Il Quaternario
Italian Journal of Quaternary Sciences
24, (Abstract AIQUA, Roma 02/2011), 54 - 56

Congresso AIQUA
Il Quaternario Italiano: conoscenze e prospettive
Roma 24 e 25 febbraio 2011

LUMINESCENCE CHRONOLOGY OF PLEISTOCENE MARINE TERRACES OF THE SICILY AND CALABRIA COASTAL AREAS

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ABSTRACT: Ristuccia G.M. *et al., Luminescence chronology of Pleistocene marine terraces of the Sicily and Calabria coastal areas.* (IT ISSN 0394-3356, 2011)
The Calabrian Arc and north-eastern Sicily are sectors of central Mediterranean where the effects of Quaternary tectonics are visible and regional uplift is accompanied by marine terracing along the coastal areas. In this paper, the application of Optically Stimulated Luminescence (OSL) dating based on the single-aliquot regenerative-dose (SAR) protocol for sand-sized quartz is investigated. We present new OSL age estimates of Pleistocene marine terrace deposits located in Capo Vaticano peninsula and in the Sant'Agata di Militello costal area, where a complete series, characterized by both marine and continental deposits, occurs. Current elevations of marine terraces also suggest that these portions of the Calabrian Arc have been affected by a vigorous tectonic uplift during the last 330 ka, probably due to sum of regional uplift and fault activity.

RIASSUNTO: Ristuccia G.M. *et al.,* Cronologia tramite luminescenza dei terrazzi marini Pleistocenici presenti lungo l'area costale della Sicilia e della Calabria meridionale. (IT ISSN 0394-3356, 2011)
L'Arco Calabro e la Sicilia nord-orientale sono settori del Mediterraneo centrale dove gli effetti della tettonica Quaternaria sono ben visibili e il sollevamento regionale è evidenziato da un terrazzamento marino lungo le aree costiere. In questo lavoro è stata investigata la possibilità di datare i depositi terrazzati tramite la Luminescenza Otticamente Stimolata (OSL) mediante il protocollo della singola aliquota (SAR) su quarzo estratto dai sedimenti. I risultati ottenuti hanno permesso di ottenere nuove cronologie dei terrazzi Pleistocenici localizzati lungo la penisola di Capo Vaticano e l'area costiera di Sant'Agata di Militello. Le attuali linee di costa suggeriscono, insieme ai dati ottenuti, che queste porzioni dell'Arco Calabro sono state soggette ad un forte sollevamento durante gli ultimi 330 ka, probabilmente a causa della componente regionale sommata ad attività di faglie.

Key words: marine terraces, uplift rate, luminescence

Parole chiave: terrazzi marini, rate di sollevamento, luminescenza

1. INTRODUCTION

Marine terraces are geomorphic surfaces that have been exposed by a lowering of sea level or a tectonic uplift; their inner edges indicate the location of a palaeoshoreline. Therefore the timing of terrace formation can provide information on coastal uplift and allows to determine local deformation related active faulting. In this paper we investigate the middle-upper pleistocene deformation rates of some terraces of the Sicily and Calabria coastal areas (Capo Vaticano, western Calabria; Sant'Agata di Militello, northern Sicily). In these southern Italy regions, the effects of intense quaternary tectonic activity were evident. At first, the marine surfaces, with their relative inner edges, have been mapped using 1:25000 scale topographic maps of the IGM integrated with analysis of 1:33000 and 1:10000 scale aerial photographs. Moreover, OSL dating of marine terraces deposits, together with detailed morpho-structural analysis of tectonic elements, allowed us to reconstruct the tectonic evolution of analyzed coastal area and to constrain the relationships between marine terracing and normal faulting in a precise time range.

2. GEOLOGICAL SETTING

The Capo Vaticano peninsula is a structural high located along the Tyrrhenian side of the Calabrian Arc (Fig. 1), an arc-shaped portion of the central Mediterranean orogen extruded towards the oceanic crust of the Ionian Basin during the final stage of the Africa-Europe collision (MALINVERNO & RYAN, 1986).
Late Quaternary tectonics along the Calabrian Arc are characterized by the occurrence of a prominent normal fault belt along the western side of Calabria and NE coast of Sicily, developed in response to WNW,ESE regional extension (Siculo-Calabrian rift zone; MONACO & TORTORICI, 2000). Since the middle Pleistocene, extensional tectonics have been coupled with a strong regional uplifting which developed spectacular flights of marine terraces (WESTAWAY, 1993; GHISETTI, 1981; 1984; MIYAUCHI *et al*., 1994; BIANCA *et al*., 1999; CATALANO & DE GUIDI, 2003; TORTORICI *et al*., 2003; VALENSISE & PANTOSTI, 1992; FERRANTI *et al*., 2006).

The Sant'Agata di Militello coastal area is located along the Tyrrhenian shore of NE Sicily about 100 km west of the town of Messina. The area is a part of the southernmost sector of the Calabrian Arc.
The samples from each marine terrace (seven samples from Capo Vaticano peninsula and three from Sant'Agata di Militello) were collected from 60 cm long cylindrical cores (5 cm) extracted from fresh outcrops by black corebarrel to dating by Optically Stimulated Luminescence (OSL) methodology. The ends of each cylinder were sealed with black tape for transportation because it is of critical importance for OSL measurements that the samples are not exposed to daylight. However, the outer layers have been used in the laboratory for radioactivity measurements and water content determination.

3. METHODOLOGY

OSL has become an important technique for studying Earth surface processes and dating sediments. The general equation used to determine the age, time from the last optical bleaching until today, is:

$$Age\,(a) = \frac{Equivalent\ dose\,(Gy)}{Annual\ dose\,(Gy/ka)}$$

where the *equivalent dose* (*ED*) is the total dose absorbed from instant zero until the moment of measurement in the laboratory, while the *annual dose* (*AD*) is the average energy absorbed for unit mass by the specimen in one year as the result of the radioactivity present both in the specimen itself and in the environment. In the present work, the experimental values of *ED* were determined using the single aliquot regeneration protocol (SAR) (MURRAY & WINTLE A. G., 2000; 2003) coupled with *coarse grain* sample preparation technique (BIANCA et al., 2010). The coarse grain fraction consists in HF etched quartz grains within the size range 100-300 μm that were extracted from the sediment using standard separation procedures. The purity of quartz fraction was verified by infrared stimulation on some representative aliquots for each sample (AITKEN, 1998). The age is calculated as outlined in equation:

$$Age = ED/(f \cdot D_{\beta} + D_{\gamma+cosm})$$

where f is the attenuation factor depending on grain size (MEJDAHL, 1979); D_{β} contribution was calculated using concentration values of U, Th and K determined by the ICP-MS technique. To determine beta and gamma dose rates, annual dose conversion factors by ADAMIEC & AITKEN (1998) were used. These dose rates were validated from a comparison with gamma dose measured *in situ* at the sampling points with a portable NaI(Tl) probe. The contribution of cosmic radiation to the total dose-rate was calculated using present depth (PRESCOTT & HUTTON, 1988; 1994) considering the density and the depth of the sample below the surface. The moisture-corrected dose-rates values are obtained considering the present-day water content from $W_{in\text{-}situ}$ values (AITKEN, 1998) using the attenuation factors given by ZIMMERMAN (1971).

4. RESULTS AND CONCLUSIONS

Absolute dating of middle-upper Pleistocene marine sediments by OSL methodology yielded new constraints for correlating the seven orders of marine terraces exposed in the Capo Vaticano peninsula with the last Quaternary interglacial stages. In fact, the distinct marine terraces can be correlated with the last seven high-stands of the global

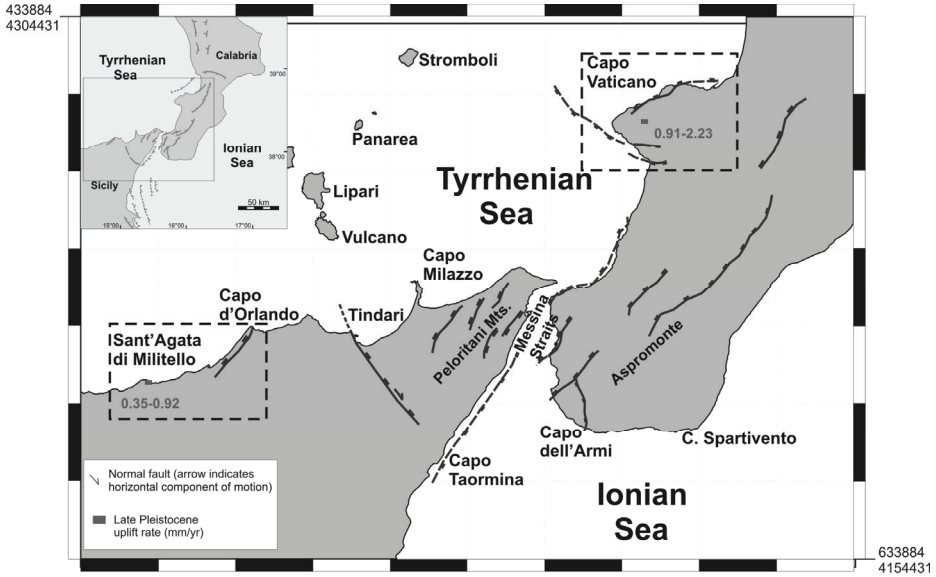

Fig. 1, Regional tectonic map of the southern part of the Calabrian Arc
Carta tettonica regionale della porzione meridionale dell'Arco Calabro

eustatic curve (MIS 7.5, 7.3, 7.1, 5.5, 5.3, 5.1 and 3.3). Present marine terrace elevations also suggest that this portion of Calabrian Arc has been affected by a vigorous tectonic uplift during the last 236 ka, locally characterized by rates up to ~2 mm/a, responsible for the preservation of all marine terraces related to the entire series of the last major sea level high-stands. Moreover, the geometry of the palaeoshorelines indicates that the raising process was characterised by uplift rates increasing toward the SW, resulting in the tilting of the whole peninsula toward the NE. It represents the footwall of both the SW,NE and the WNW,ESE striking onshore and/or offshore normal fault systems. Consequently, the uplifting of the area, started just before 236 ka ago, can be considered to represent the sum of the activity of these fault segments and the regional uplift.

In the NE sector of Sicily, between Acquedolci and Sant'Agata di Militello, the estimated rates highlight a constant uplifting of 0.7-0.8 mm/a during the last 330 ka. Instead, between Sant'Agata di Militello and Capo d'Orlando, the uplifting is not constant, probably due to the activity of the Capo d'Orlando fault. By comparing the uplift rates along cross-sections through the NE sector, where the Capo d'Orlando fault occurs, and the SW sector, where it ends, terraces I, II and III, laying on the hanging wall of the fault, raised at a slower rate (0.35 mm/a) than the terraces located in the SW sector. In the same way, the terraces IV and V, laying on the footwall of fault, raised at a faster rate (0.92 mm/a) than the SW terraces (ORIOLI *et al*., 2011, *in preparation*). In conclusion, the morphological analysis of the marine terraces and the deformation pattern confirm the occurrence of an important tectonic component in the total amount of uplift, which is related to the middle-upper Pleistocene activity of normal faults.

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Ms. received: *January 13, 2011*
Testo ricevuto il *13 gennaio 2011*