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Discussion

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

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ABSTRACT

In this study the total radiocarbon dataset published by Rodríguez-Ramírez and Yáñez-Camacho [A. Rodríguez-Ramírez, C.M. Yáñez-Camacho, Formation of chenier plain of the Doñana marshland (SW Spain): Observations and geomorphic model, Marine Geology 254 (2008) 187–196.] has been re-calibrated using new regional reservoir corrections. It is very important to take into account these corrections, since all published works in the Atlantic Iberian Spanish coast from the year 1996 have an incorrect value of regional reservoir (ΔR) and, therefore, all calibrated ages and obtained conclusions must be kept in quarantine, until new revision. The re-calibration that we have carried out demonstrates that the sandy and shelly ridges are 430 to 637 years older than what RR&YC calculated. These are considerable errors that hinder the establishment of the precise age of short-term events, such as those which seemed to generate the estuarine ridges. Another question rises from the apparent haste with which fluctuations of sea-level are established. Our general objections lead us to conclude that the evolutionary model stems from a preconceived idea of how the Guadalquivir's estuary Holocene filling should have been built.

1. Introduction

The present manuscript is based on wide knowledge of the Atlantic Iberian coast and the need for incorporating the advances produced in the methods and techniques of dating by radiocarbon in the regional works about palaeoenvironmental evolution, especially given that the mentioned advances were published several years ago (Soares and Dias, 2006a,b). We do not include in this study the specific disagreements we hold against the model published by Rodríguez-Ramírez and Yáñez-Camacho (2008) (from now on RR&YC), since we propose a re-calibration of their own dates that will leave our approach clear enough. However, we will make some general comments on the evolutionary model.

2. Some radiocarbon concepts

The reliable radiocarbon dating of marine fossils is hard to carry out since the initial specific ^{14}C activity may differ from that of the contemporaneous atmosphere. The measured remaining ^{14}C activity of samples formed in such reservoirs not only reflects ^{14}C decay (related to sample age) but also the reservoir ^{14}C activity (Stuiver and Braziunas, 1993a). A correction for the apparent age anomaly is possible when the reservoir-atmosphere offset in specific ^{14}C activity is known. The offset $R(t)$ is expressed as a reservoir ^{14}C age, which does not need to be constant with time.

Secular ^{14}C variations in the marine environment are represented by the modeled world ocean marine curve, but a world average curve does not account for the regional oceanic differences in specific ^{14}C activity; this is caused in part by regional variations in upwelling of ^{14}C-deficient waters. Stuiver and Braziunas (1993a) define a region-specific ΔR term that represents the ^{14}C activity differences (in ^{14}C yr) of regional and world ocean surface layers. Regional differences in ^{14}C content between the sea surface water of a specific region and the average surface water are due to several causes and anomalies, namely the upwelling of deep water. Thus, a parameter, denoted as ΔR, can be defined as the difference between the reservoir age of the mixed layer of the regional ocean and the reservoir age of the mixed layer of the average world ocean.

The $R(t)$ term accounts for secular changes, whereas ΔR represents the time-independent regional offsets from the world ocean ^{14}C age.

3. Regional reservoir effect

The first time the regional reservoir effect ΔR was incorporated to some of the Gulf of Cádiz radiocarbon dates, obtained in sea shells, was in Lario's Doctoral Thesis (1996). The material that was used came from a core in the Lucio del Pescador (Doñana, Guadalquivir estuary) where ^{14}C AMS ages were compared in an organic rich level (2490 ± 60 yr BP) with sea shells remainings (2930 ± 60 yr BP) (Table 1). These ages were published by Dabrio et al. (1999, 2000), adding a ΔR

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Table 1
Lucio del Pescador ^{14}C dates (Lario, 1996; Dabrio et al., 2000) and our re-calibration.

Core location[a]	Laboratory[a]	Material[a]	^{14}C age[a]	Error[a]	2σ ranges Cal BP[b]	2σ ranges Cal BC[b]
Lucio del Pescador	UtC-4028	Twigs	2490	60	2685–2570–2455	735–620–505
Lucio del Pescador	UtC-4031	Shell	2930	60	2832–2610–2299	882–660–349

[a] Lario (1996), Dabrio et al. (2000).
[b] This work.

of -440 ± 85 ^{14}C yr (1) that, although they do not indicate the procedure, was apparently calculated from the following formula:

$$\Delta R = {}^{14}C_C - {}^{14}C_m \pm \sqrt{E_c^2 + E_m^2}$$
$$\Delta R = 2490 - 2930 \pm \sqrt{60^2 + 60^2} = -440 \pm 85, \quad (1)$$

where the obtained radiocarbon ages are substracted, for the continental (c) and marine (m) samples, and the error is the sum of the square root of both square errors (1).

Observing the way this value was obtained, we realize that the result of ΔR follows almost the same procedure of calculation as $R(t)$, although they should have deduced the continental age from the marine age, and not the other way around. That way, the result would be a positive value of $R(t)+440\pm85$ ^{14}C yr (Lario, 1996), but it would remain not to be ΔR.

Since then, all regional publications about Holocene coast evolution have used that value (positive or negative, no matter which) to carry out the calibration of sea shell samples, including this work by RR&YC that we revisit.

Recent research concerning the reservoir effect in the coastal waters off Portugal (Soares and Dias, 2006a), Galicia (Soares and Dias, 2007) and the Gulf of Cádiz (Soares and Dias, 2006b; Soares, 2008) suggests a significant fluctuation with time in ΔR values during the Holocene. The calculated weighted mean for the Gulf of Cádiz is -135 ± 20 ^{14}C yr. For the time interval 4400–4000 yr BP with positive ΔR values, we must be careful and wait for more results in order to determine a mean value to be used with the marine calibration curve (see Table 2). A first aproach, not yet published, is done by Soares (personal communication) for the interval 4000–2500 yr BP with a ΔR value of $+100\pm100$ ^{14}C yr, as a result of the data published by Soares and Dias (2006b).

4. Calibrated age vs re-calibrated age

For their Holocene evolutionary model, RR&YC have used a great number of dates already published in other works and they have calibrated them again using different ΔR for every time period, same as did other authors recently (e.g., Morales et al., 2008).

The quote about ages is as follows: "Data were calibrated using CALIB version 5.0.2 html (Stuiver and Reimer, 1993b) and the Stuiver et al. (1998) calibration dataset. The final results correspond to calibrated ages (cal.) using 2σ intervals. The data of marine reservoir variation (ΔR) differed according to the sample age range; thus, for samples older than 2500 yr, a $\Delta R=440\pm84$ was employed (Dabrio et al., 2000; Lario et al., 2002); for samples between 2500 and 1700 yr, a $\Delta R=412\pm45$, for samples between 1700 and 1000 yr, a $\Delta R=304\pm70$; and for samples younger than 1000 yr, a $\Delta R=114\pm90$ was used (Soares, 1993)". This quote is identical to the one published in the work by Morales et al. (2008).

The samples used for the calculation of regional ΔR (Lucio del Pescador, Table 1), since the year 1996 (Lario, 1996; Dabrio et al., 2000), have been re-calibrated by us the same way as all the samples from Table 2 (Soares and Dias, 2006b; Soares, 2008), although we have added the suggested ΔR by Soares for immediately older ages of 2500 yr BP ($+100\pm100$ ^{14}C yr). There is a time step of only 40 years between the most probable average ages of both samples, and also the level between the maximum and minimum ages is proportional. This means that the two samples from Lucio del Pescador are almost contemporary, as published by Lario (1996) and Dabrio et al. (2000), and they prove that the gauge and reservoir methods we put into practice for this work to be highly reliable.

In the present study the total published dataset (Table 2) has been re-calibrated using CALIB version 5.0.2. (radiocarbon.pa.qub.ac.uk/calib/calib.html) for marine samples, and CALPAL (www.calpal-online.de) for terrestrial samples. The final results correspond to

Table 2
Data base of ^{14}C results (after RR&YC) and our re-calibration.

Core location[a]	Laboratory	^{14}C age[a]	Error	2σ ranges Cal BP[a]	Highest probability Age Cal BP[a]	2σ ranges Cal BP[b]	Highest probability Age Cal BP[b]
Las Nuevas							
N1	R-2278	2284	39	1289–1545	1417	1917–2187	2050
N1	GX-21825	2895	75	1820–2347	2083	2240–2808	2540
N1	GX-21826	2010	110	821–1389	1105	1456–1999	1720
N2	B-145202	2570	70	1444–1977	1710	1817–2416	2140
N2	GX-21823	1960	120	824–1343	1083	1382–1952	1720
N2	GX-21824	1955	80	917–1273	1095	1472–1873	1680
N3	B-154082	1940	60	927–1241	1084	1501–1815	1650
N3	B-154079	1960	40	962–1240	1101	1549–1800	1680
Vetalengua							
V1	R-2283	2171	36	1179–1433	1306	1812–2036	1920
V1	B-88016	2230	60	1230–1533	1381	1825–2149	2000
V2	B-154088	1710	50	689–967	828	1284–1512	1380
Carrizosa							
C2	R-2273	4548	59	3867–4428	4147	4782–5134	4870
C3	B-88017	3460	90	2461–3137	2799	2858–3531	3260
C4	B-154084	3380	40	2424–2935	2679	2835–3369	3140
Marilópez							
M1	B-154087	3460	40	2555–3058	2806	2916–3414	3240
M1	B-154085	4260	40	3534–4047	3790	no Cal BP	no Cal BP
M2	R-2279	3679	48	2816–3318	3067	3210–3776	3480
M3	R-2280	3694	61	2816–3340	3078	3227–3808	3520

[a] Rodríguez-Ramírez and Yáñez-Camacho (2008).
[b] This work.

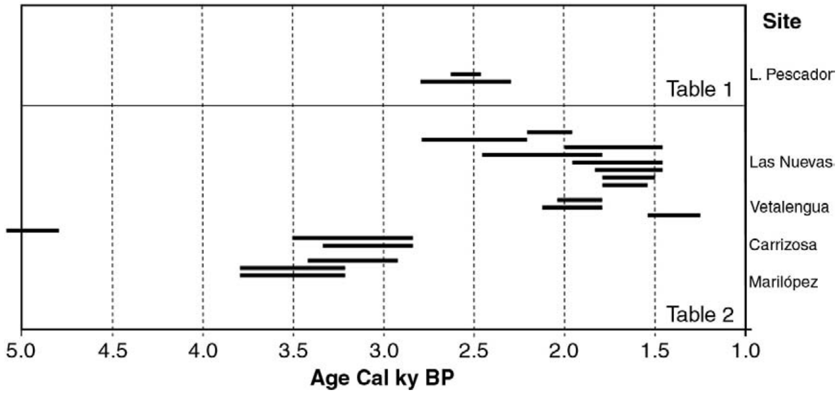

Fig. 1. Re-calibrated ^{14}C ages from RR&YC's paper (Table 2) and Lucio del Pescador site (Table 1).

calibrated ages (ca.) using 2σ intervals, with the new reservoir correction (-135 ± 20 ^{14}C yr) suggested by Soares and Dias (2006b) and Soares (2008) for this area. Calibrated ages are expressed as the highest probable age of the 2σ calibrated range (e.g., Van der Kaars et al., 2001).

5. Discussion and final considerations

The re-calibration that we have carried out for the radiocarbon dates (Table 2 and Fig. 1) and the comparison of these to the ones published by RR&YC, demonstrates that these authors attached little importance to the chronology of the estuary events, suggesting a greater interest about getting their evolutionary model to agree with established geomorphologic ideas.

In a general way, the sandy and shelly ridges are 430 to 637 years older than what RR&YC calculated. The newest systems, like Vetalengua and Las Nuevas, have the greatest deviations, between ~550–630 years. The oldest systems, like Carrizosa and Marilópez, have important deviations, although they are lower, between ~430–~460 years. This means an absolute chronologic error between 20–40% for the first ones and 12–15% for the second ones. These are considerable errors that hinder the establishment of the precise age of short-term events, such as those which seemed to generate the estuarine ridges.

But, facing the model proposed by RR&YC, a number basic questions arise that are not answered in their work or that are supposedly already answered, without making genetic clarifications.

The first one refers to the suggested model of the chenier plain and to the close relationship between these and the progradation of the inner delta of Guadalquivir River (Fig. 2, RR&YC). Sea shell ages in the chenier were obtained mainly from previous publications by other authors, however no core samples are run and neither do they give dates of the vast deltaic and tidal plains to which the cheniers are fixed to. Further, they do not rely on recent publications from other authors who do give contributions in this manner. It will be hard to establish an evolutionary model when RR&YC do not give dates for the sedimentary formations that fill almost the entire estuary.

The second question rises from the apparently haste with which fluctuations of sea-level are established (Fig. 7, RR&YC) for the Iberian Atlantic coast. In the field of sea-level change, all researchers know how difficult it is to find reliable criteria that allow establishment of marine paleo-levels. It is scientifically inappropriate to use the absolute estuary ridges height as a sea-level marker, especially when the authors indicate that their genesis was produced by extraordinary events of high energy, like great storms and/or tsunamis.

The re-calibration of the samples considered by RR&YC that we have carried out and the general objections we present lead us to conclude that the presented evolutionary model stems from a preconceived idea of how the Guadalquivir's estuary Holocene filling should have been built. The paleoenvironmental reconstructions need multidisciplinary investigations that consider all possible scenarios and register the time-space evolution of all morphosedimentary formations.

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