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Research paper

The Usiminas shellmound on the Cabo Frio Island: Marine reservoir effect in an upwelling region on the coast of Brazil

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ABSTRACT

The mixture of different water masses can strongly influence the marine reservoir effect (MRE) in localities under the effect of coastal marine upwelling. The Cabo Frio region, on the southeastern Brazilian coast, is well known for its seasonal marine upwelling and for its rich landscape of Holocene shellmounds. In this kind of archaeological settlement, common on the southern and southeastern Brazilian coasts, marine mollusk shells are frequently used for radiocarbon dating and can represent a valuable tool in the study of MRE. On the other hand, terrestrial mollusks have proven to be an important alternative to represent the atmospheric carbon isotopic concentration. In this work we analysed the most frequent terrestrial and marine mollusk shells from the Usiminas shellmound, on Cabo Frio Island. The radiocarbon signal of marine shells from *Pinctada imbricata* (Röding, 1798), Ostreidae (Rafinesque, 1815), *Cymathium parthenopeum* (Von Salis, 1793), *Leucozonia nassa* (Gmelin, 1791), *Lithopoma olfersii* (Philippi, 1846), and that of terrestrial shells from *Thaumastus achilles* (Pfeiffer, 1852) and *Megalobulimus terrestris* (Spix, 1827), collected from the archaeological layers in the sequence, were measured and a value of 67 ± 33 ^{14}C yr was obtained for the local offset from the average global marine reservoir age. The effect of upwelling in this region and in its surrounding area is discussed.

1. Introduction

Radiocarbon marine reservoir effect (MRE) variations can be associated with oceanographic and climate dynamics along coasts and can be useful as an auxiliary tool in palaeoceanography research. The characterization of water masses and circulation patterns along the Atlantic coast of South America is critical to take into account when MRE studies are performed on the coast of Brazil. The Cabo Frio region where the Cabo Frio Island is located, close to Arraial do Cabo municipality, in Rio de Janeiro state (Fig. 1), is influenced by seasonal coastal upwelling events of the South Atlantic Central Waters (SACW) (Cordeiro et al., 2014). Such influence is expected to increase the MRE local offset, leading to positive ΔR values. According to Goodfriend and Flessa (1997), areas of strong upwelling of old, cold and deep water such as the California coast and the Pacific coast of South America have reservoir effects higher than average.

The first MRE study on the headland of Arraial do Cabo and Cabo Frio Island (based on the Usiminas and Ilha do Cabo Frio shellmounds on Cabo Frio Island, and Boqueirão shellmound in Arraial do Cabo), was undertaken by Angulo et al. (2007). However, the authors considered the study inconclusive to identify an upwelling effect on the MRE. There were significant age differences between terrestrial (charcoal or carbonized seed) and marine (sea urchin and mollusk shells) samples from the same archaeological layers on the Cabo Frio Island and Boqueirão sites that could not be explained by reservoir and old-wood effects alone. From the Usiminas site, three pairs of samples were measured and the age differences were between 358 ± 44 and 565 ± 44 ^{14}C yr, comparable to pre-bomb values in other regions of Brazil (Nadal de Masi, 2001; Eastoe et al., 2002; Angulo et al., 2005). Therefore, Macario et al. (2015a)

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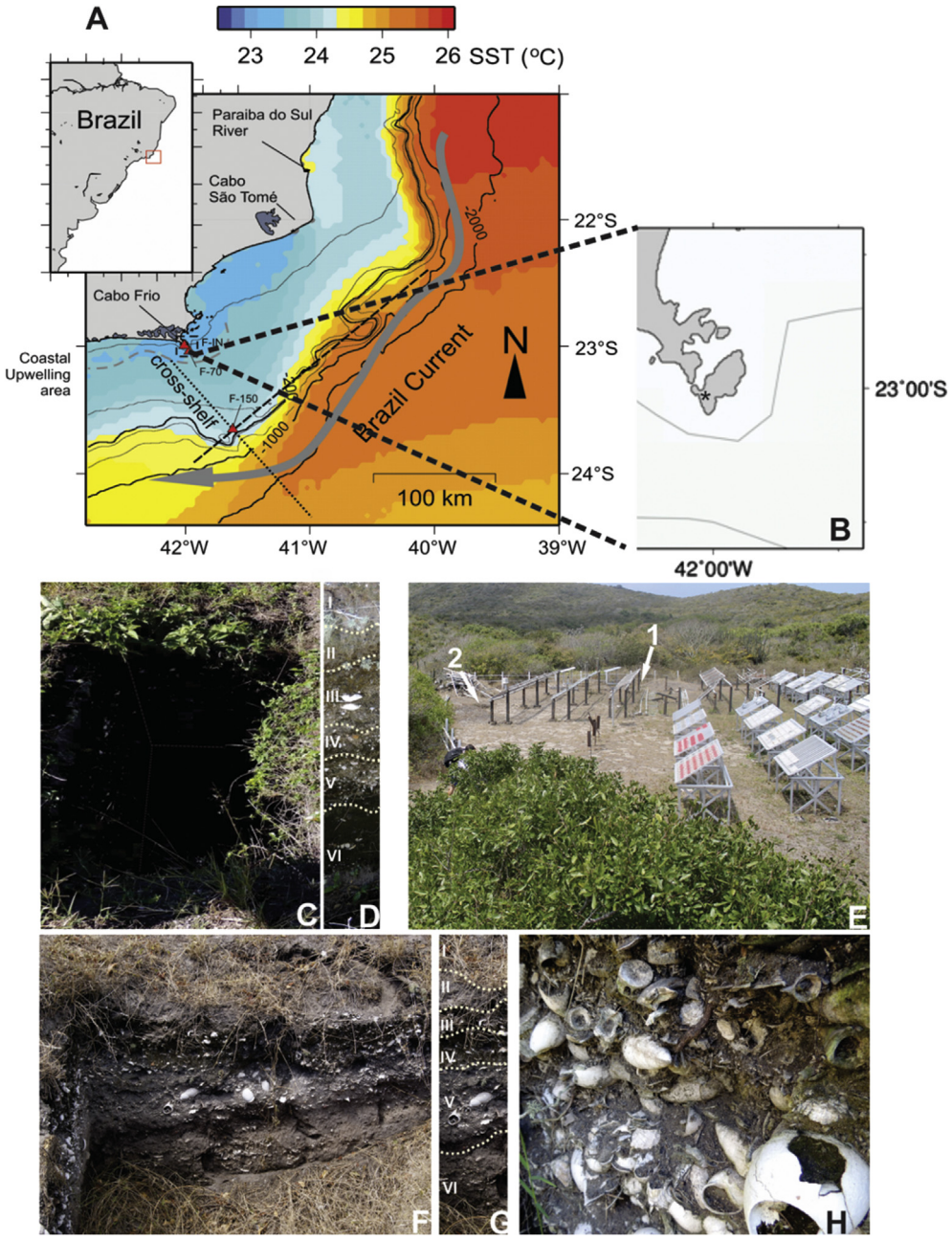

Fig. 1. **A**. Map of the studied region, under coastal marine upwelling influence **B**. Location of the Usiminas shellmound on the Cabo Frio Island; **C**. Secondary excavation (NT); **D**. Archaeo stratigraphic section of NT (dashed lines divide the different layers); **E**. Outcrop of Usiminas shellmound (arrows indicate the main (1) and the secondary (2) excavations); **F**. Main excavation; **G**. Archaeo stratigraphic section of main excavation (dashed lines divide the different layers); **H**. Detail of archaeological layers with high terrestrial mollusk concentration.

re-calculated the mean ΔR value of 179 ± 170 ^{14}C yr, based on the data published by Angulo et al. (2007) for the Usiminas shellmound, following the weighted mean of each ΔR uncertainty and the standard deviation from the mean (Russell et al., 2010). Alternatively, combining all the previous results of Angulo et al. (2007) within the OxCal software (Bronk Ramsey, 2009) to generate a common ΔR for the three pairs of samples, returns a value of 152 ± 110 ^{14}C yr. Recently, Alves et al. (2015a) calculated a ΔR value of 96 ± 48 ^{14}C yr from a known-age pre-bomb shell collected in Cabo Frio. The positive ΔR values could be related to the SACW influence on natural populations of coastal marine mollusks.

Archaeological shellmounds in nearby regions have yielded negative ΔR values. For the Tarioba shellmound, in Rio das Ostras (22° 31′ 37″ S, 41° 56′ 42″ W), a value of −127 ± 67 ^{14}C yr was obtained from the cross-comparison of charcoal and marine mollusks from the same archaeological context (Macario et al., 2014, 2015a). In the Saquarema city (22° 55′ 12″ S, 42° 30′ 36″ W), two archaeological shellmounds were studied. At the Manitiba the cross-comparison of charcoal, terrestrial and marine mollusks resulted in a ΔR value of −82 ± 71 ^{14}C yr (Carvalho et al., 2015). At the Saquarema charcoal, marine shells and fish otoliths yielded a ΔR of −140 ± 66 ^{14}C yr (Alves et al., 2015b). Those negative values could be related to freshwater influence in the isotopic composition of the marine samples.

The paired sample approach to calculate the local offset from the marine calibration curve has been used in several regions over the