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Geochronology for some key sites along the coast of Sardinia (Italy)

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A B S T R A C T

Recent stratigraphic surveys and facies analyses have questioned long-held interpretations of the development and furthermore the age of Quaternary sediments along the coast of Sardinia. The matter of debate is whether the investigated sediments were deposited during the Late Würmian and Holocene or during marine isotope stage (MIS) 5 and older stages. Optically stimulated luminescence (standard blue optically stimulated luminescence (OSL), post-infrared (IR) pulsed blue OSL and post-IR infrared stimulated luminescence (IRSL)) dating was applied to shallow marine and aeolian deposits as well as radiocarbon dating to bulk organic material in palaeosols. Radiocarbon dates suggest sedimentation during the Late Würmian and Holocene, whilst the luminescence results for both quartz and potassium feldspar indicate a depositional age for most of the investigated sites prior to and during MIS 5. From a geochronological point of view the luminescence ages are considered reliable because they passed all quality tests; furthermore there is good agreement of two dosimeters with different bleaching and luminescence properties. The radiocarbon ages might suffer from underestimation due to some contamination with young carbon, which however cannot be large enough to yield such young ages.

1. Introduction

The island of Sardinia has been considered tectonically stable and has therefore been used to model the sea level changes in the Mediterranean Sea during the Last Interglacial (Antonioli et al., 1999; Lambeck et al., 2004). The elevation of the Last Interglacial sea level high stand (marine isotope substage, MIS 5e) is characterized by morphological and stratigraphical markers such as notches and beach deposits that often contain the typical warm-fossil fauna association (Senegalese fauna) including *Strombus bubonius* (Issel, 1913; Ozer et al., 1980; Hearty et al., 1986; Lambeck et al., 2004). These beach sediments as well as the marine notches occur at elevations of 3.5–11 m above sea level along the Sardinian coastline (Ozer et al., 1980; Ulzega and Ozer, 1982; Antonioli et al., 1999). The elevation on its own or in combination with the occurrence of the Senegalese fauna has often been used to correlate deposits to MIS 5e, based on the assumption that the sea level of MIS 5e has been the highest ever since. Carboni and Lecca (1985), Davaud et al. (1991) and most recently Andreucci et al. (2009) have presented another interpretation and state that at least two sea level high stands during MIS 5, most likely during substages 5e and 5c, can be found in Sardinian coastal sediments. Recently, stratigraphical surveys, facies analyses and geological mapping of some key sites along the coast of Sardinia have favoured attribution to the Holocene and Late Würmian of the deposits under study (APAT, submitted a,b; Coltorti et al., 2007, 2010) and thus question the former assumptions and the proposed sea level models.

To address the debate geochronological data are needed because stratigraphical investigations and correlations on its own are not sufficient. Apart from amino-acid racemisation (AAR) data, which are relative age attributions, and some radiocarbon and U/Th ages (Belluomini et al., 1986; Ulzega and Hearty, 1986; Coltorti et al., 2007) a reliable chronological framework has not yet been established for most of the Quaternary sediments along the Sardinian coast. Most recently, Andreucci et al. (2009) presented quartz luminescence ages for a sediment succession at San Giovanni di Sinis (western Sardinia) showing the applicability of this dating method for the deposits under investigation.

Luminescence dating techniques determine the time passed since the last exposure of mineral grains to sunlight, and thus enable to constrain the time of deposition (Aitken, 1998). Furthermore, luminescence dating spans a wide time range (few years to, theoretically, several hundred thousand years) and is suitable for a variety of sediments, e.g. aeolian, (shallow) marine, fluvial and glacio-fluvial deposits. Therefore, this dating method is a valuable tool to address the debate whether the deposits are Holocene

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(Coltorti et al., 2007, 2010) or MIS 5 (Belluomini et al., 1986; Ulzega and Hearty, 1986; Andreucci et al., 2009). If these sediments are Holocene or slightly older, as suggested by Coltorti et al. (2010), radiocarbon dating is another suitable method to determine the age of the sediment. Whereas luminescence dating determines the time of deposition and therefore dates the sediment itself, radiocarbon dating estimates the time elapsed since the death of an organism (Geyh, 2005; Hogg et al., 2006); the applicability of this method is up to about 50 ka (Hajdas, 2008).

This study presents luminescence ages for both quartz and potassium feldspar of shallow marine and aeolian deposits and radiocarbon ages of bulk organic material from four sectors along the coast of Sardinia: i) San Giovanni and Capo San Marco at Sinis Peninsula, ii) Santa Reparata near Santa Teresa di Gallura, iii) Scala é Croccas in the Orosei Gulf and, iv) Is Arenas in the Cagliari Gulf (Fig. 1) in order to address the debate whether the sediments were deposited during the Late Würmian and Holocene or during MIS 5 and older stages.

2. Geological setting and sampling locations

The section of San Giovanni di Sinis (Location 1; Fig. 1) is located 10 km west of Oristano. The sediment succession, which has a maximum thickness of 8 m (see Fig. 2 and Coltorti et al., 2010), has been described by Lecca and Carboni (2007 and references therein). They interpret the outcrop as a shore unit, with foreshore facies evolving into a backshore and coastal dune sand, and distinguish different transgression and regression units. Recently, Andreucci et al. (2009) have described four unconformity-bounded units with three transgressive and two regressive surfaces. Coltorti et al. (2010) interpret the sequence as aeolian in origin. In total, four samples for luminescence dating were taken from two adjacent outcrops (southern and northern outcrop, Fig. 2). Samples SG_1 and SG_2 were taken in carbonate-rich laminated sandstone. Whereas Coltorti et al. (2010) claim that SG_1 and _2 are from the same stratigraphical unit, Lecca and Carboni (2007) allocate SG_1 to aeolian deposition and SG_2 to foreshore environment. Sample SG_3 was taken in carbonate-rich sandstone with coarse quartz pebbles. The lowermost sample (SG_4) comes from consolidated fine sands containing small shell fragments. At this site, all luminescence samples were cut off the outcrop as blocks because of the cementation. Additionally, three palaeosols were sampled for radiocarbon dating (DP018, DP028, DP029) from the northern outcrop (Fig. 2). These palaeosols are locally consolidated (Andreucci et al., 2009); however, samples were derived from an unconsolidated part of the outcrop.

The deposits of Capo San Marco (Location 2; Fig. 1) are located close to the San Giovanni di Sinis section on the south western side of the promontory. The sequence is composed of coarse gravels and boulders that locally created a notch in aeolianites at ca. 6–7 m asl (Fig. 3; Coltorti et al., 2010). The aeolianite was sampled for luminescence dating (CSM_1).

The outcrop at Santa Reparata (Location 3; Fig. 1) is located on the east of the isthmus in the northernmost tip of Sardinia. The deposits were at first investigated by Ulzega and Ozer (1982), and later Ulzega and Hearty (1986). In their opinion the coarse beach sands and gravels rest below aeolian deposits attributed to the Last Glaciation. Further descriptions of the

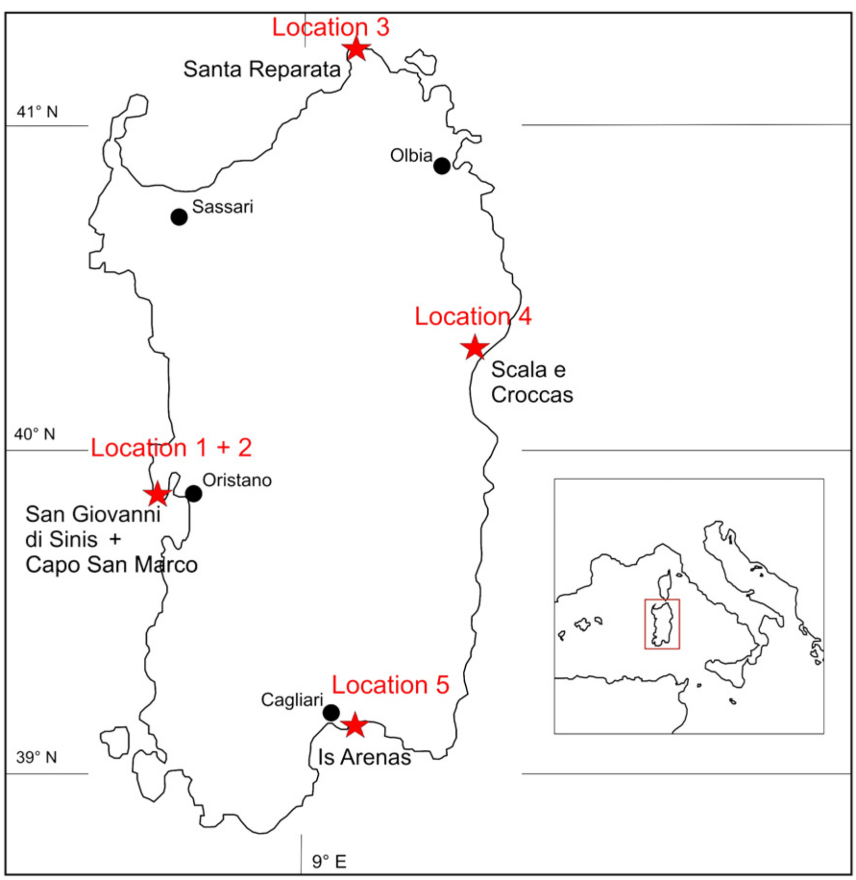

Fig. 1. Sardinia and the study locations. 1. San Giovanni di Sinis; 2. Capo San Marco; 3. Santa Reparata; 4. Scala é Croccas, Orosei Gulf; 5. Is Arenas, Cagliari Gulf. The inset shows the location of Sardinia in the Mediterranean Sea.