

Comment on “Formation of chenier plain of the Doñana marshland (SW Spain): Observations and geomorphic model” by A. Rodríguez-Ramírez and C.M. Yáñez-Camacho [Marine Geology 254 (2008) 187–196]

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A B S T R A C T

Rodríguez-Ramírez and Yáñez-Camacho (2008), Rodríguez-Vidal et al. (2009) and Rodríguez-Ramírez et al. (2009) have kept an ongoing discussion about the validity of radiocarbon ages in reconstructing Holocene palaeogeographical models in the Gulf of Cadiz. The discussion considered the validity and correctness of the ΔR value to be used in the area to calibrate radiocarbon ages of marine samples. These papers suggest that the ΔR value proposed by Lario (1996) and Dabrio et al. (1999, 2000) is erroneous, and consequently, that all the evolutionary models based on radiocarbon ages from marine samples that have been proposed in this area since 1996 must be revised. However, the papers commented here use erroneously the R , regional R and ΔR values. After reviewing the published data, it is apparent that the most reliable values of ΔR in the Gulf of Cadiz for middle-late Holocene samples range between $\Delta R = 35 \pm 85$ yr and $\Delta R = 95 \pm 15$ yr. This means that the values used in Lario (1996) and Dabrio et al. (1999, 2000) fall in this range, and also that the calibrated ages used by several authors adopting these values are fully reliable. Calibrations using ΔR values inside this range do not yield significant differences in terms of geological age owing to the magnitude of errors resulting from the methods employed.

Keywords:
radiocarbon
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1. Introduction

Rodríguez-Vidal et al. (2009) consider that: “all the published works about the Atlantic Iberian Spanish coast since the year 1996 have an incorrect regional reservoir value (ΔR) and, therefore, all calibrated ages and the conclusions obtained must be kept in quarantine, until a further revision” and suggested that Lario (1996) and Dabrio et al. (1999, 2000) proposed and used this supposedly-erroneous reservoir value to calculate radiometric ages. Such statements are, as demonstrated later, exaggerated, unfair and out of focus.

It is not our aim to discuss the evolutionary models presented in the papers commented here, but to constrain to the radiocarbon issues. Of course, we are aware that, as long as radiometric methods, calibration curves, models and software keep improving, there will be a growing

need for readjusting the radiometric ages published in the area. In fact, in an effort to minimize these shortcomings, the ages proposed by us in the last 40 yr have been backed by wide-scope studies of regional sedimentology, geomorphology, tectonics and palaeontology, with further chronological support by archaeology and other dating techniques such as TL and OSL.

We address in detail the main flaws of the papers cited and draw some conclusions regarding the usage of reservoir values that may be of general interest for researchers working in the Gulf of Cadiz, but not specialized in radiocarbon dating.

2. The mistaken use of R vs. ΔR in the discussed papers

The comments and criticisms (Rodríguez-Ramírez and Yáñez-Camacho, 2008; Rodríguez-Vidal et al., 2009; Rodríguez-Ramírez et al., 2009) about the erroneous values used by us to correct the reservoir effect in ^{14}C dating from the Gulf of Cadiz derive from a misunderstanding of the terms: global average R , regional R and ΔR .

Rodríguez-Vidal et al. (2009) acknowledged that Lario (1996) and Dabrio et al. (1999, 2000) pioneered the use of a regional reservoir effect in some of the radiocarbon age measurements from the Gulf of

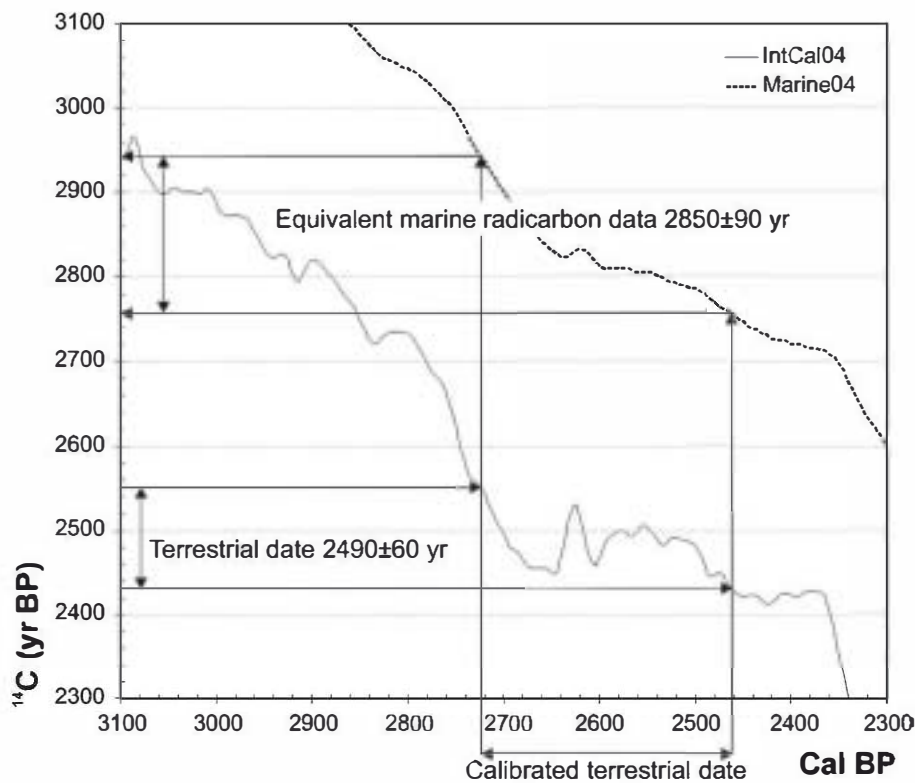


Fig. 1. Calculation of ΔR using Lucio del Pescador sample UtC-2031 (Lario, 1996; Dabrio et al., 1999, 2000) applying the Southon et al. (1995) and Hughen et al. (2004) methods.

Cadiz, but erroneously stated: “they do not indicate the procedure”. However, Lario (1996, p. 202) did explain that he used ^{14}C AMS dates from contemporary shell and peat samples collected from the same layer at Lucio del Pescador (Table 1 of Rodríguez-Vidal et al., 2009), proposing a reservoir effect correction for marine and estuarine samples (440 ± 85 yr) that was subsequently applied by Dabrio et al. (1999), Borja et al. (1999) and Dabrio et al. (2000). These authors used the same samples and methodology as Rodríguez-Vidal et al. (2009).

From this partly correct starting point, there follow some misunderstandings that essentially alter the final result of Rodríguez-Vidal et al.’s reasoning. In fact, we (Lario, 1996; Dabrio et al., 1999, 2000; Lario et al., 2002) did not write that the result (440 ± 85 yr) was ΔR , but that it is the regional reservoir effect. Unfortunately, Rodríguez-Ramírez and Yáñez-Camacho (2008) and Rodríguez-Ramírez et al. (2009) went further and, erroneously, implied that it was us who proposed this value as ΔR .

We performed the calibration of radiocarbon ages using the CALIB Program and the revised versions available at the time (Stuiver and Reimer, 1993a,b; Stuiver et al., 1998). Stuiver and Braziunas (1993) proposed an average marine reservoir correction of 402 yr, and used the parameter ΔR as the difference between the regional marine reservoir correction minus the average global marine reservoir correction. Following this procedure, we used $\Delta R = 35 \pm 85$ yr in the various versions of CALIB, as this figure was significantly similar to the 400–500 yr calculations by Harkness (1983), Stuiver et al. (1986), Bard (1988), Southon et al. (1990) and Siani et al. (2000) for areas of the North Atlantic Ocean affected by the Gulf Stream.

In contrast, as pointed out by Rodríguez-Vidal et al. (2009), Rodríguez-Ramírez and Yáñez-Camacho (2008) and Rodríguez-Ramírez et al. (2009) use the reservoir effect correction (440 ± 84 yr) proposed by Morales et al. (2008) as ΔR and, as a result, they obtain calibrated ages that are, probably, almost 400 yr younger than if either our correct proposed ΔR value (35 ± 85 yr) or the average correction proposed by Stuiver and Braziunas (1993) had been employed.

3. The need to calibrate and use appropriate curves and, where available, a local ΔR

The first mean value of ΔR in SW Iberia was calculated by Soares (1989, in Stuiver and Braziunas, 1993) as 250 ± 25 yr, using shells from marine molluscs collected alive along the Portuguese coast between 1886 and 1937. However, this figure represents only the modern value. New data from the Portuguese coasts of SW Iberian Peninsula (Soares and Dias, 2006a) suggest that the value of ΔR varies with time because it is affected by changes in upwelling along this coastal tract. This variation on the reservoir effect with time was also noted elsewhere around the world by Stuiver and Braziunas (1993) owing to a variety of causes. Soares and Dias (2006a) concluded that ΔR values ranged from $\Delta R = +940 \pm 50$ yr to $\Delta R = -160 \pm 40$ yr, but they proposed that the only realistic values were the ones determined by Soares (1989, in Stuiver and Braziunas, 1993) for modern times (250 ± 25 yr) and the mean of another 30 values of ΔR , covering the interval 3000 to ca. 600 BP with an average $\Delta R = 95 \pm 15$ yr.

The average value does not differ much from the one calculated by Lario (1996) and assumed by Dabrio et al. (1999, 2000), in samples of similar ages. Differences result largely from the methodology that was used: Lario (1996) and Dabrio et al. (1999, 2000) calculated the local reservoir value and compared it with the average global marine reservoir correction proposed by Stuiver and Braziunas (1993), without correcting the variability in time. In contrast, Soares and Dias (2006a) took into account the variation with time, and worked with the average of more than 30 values from samples encompassing a 2500 yr interval.

The fluctuation with time in ΔR values during the Holocene in the Western Iberian coasts was also pointed out in Soares and Dias (2006b), Soares and Dias (2007) and Soares (2008). In their comments Rodríguez-Vidal et al. (2009) do not present new ΔR values but simply re-calibrate all of the samples listed in these papers. They (a) propose using $\Delta R = 100 \pm 100$ yr for samples between 4000 and 2500 yrBP, based on Soares’ personal

communication and data from Soares and Dias (2006b) data, (b) prefer to not calibrate samples aged between 4400 and 4000 yrBP since Soares (2008) found anomalous high positive ΔR values in this time interval and did not propose any value, and (c) suggest using the calculated weighted mean $\Delta R = -135 \pm 20$ yr proposed by Soares and Dias (2006b) and Soares (2008) for the remaining samples. In our opinion, the usage of “personal communication” data in scientific debates does not seem elegant; it is more sensible to wait until such data have been published and are available for the scientific community. Although we respect and acknowledge the work by Soares and collaborators, the Soares (2008) paper referred to in the discussion does not offer any information about the location of particular samples, radiocarbon ages, ΔR values, sample material, laboratory code, etc. More important, Soares and Dias (2006b) do not suggest any ΔR value; in fact, they include only nine contradictory ΔR values without further information about the analyses carried out or discussion of the quality of the data. Therefore, the ΔR values proposed by Soares and Dias (2006a) were, at that time, the only published data (more than 40 accepted ΔR values in nearly 200 analyses) for re-calibrating ^{14}C ages using values different than those proposed back in 1996. Also, the unavailability of ΔR values for the interval 4400 to 4000 yrBP does not necessarily imply the impossibility of calibrating ages in this time span. The Marine04 radiocarbon calibration curve, proposed by Hughen et al. (2004) and incorporated in the calibration software, applies to the global marine reservoir age (R); consequently, using $\Delta R = 0$ in the software gives an approximate calibrated age value that is, undoubtedly, more useful than any un-calibrated ^{14}C age. Therefore, the use of ΔR values of $\Delta R = -135 \pm 20$ yr in samples younger than ^{14}C 2500 yrBP by Rodríguez-Vidal et al. (2009) in Table 2 and Fig. 1 is not supported by conclusive data. In fact, the large database supplied by Soares and Dias (2006a) recommends using a positive value of ΔR in this age-span.

Rodríguez-Ramírez and Yáñez-Camacho (2008) and Rodríguez-Ramírez et al. (2009) re-calibrated all these ages with the same methodology (CALIB 5.02 with variable ΔR for the different time intervals) but applying the values of Lario (1996), Dabrio et al. (2000) and Soares (1993). This means that they erroneously used the regional reservoir value of Lario (1996), as discussed before, and, inadequately, used the data by Soares (1993) instead of the more complete and accurate, recent figures available (Soares and Dias, 2006a). Consequently, the results presented in Table 1 of Rodríguez-Ramírez and Yáñez-Camacho (2008), Table 1 and Fig. 1 of Rodríguez-Vidal et al. (2009) and Table 1 of Rodríguez-Ramírez et al. (2009) are largely uncertain.

4. The need to review ΔR for the area: what reservoir effect correction should be used in the Gulf of Cadiz?

The regional reservoir effect is an absolute value, while ΔR is a relative value as it depends on the reservoir values used in calculations. Therefore, it is most desirable to specify in all published papers the values of regional R and ΔR incorporated in calculations (as in Soares and Dias, 2007); this procedure should facilitate future adjustments of ages and reduce undesired biases.

Hughen et al. (2004) proposed that, to evaluate ΔR , terrestrial-marine pairs must be dated. Then, ΔR can be calculated either (i) by calibrating the terrestrial ^{14}C age and comparing the difference between the equivalent marine age and the measured marine age (Southon et al., 1995) or (ii) by comparing the terrestrial ^{14}C age and the marine age using the combined IntCal04–Marine04 data set, according to the method of Stuiver and Braziunas (1993) and Reimer et al. (2002).

We followed these two methods to check our previous calibrations. According to the first method we re-calculated ΔR from the data listed in Lario (1996) and Dabrio et al. (1999, 2000) and concluded that ΔR should be readjusted to $\Delta R = 80 \pm 110$ yr (Fig. 1). When the second method is employed, and radiocarbon values are introduced without error, the result is that the two samples are not coeval: there is a difference of 35 yr between them (which, incidentally, is the same figure obtained by Rodríguez-Vidal et al., 2009 using a different method). However, as the error of radiocarbon ages is greater than this value, these samples can be considered contemporary from a geological point of view. As the global ocean mixed-layer reservoir age (R) for that time has been estimated as $R = 400$ yr, and the regional reservoir age is still 440 ± 85 yr; the resulting value $\Delta R = 35 \pm 85$ yr is the same as in the original proposal (Lario, 1996; Dabrio et al., 1999, 2000).

As cited previously, Soares and Dias (2006a) calculated a mean $\Delta R = 95 \pm 15$ yr for the interval 3000 to ca. 600 BP. However, since they admit that ΔR varies with time, the average ΔR calculated for a relatively long interval may be inadequate when a given, shorter period inside the interval is considered. In this respect, calculating ΔR for a short interval, closer to the ^{14}C age of the marine sample cited in Lario (1996) and Dabrio et al. (1999, 2000), yields a figure of $\Delta R = 60 \pm 245$ yr. In fact, the large databases by Soares and Dias (2006a, 2007) allow calculating much more adjusted values of ΔR for shorter time spans.

It is interesting to note that, in spite of the efforts made in calculating ΔR , the Marine04 global marine ^{14}C calibration curve, and the associated software, considers time-constant values of site-specific reservoir and ΔR (Hughen et al., 2004). In contrast, it is well known that ΔR varies with time, and it does irregularly; it also

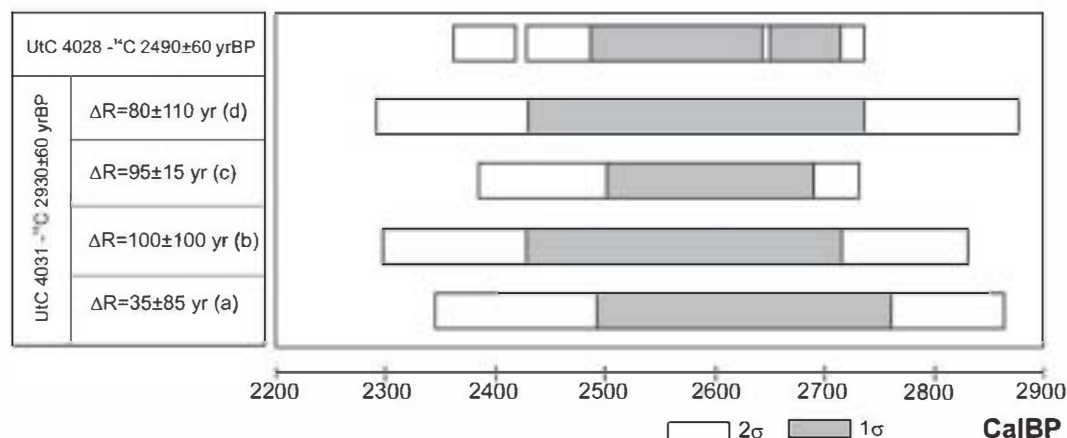


Fig. 2. Calibration of samples UtC-4028 and UtC-4031 used in Lario (1996) and Dabrio et al. (1999, 2000). The non-marine sample (UtC-4028) has been calibrated using CALIB 5.1 and INTCAL04 curve. The marine sample UtC-4031 has been calibrated using CALIB 5.1 and MARINE04 curve, as well as various ΔR values proposed by: (a) Lario (1996), (b) Rodríguez-Vidal et al. (2009), (c) Lario et al. (this work), and (d) Soares and Dias (2006a). Note that variations of 2σ and 1σ intervals of these samples deviate less than 3% from sample UtC-4031.

changes in different species, and even during the growing life of specimens (see a revision in [Ascough et al., 2009](#)). The magnitude of errors in all proposed ΔR values implies that calibrated ages are implicitly uncertain: this effect is magnified if different values of ΔR are used, even for a same time interval ([Fig. 2](#)).

We estimate that the more reliable values of ΔR in the Gulf of Cadiz for middle-late Holocene samples seem to range between $\Delta R = 35 \pm 85$ yr and $\Delta R = 95 \pm 15$ yr. In the long run, using the different values proposed by various authors will not produce major dissimilarities in age owing to the uncertainty range inherent to all calibrated ages that result from the methodology employed when constructing the marine calibration curve plus the various, non-standardized, methods of ΔR calculation.

5. The importance of assessing mixed marine and terrestrial signals

There is still a further mistake in the tables of re-calibrated ages presented by [Rodríguez-Ramírez and Yáñez-Camacho \(2008\)](#); [Rodríguez-Vidal et al. \(2009\)](#) and [Rodríguez-Ramírez et al. \(2009\)](#) that renders them erroneous. The reason is that the authors failed to realize that some essential samples are estuarine mollusc shells that cannot be calibrated directly using the marine reservoir effect and the Marine04 calibration curve, but must be corrected with the mixed marine and NH Atmosphere calibration curve, with additional correction for the percentage of marine carbon ([Stuiver and Reimer, 1993a,b](#); [Stuiver et al., 2005](#)). By doing so, the resulting error amply surpasses the errors discussed in the papers by [Rodríguez-Ramírez and Yáñez-Camacho \(2008\)](#) and [Rodríguez-Vidal et al. \(2009\)](#). We assume that this error have been produced also in some of our calibrated ages.

In conclusion, we keep to the calibrated ages of [Lario \(1996\)](#) for the *chenier-like* sandy, muddy and shelly ridges along the Gulf of Cadiz, and suggest that the discussion on the divergent ages calculated in the Doñana marshlands be set aside until these matters are adequately understood and settled.

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