

COMPARING MARINE GEOLOGY AND COASTAL GEOMORPHOLOGY VERTICAL TECTONIC DATA, A CASE STUDY BETWEEN ACQUEDOLCI AND PATTI (MESSINA)

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ABSTRACT: Lo Presti V. *et al.*, *Comparing marine geology and coastal geomorphology vertical tectonic data, a case study between Acquedolci and Patti (Messina)*. (IT ISSN 0394-3356, 2011)

The study of new data on vertical movements show a complex geologic response in a restricted sector of coastal area between Acquedolci and Patti (north-eastern Sicily). Different surveys allowed to the recognition of morphological, biological and archaeological markers of paleo-sea level. The analysis of these markers and the absolute datings performed, allowed to reconstruct the history of vertical deformation of this sector but only the comparison among coastal geomorphological data and marine geological data of platform-scarp continental system associates, allowed to find the necessary keys words to explain the geologic complexity of this sector.

RIASSUNTO: Lo Presti V. *et al.*, *Dati di geomorfologia costiera e geologia marina a confronto nella valutazione di tassi verticali nel quaternario. Il caso della Sicilia nord-orientale nel settore fra Acquedolci e Patti (Messina)*. (IT ISSN 0394-3356, 2011)

Lo studio di nuovi dati sui movimenti verticali mostra una complessa risposta geologica in un settore ristretto della fascia costiera fra Acquedolci e Patti (Sicilia nord-orientale). Diverse campagne di indagine hanno portato al riconoscimento di indicatori morfologici, biologici e archeologici del paleo livello del mare. L'analisi di questi markers e le datazioni assolute eseguite, hanno permesso di costruire un quadro sulla storia della deformazione verticale di questo settore ma solamente il confronto fra i dati geomorfologici costieri e gli ambienti marini di piattaforma e scarpata continentale ad essi associati, ha permesso di trovare le chiavi di lettura necessarie a spiegare la complessità geologica di questo settore.

Key words: Coastal geomorphology, Tectonic uplift, North-eastern Sicily.

Parole chiave: Geomorfologia costiera, Sollevamento tettonico, Sicilia nord-orientale.

1. INTRODUCTION

The Calabrian arc records one of the major Quaternary vertical movement in the whole Mediterranean region. Data on vertical movements calculated for the coastal area along the north-Sicilian continental margin indicate that, from East to West, a strong variation of vertical rates of uplift are recognized during both middle-late Pleistocene and Holocene.

Vertical position of sea-level, related deposits and morphologies provide useful markers to estimate uplift rates (LAMBECK *et al.*, 2004; FERRANTI *et al.*, 2006, ANTONIOLI *et al.*, 2009). In the northwest Sicily coast the uplift rates estimated for the Holocene are greater than those estimated at the same point from the Last Interglacial (LIG, 125 ka) (ANTONIOLI *et al.*, 2006). The measured uplift misured appear as the result of two different processes, due to a "continuous regional" component and an "episodic coseismic"

component respectively (FERRANTI *et al.*, 2007).

This study, based on published (FERRANTI *et al.*, 2010) and new data, deals with the vertical tectonic movements calculated in the sector between Acquedolci and Patti (Sicily northern coast). We focus our attention on the eastern sector of the Sicilian northern coast and particularly immediately to the west of the Vulcano-Tindari fault system, where several evidences of vertical movements during the Pleistocene-Holocene have been recognized.

In this active sector the tectonic lineaments show different trends (NICOLICH *et al.*, 1982; NIGRO & SULLI, 1995) both onland (MONACO & TORTORICI, 2000; ATZORI *et al.*, 1978) and offshore (GABBIANELLI *et al.*, 1996; CUPPARI *et al.*, 1999).

The occurrence of both oblique and normal fault systems and the alternation of rocks with different competence, as the Hercynian metamorphic basement, its Meso-Cenozoic carbonate and Oligocene-Miocene terrigenous cover and

Pleistocene deltaic ore and gravels (CARBONE *et al.*, 1998), determine a complex geomorphological setting.

The morphological response to the active tectonics is very different onland and in the offshore areas, due to the occurrence in the submerged areas of preserved structures, which are obliterated, eroded or covered in the exposed areas, as well seismic reflection data reveal trends and mechanisms of the relative motion from land to sea, through the analysis of the recognized fault systems. On the other hand the outcropping biological and geomorphological markers provide to estimate tectonic uplift rates, which are not allowed in the marine areas.

2. DATA ANALYSIS

In the coastal sector from Acquedolci and Patti geomorphologic survey provided new data on Quaternary uplift rates. It induced us to divide this area, close to the Capo d'Orlando promontory, in two sector with different deformational response to the regional tectonics, as evidenced by the different distribution of the Pleistocene marine terraces. Between Capo d'Orlando and Patti marine abrasion surface are infrequent as well the marine terrace deposits, which are difficult to age-date. On the contrary to the west of Capo d'Orlando the pleistocene marine terraces morphologies are well preserved. Between Acquedolci and Capo d'Orlando we recognized a well preserved set of four orders of marine terraces. The terrace located at about 40 m (Rocca Scodoni) presents a marine deposit; the inner margin, located at 45-50m, is constituted by a cliff with several Lithodomus holes. Here a shell of *Spondylus* s.p. in physiologic position was found; the U/Th analysis on shell provides (with large error bar) an MIS 5 age (between 100 and 125 ka) (SCICCHITANO *et al.*, 2011; GASPARO MORTICELLI *et al.*, 2010). For this sector we estimate the tectonic uplift rate between 0.36-0.5 mm/yr. To the east of Patti several authors calculated regional uplift rates between 0.62 and 0.67 mm/yr from the last interglacial (FERRANTI *et al.*, 2006).

A few kilometers east of Rocca Scodoni, archaeological markers occur (SCICCHITANO *et al.*, 2011) along the coastal sector east of Capo d'Orlando. Here an ancient quarry of grinding wheels for oil has been found. They present sub-circular holes in the materials coming from the Upper Oligocene-Lower Miocene Stilo-Capo d'Orlando deposits (CARBONE *et al.*, 1998). The tectonic uplift was evaluated as the difference between the observed local paleo-sea level position and the predicted sea-level curve for the

same locality. The resulting uplift rates of 0.36 mm/yr (SCICCHITANO *et al.*, 2011) suggests similar tectonic uplift rates of Rocca Scodoni but relative to the Holocene.

Between Capo d'Orlando and Capo Calavà, we studied the Brolo Island, located in the central part of a small bay; it is a "lentil" of metamorphic rocks emerging above the 14-18 m deep seafloor, at 450 m from the coastline. A detailed geomorphological sub aerial and underwater survey was conducted, which led to discovery a fossils-bearing conglomerate, in protected trays at 3.5 m from sea level, and well preserved lithophaga holes at about 70 cm from sea level. Radiocarbon analysis on a gastropod found in the marine conglomerate gave us an age of 4745 yr +/- 59 (4965 years +/-70 cal BP). If we compare this data with the predicted local sea level curves (LAMBECK *et al.*, 2011), we obtain an uplift rate about 1.5 mm/yr (LO PRESTI *et al.*, 2010), which is higher than that calculated for the last interglacial and for the Holocene in the study of archaeological rest.

Westward of Capo Calavà a "suspended" alluvial fan outcrops in a cliff a few meters back to the coastline. At the base of the cliff, around 1.3 meters above sea level, we recognize the stratigraphic contact between the alluvial fan deposit and the paleo-beach. The alluvial fan is incised in the highest part by a little river that flows into the sea with a fall of around 12 meters of height.

In the Patti area, near Mongiove promontory, Lithodomus holes on metamorphic rocks can be observed between 2.2 and 3.5 meter above sea level. Also not allowing the calculation of tectonic uplift rates, the presence of a suspended alluvial fan and the recovery of Lithodomus holes constitute a further evidence of effects of vertical tectonic movements along the coastal areas.

The analysis of marine geology data demonstrates that the active tectonics determines the morphological feature of the continental shelf-slope system (LO PRESTI, 2010). Multibeam data evidenced structures connected to different faults systems, such as the submarine canyons which incised the continental slope in the Acquedolci to Patti offshore. Most of the canyons are the continuation of fluvial beds ("Fiumare"), demonstrating the occurrence of sea-land tectonic lineaments. Mainly in the Capo Calavà sector submarine canyons are characterized by V-shaped valleys, very incised gullies and steep flanks, testifying the role of active tectonics. Marine geology data evidenced also tilted NE-ward submerged surfaces, indicating existing structural movements, interesting only restricted areas, a few kilometers wide.

3. CONCLUSIONS

Geomorphological surveys, radiocarbon analysis and marine geology data in the northwestern sector of Peloritani Mountains and its offshore evidenced significant assessment about uplift rates in the Quaternary. Field data reveal from Capo d'Orlando towards the east a sharp increase of the tectonic uplift rates during the Holocene, with respect to the values calculated from the last interglacial. Very different uplift rates mainly in the Holocene in very close areas: 0.36 mm/yr (SCICCHITANO *et al.* 2011) and 1.5 mm/yr (LO PRESTI *et al.* 2010) distant only about 10 kilometers, has evidenced the role of tectonic lineaments, acting as releasing features during the Holocene. Seismic reflection profiles support this assumption, showing the metamorphic basement strongly dissected by high-angle faults, which at place determines the occurrence of emergent rock bodies (e.g. the Brolo Island). More the morphobathymetric data show tilted surfaces, suggesting the occurrence of "restricted regions" in the coastal-marine sector with different geological behavior as response to prominent tectonic releasing bands, determining their horizontal and vertical movements.

REFERENCES

- ANTONIOLI F., KERSHAW S., RENDA P., RUST D., BELLUOMINI G., RADTKE U. & SILENZI S. (2006) - *Altitude of the last interglacial highstand in Sicily (Italy) and its implications for tectonic*. QUATERNARY INT., **145** -146, 3-18.
- ANTONIOLI F., FERRANTI L., FONTANA A., AMOROSI A., M., BONDESAN A., BRAITENBERG C., DUTTON A., FONTOLAN G., FURLANI S., LAMBECK K., MASTRONUZZI G., MONACO C., SPADA G. & STOCCHI P. (2009) - *A review of the Holocene sea-level changes and tectonic movements along the Italian coastline*. QUATERNARY INT., **206**, 102-133.
- ATZORI P., GHISSETTI F., PEZZINO A. & VEZZANI L. (1978) - *Strutture ed evoluzione geodinamica recente dell'area peloritana (Sicilia nord-orientale)*. BOLL. SOC. GEOL. IT., **97**, pp.31-56.
- CARBONE S., LENTINI F. & VINCI G. (1998) - *Carta geologica del settore occidentale dei Monti Peloritani (Sicilia nord-orientale)*. S.EL.CA., Firenze.
- CUPPARI A., COLANTONI P., GABBIANELLI G., MORELLI D. & ALPARONE R. (1999) - *Assetto ed evoluzione morfostrutturale dell'area marina compresa tra il margine della Sicilia settentrionale e le Isole Eolie (Golfo di Patti)*. ATTI ASS. IT. OCEAN. LIMNOL., **13** (1), 137-149.
- FERRANTI L., ANTONIOLI F., ANZIDEI M., MONACO C. & STOCCHI P. (2010) - *The timescale and spatial extent of vertical tectonic motions in Italy: insights from relative sea-level changes studies*. Journal of the Virtual Explorer, Electronic Edition, ISSN 1441-8142, **36**, paper 30.
- FERRANTI L., MONACO C., ANTONIOLI F., MASCHIO L., KERSHAW S. & VERRUBBI V. (2007) - *The contribution of regional uplift and coseismic slip to the vertical crustal motion in the Messina Straits, Southern Italy: evidence from raised Late Holocene shorelines*. Journal of Geophysical Research, **112**, B06401, DOI: 10.1029/2006JB004473.
- FERRANTI L., ANTONIOLI F., AMOROSI A., DAI PRÀ G., MASTRONUZZI G., MAUZ B., MONACO C., ET AL., (2006) - *Elevation of the last interglacial highstand in Italy: A benchmark of coastal tectonics*. Quat. Int., **145-146**, 30-54.
- GABBIANELLI G., TRAMONTANA M., COLANTONI P. & FANUCCI F. (1996) - *Lineamenti morfostrutturali e sismostratigrafici del Golfo di Patti (Margine nord siciliano)*. F.M. FARANDA & P. POVERO (EDS.), DATA REPORT EOCUMM95, CONISMA, 443-453.
- GASPARO MORTICELLI M., LO PRESTI V., ANTONIOLI F., MONACO C., SULLI A. & ZUCCARELLO A. (2010) - *Spatial extent of vertical tectonic motions in northern Sicily using Holocene and Last Interglacial sea level markers: a case study between Acquedolci e Capo d'Orlando*. Rend. Online Soc. Geol. It., **2**, 668-669.
- LAMBECK K., ANTONIOLI F., PURCELL A., SILENZI S. (2004a), *Sea level change along the Italian coast for the past 10,000 yrs*. Quat. Science Revue. **23**, 1567-1598.
- LAMBECK K., ANTONIOLI F., ANZIDEI M., FERRANTI L., LEONI G., SCICCHITANO G. & SILENZI S. (2011) - *Sea level change along Italian coast during Holocene and a projection for the future*. Journal of Quaternary International. In print.
- LO PRESTI V., GASPARO MORTICELLI M., ANTONIOLI F., SULLI A. & CATALANO R. (2010) - *The Brolo island, a lentil in the "Ocean"*. Rend. Online Soc. Geol. It. **2**, 672-673.
- LO PRESTI V. (2010) - *Analisi morfologica ed oceanografica del margine continentale della Sicilia nord-orientale. Relazione fra la fascia costiera e il Sistema Piattaforma-Scarpata*. Tesi di Dottorato.
- NICOLICH R., CITA M.B., FABBRI A., FANUCCI F., TORELLI L. & WEZEL F.C. (1982) - *Bacini sedimentari: ricerche geofisiche e di geologia marina*. P.F. OCEANOGRAFIA E FONDI MARINI, S.P. RISORSE MINERARIE, C.N.R., ROMA.
- NIGRO F. & SULLI A. (1995) - *Plio-Pleistocene extensional tectonics in the Western Peloritani area and its offshore (northeastern Sicily)* - Tectonophysics, **252**, 295-305.
- MONACO C. & TORTORICI L. (2000) - *Active faulting in the Calabrian Arc and eastern Sicily*. J. Geodyn. **29**, 407-424.
- SCICCHITANO G., LO PRESTI V., SPAMPINATO C. R., GASPARO MORTICELLI M., ANTONIOLI F., AURIEMMA R., FERRANTI L. & MONACO C. (2011) - *Millstones as indicators of relative sea level changes in northern Sicily and southern Calabria coastlines, Italy*. Quaternary Int., in press.