ka (~4.0, ~2.0 and ≤1.0 ka ago). Archaeological markers represented by ancient slipways in the Naxos site of Classic Greek period (BLACKMAN & LENTINI, 2007), suggesting the occurrence of a 2.4 ka old palaeoshoreline at elevation of 2.4 m a.s.l., are consistent with morphologic and biological markers. Taking into account the measured co-seismic displacements, seismic events should be related to the activity of an offshore tectonic structure (e.g. the Taormina fault; Fig. 1; DE GUIDI *et al*, 2003).

In the south-eastern sector of the Messina Straits (Capo dell'Armi, Fig. 1), Holocene uplift is suggested by coastal deposits and archeological remains tied to the coeval sea-level. Along a 10 km coastal stretch, in the footwall of the Armo fault (Fig. 1), a continuous beachrock (see also PIRAZZOLI *et al*., 1997) is raised up to 2 and locally to 3 m a.s.l., and was dated by radiocarbon analysis at ~5 ka BP. Correction for the sea-level rise occurred since 5 ka yields uplift rates up to 1.2 mm/yr, a value comparable to the long-term footwall uplift rate, interpreted here as suggestive of ongoing Late Holocene fault activity. Partly contrasting information for the historical time-span

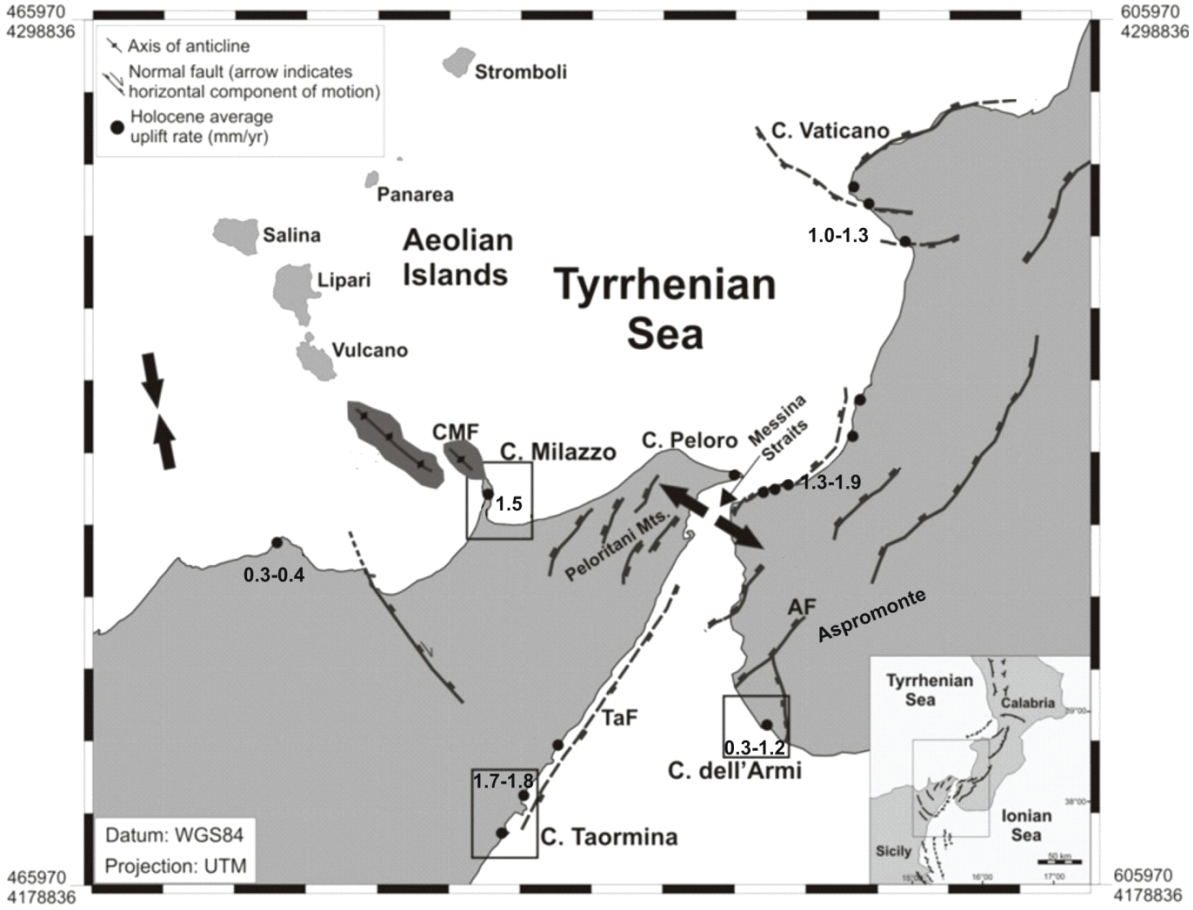

Fig. 1 - Regional tectonic map of the southern part of the Calabrian Arc. Double arrows show extension direction in Western Calabria and Eastern Sicily and contraction direction in the northern Sicily offshore. AF, Armo fault; TaF, Taormina fault. The uplifted areas between Capo Milazzo and Vulcano (from ARGNANI et al., 2007) are indicated in grey (CMF, Capo Milazzo fold).

Carta tettonica regionale della porzione meridionale dell'Arco Calabro. Le doppie frecce mostrano la direzione di estensione in Calabria occidentale e Sicilia orientale e la direzione di contrazione nell'offshore della Sicilia settentrionale. AF, faglia di Armo, TaF, faglia di Taormina. Le aree sollevate tra Capo Milazzo e Vulcano (da ARGNANI et al., 2007) sono indicate in grigio (CMF, piega di Capo Milazzo).

come from archaeological sea level markers of inferred Hellenistic age discovered in the area and studied by SCICCHITANO *et al*. (2011b). In fact, a millstone quarry dips from the emerged beach down to 0.2 m below sea level. Corrections for the functional height and for sea-level rise occurred since Hellenistic times yields an uplift rate of 0.3 mm/yr. The different values of uplift rate obtained by geological and archaeological markers at Capo dell'Armi, located way far in the footwall of the Armo fault, but in the immediate hanging-wall of a fault splay, could be explained by a cyclical alternation of co-seismic events on the two faults (ALOISI *et al*., 2009).

3. DISCUSSION AND CONCLUSIONS

The analysis indicate that vertical displacement occurred as an alternation of steady and episodic motions. Precise compensation for eustatic changes and hydro- glacio-isostatic adjustments (LAMBECK *et al.,* 2010) constrains Late Holocene total uplift at ~ 1.2-2.0 mm/yr, almost equally balanced between the steady and the stick-slip components. Late Holocene steady uplift during the interseismic intervals at 1.0 mm/yr is consistent with long-term (0.1-1 Ma) estimates (WESTAWAY, 1993). Abrupt displacements are attributed to co- and post-seismic footwall uplift along normal faults (Taormina, Capo dell'Armi) or transpressive structures (Milazzo), which occur onshore or are inferred to run immediately offshore the studied coastal outcrops.

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