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LATE QUATERNARY STRATIGRAPHY OF WESTERN SARDINIA (CENTRAL MEDITERRANEAN) BASED ON LUMINESCENCE AGE DATING

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ABSTRACT: We present the revised stratigraphic setting of the late Quaternary deposits cropping out along the western coast of Sardinia (Italy). The height defined units have been dated using luminescence.

KEYWORDS: OSL, climate changes, Eemian, marine isotopic stages

1. INTRODUCTION

Numerous scientific models suggest that in 2100 the global temperature will be about 2 °C higher than today, with consequent rise of the sea level (Antonioli et al., 2017). Main effect of these rapid variations will result in a radical change of the coastal geography of the entire planet. However, no one model considers: 1) the adaptability of natural systems to the new physical conditions, 2) the differences between less and more urbanized coasts and, 3) the behaviour of areas with different tectonic regimes. Investigating how the coastal plains reacted in the past in response to climate changes is one of the keys to hypothesise possible future scenarios in the short/medium term (Amorosi et al., 2018). It is therefore necessary an accurate study of the climate/sea-level changes of the past glacial-interglacial cycles and recent warm-cold Holocene fluctuations to improve the climate-changes future projections. To define the coastal response to the high and very high frequency glacio-eustatic fluctuations of the late Quaternary (last 300 ka) and in particular of the last interglacial (125-85 ka) becomes of utmost importance (Amorosi et al., 2005; Vacchi et al., 2016).

The marine palaeosea level markers consist of various erosive (tidal notches, raised marine terraces), sedimentary (palaeo-beaches and coral reefs) and stratigraphic (transgressive/regressive successions) features useful to estimate the palaeo-sea level (De Muro & Orrù, 1998; Pascucci et al., 2009; Antonioli et al., 2015). They, however, are reliable if used in tectonically stable areas and precisely age dated.

The use of an absolute dating methodology for these sedimentary and stratigraphic marine palaeosea-level markers may provide a unique opportunity to precisely define the chronology of the response of the coastal systems to sea-level changes, and define the climatic changes occurred from the middle Pleistocene.

2. MATERIAL AND METHODS

The west and northwest coasts of Sardinia have been chosen as a case study, because the island is generally considered stable, being tectonically inactive since 1 Ma (Fig. 1). The adopted absolute dating methodology is the Luminescence (Murray & Wintle, 2000; Buylaert et al., 2011).

The west and northwest coasts of Sardinia are quasi continuously draped by late Quaternary strata overlapping the older substrate. They have been referred by authors to either the Tyrrhenian interglacial, if characterised by marine deposits resting above the present sea level, or to the "Wurmian" glacial if continental. Just few are referred to the "Riss" glacial phase (Carboni & Lecca, 1985; Carmignani et al., 2001). According to the modern Marine Isotope Stratigraphy (MIS) adopted for Quaternary studies, a deep review of the stratigraphy, especially adopting absolute dating methodologies is needed.

Fig. 1 - Sardinia Island (Italy) in the center of the Mediterranean Sea.

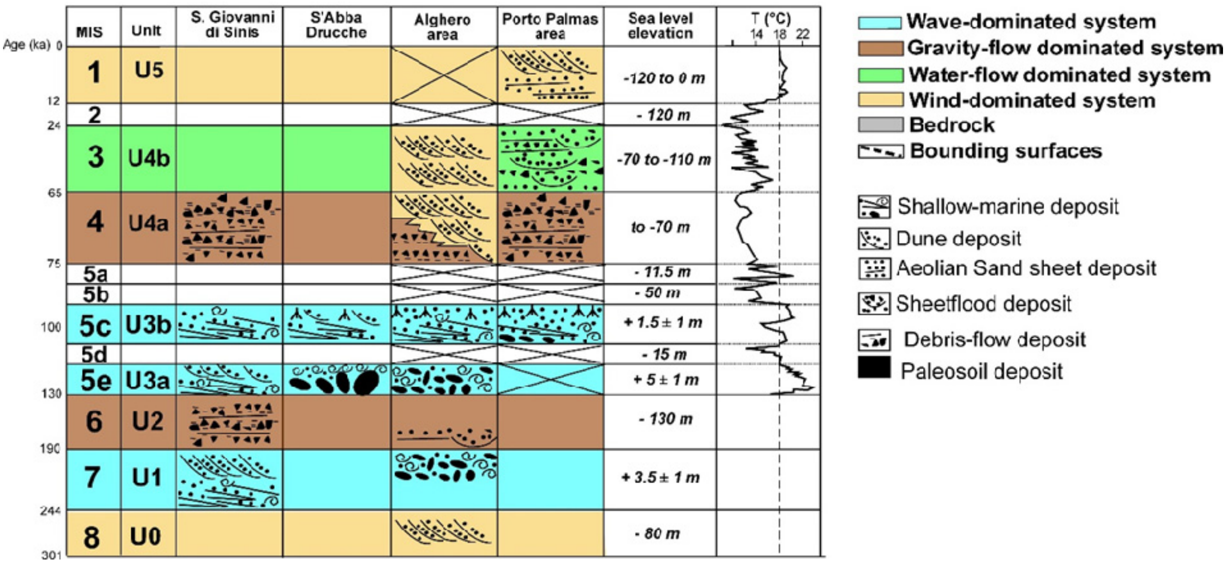

Fig. 2 - Relationships and main features of the eight unconformity bounded units cropping out along the west and northwest coast of Sardinia. Units cover the last 300 ka. Right columns report the estimated sea level elevations and temperatures from Marine Isotopic Stage 5 (MIS 5) to MIS1 (Modified after Pascucci et al., 2014).

Given the limit of ^{14}C for dating sedimentary deposits older than 45 ka, several different dating methods have been recently tested to date the late Quaternary succession of west and northwest Sardinia (i.e. U/Th, Aminoacid Racemisation, and Luminescence) (i.e. Andreucci et al., 2009, 2010, 2014, 2017; Thiel et al., 2010). However, due to the clastic nature of these deposits, the Luminescence is the most suitable methodology. The method estimates the time elapsed since the last exposure to sunlight of quartz (Optically Stimulated Luminescence) and alkali feldspar (post IR IRSL 290) grains and thus enabling us to constrain the burial time.

3. RESULTS AND DISCUSSION

The revised late Quaternary stratigraphy of the west and northwest coasts of Sardinia enabled us to identify the role played by sea level and climate changes, in controlling sedimentation.

The luminescence dated outcropping succession, has been grouped into eight major stratigraphic units mainly represented by coastal dunes, shallow marine and alluvial systems (Pascucci et al., 2014). These units range in age from MIS 8 (300 ka) to MIS1 (last 11.8 ka) (Fig. 2).

Data provided are not useful to clearly define what happened between MIS 8 and 7. It is, however, worthy to note that in some areas marine MIS7 deposits crop out above the present sea level. This could imply that the claimed tectonic stability of the island needs to be revised. MIS6 deposits are scattered and discontinuous. They are mostly made by gravity flow and occasional wind dominated systems. A better dataset encompasses the last 125 ka and allows inferring the climatic events occurred during the last interglacial (MIS 5) and glacial (MIS 4-2) times. MIS5 is subdivided in five substages (e-a). MIS5e (Eemian) is considered the climate optimum of this interglacial. In Sardinia the sea level was 4-6 m higher than today and climate conditions were warmer and more humid. During this high stand sea level, not many beaches developed, whereas tidal notches and bioherms were common. The last have been herein dated for the first time with luminescence and range in age from 138 to 114 ka. MIS 5c (110 -95 ka) is the second high stand peak. The error of the luminescence technique, however, does not allow discriminating MIS5e and 5c. The stratigraphic data, in any case, indicate that around 100 ka a sea level still stand occurred. During this time, the sea level was about 1.5 m higher than todays, several sandy beaches developed, and palaeoclimatic and palaeogeographic conditions were similar to the present time. During the following MIS 4, at the beginning of the glacial phase, a climatic deterioration occurred; temperature decreased of about 6 °C with respect to MIS 5e. Luminescence datings indicate that this deterioration was brief and rapid (5 to 10 ka). As a result, the sea level drops of about 60 m, the inland vegetation cover progressively educed, and a denudation of valley slopes repeatedly occurred. The sea-level fall created the accommodation space for the development of alluvial fans in sheltered and cliffy areas, where debris flows accumulated and filled almost completely the terminal parts of the narrow coastal valleys/coves, while on wider areas coastal dune fields developed. Contemporaneous occurrence of alluvial fan and dune systems is associated to the local morphology that could mitigate or amplify some moistly conditions in a general arid environment.

During MIS 3 alternate deposition of alluvial/fluvial and aeolian sediments document the occurrence of several climate fluctuations. They could be related with the wet/arid, D/O-H events (Heinrich & Dansgaard–Oeschger Events) that have been recognised in the cold MIS3 (Pascucci et al., 2014). These fluctuations, each lasting about 10 ka, are beyond the luminescence resolution. According to the available dating, we could just document that the shallow Sardinian shelf was continuously exposed throughout the MIS3, being the source area of bioclastic sands. These sands were blown inland, and formed extensive dune field systems. Dunes dominated the west coast of Sardinia under cold and relatively dry conditions. In some areas, these dune field systems were eventually almost completely dismantled and reworked into water-flow dominated alluvial fans by catastrophic rainfall events occurred during relatively more humid conditions. Thus, the local climate quickly switched from arid to humid. No record of the last Glacial Maximum deposits, MIS 2, was observed along the NW Sardinian coast. Submarine data just confirm that the lowest sea level was of -120 m below the present. During the Holocene transgression (MIS 1) the coastline progressively migrated landward as the coastal dune systems did. The temperature aumented, reaching almost the present-day values around 6ka. Since this time onward, little sea-level and climatic fluctuations occurred, leading to transgressive/regressive cycles of few thousands of years. MIS1 deposits have been dated, when possible, also using ^{14}C technique (Pascucci et al., 2018). This cross-methodology has always proven the reliability of the results obtained by means of the luminescence method.

4. CONCLUSIONS

We have documented that late Quaternary continental and shallow marine deposits may be dated using luminescence methodology both on quartz and k-feldspar grains. At the moment the erorr comprised between 10 and 5% does not allow distinguishing high frequency cycles of the order of 10 to 5 ka, but just to claim their existence.

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