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DISCUSSION

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INTRODUCTION

In a past number of the *Journal of Coastal Research,* RUTTER *et al.*, (1990) published an interesting contribution concerning the geochronology of Pleistocene paleoshorelines of the Patagonian Region (República Argentina).

They indicated their concerns about previous ^{14}C dates because "most of the samples were determined on a liquid scintillation counter at the Buenos Aires University. A high pressure counter would have probably extended the dates beyond the limit of radiocarbon dating" (emphasis by M.A.G.).

Assuming that our group has been working since 1975 on Late Pleistocene and Holocene paleoeustatism from 33°S to 40°/41°S (the last latitude is the northern boundary of the Patagonian region) and, furthermore, assuming that I personally had been working from 1981 until 1990 in the ^{14}C laboratory mentioned by RUTTER *et al.* (1990), more exactly, the Laboratory of ^{14}C of INGEIS (CONICET), I wish to discuss some comments concerning this work.

DISCUSSION

Concerning the Dates in Question

(1) RUTTER *et al.* (1990) indicate three possible origins of methodological error; only one of them, relating to ESR dates, ranges between 15% and 20%; but in the interpretation of their results, they have misconsidered these methodological errors.

(2) The different dates assigned to each system (terrace or paleoshoreline) for most of the localities have a high dispersion. Furthermore, this dispersion becomes even larger if the above mentioned methodological errors are considered for each sample.

Besides the fieldwork and the laboratory analyses, it is also important to consider whether the samples are representative of any subject or process, to consider an elemental statistical analysis of the results, to know the significance of the methodological errors, and to interpret their true geochronological meaning (GONZALEZ, ms.).

In order to appreciate the true range of assigned paleoshoreline dates for each locality, maximum and minimum ranges for each paleoshoreline must be known, including all methodological errors. The geochronological analysis thus becomes more reliable.

Moreover, to analyze the true significance of reliable (not dispersed) groups of dates, it is convenient to consider the mean maximum (*Mev*) and minimum (*mev*) of the respective extreme values, considering the respective methodological error of each sample of that group (GONZALEZ, ms.).

As for some of the presented dates without methodological errors, including those where errors are taken into account (the values of the above

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mentioned *Mev* and *mev*), most of the dates for each paleoshoreline are highly dispersed. Not only in geochronology, but in laboratory analysis as well, dispersed values for a specific subject (paleoshoreline, in this case) indicate low precision and, furthermore, might indicate:

(a) the analyzed samples were not representative of the subject due to sampling errors (*i.e. sample inadequate*);
(b) the analyzed samples were not collected from homogeneous materials (*i.e. sample inadequate*);
(c) the methodology is not reliable (*i.e. methodology inadequate*);
(d) the equipment is close to the limit of detection (*i.e. equipment inadequate*).

In principle, I have no reason to suspect the sampling judgment, or the utilized equipment, or the employed methodologies, nor the conclusions of KATZENBERGER (1988) concerning the ESR dates. According to RUTTER *et al.* (1990) the conclusions of KATZENBERGER (1988) are "pessimistic" to ESR dating of mollusk shells, but these only were objectives. There are, however, some other aspects of the utilized samples that may be of some concern, especially as they relate to ESR methodology and amino acid data.

Interpretation of the Dates in Question

(1) As commented above in the interpretation of the dates for each locality and for each paleoshoreline, significant errors were not considered for the employed methodologies (15% to 20% only to ESR dates older than Holocene, and still larger to Holocene samples; RUTTER *et al.*, 1990). Thus, the true dispersion of the dates was diminished, although not masked.

Such misconsideration of methodological errors prompted inexact interpretation of dates for some localities. For instance, in the San Blas Locality, there were two sets of dates from different identified and unidentified mollusk shells: 102,000 and 108,000 yr BP for an upper stratigraphic level; and 72,700, 79,600 and 94,500 yr BP for a lower stratigraphic level (about one meter under the upper one).

In this case, the authors cautioned: "It should be noted that the older dates are from a stratigraphically higher position". But, in spite of this note considering the methodological error for dates in both sets and their extreme values, these dates would be considered similar. The range of the 'younger' dates (lower level) are overlapped with the true range of the 'older' ones (upper level), as it is shown in Figure 1a. Thus, there is not an "older" and "younger" set of dates, both sets are considered as comprising one set.

(On other hand, concerning the Patagonian littoral deposits, at the present day with a very high tidal range and large stormwaves, one meter of vertical difference between the samples would be entirely comprised in the sedimentary reworking by one storm.)

At the San Antonio Oeste Locality, three sets of ESR dates were presented. Their differences cannot be distinguished in D/L ratios (in Figure 5 of the authors, the D/L ratios of samples older than 83,000 yr aren't different). In spite of this, the extreme values for the ESR 'intermediate' set, from samples collected all around + 10 m a.s.l. (nine dates), are overlapped with the extreme values of the 'younger' one (Figure 1b). Thus, both sets are considered as one age horizon.

For System III and System IV paleoshorelines at Caleta Valdés, a similar case occurs: an important part of the range of the extreme values for System IV are comprised in the range of the extreme ones for System III (Figure 1c). Thus, both systems are considered to be of similar age.

(2) RUTTER *et al.* (1990) in their discussion say: "Although problems encountered in ESR dating, the method is helpful especially if utilized in conjunction with other criteria and dating methods—in this case amino acid data". But, in all five localities there is no agreement among the dates respectively coming from both methodologies.

(a) At the San Blas Locality, the D/L ratios suggest older ages, like "pre-last interglacial" (RUTTER *et al.*, 1989); but, in the commented work, these deposits were interpreted as formed during the last interglacial, only according to ESR data.

(b) At the San Antonio Oeste Locality, the interpretation is not clear. For sampling sites A-8 and A-15, they expressed the coincidence between D/L ratios and ESR dates "... if the mean D/L ratios are considered or when the D/L ratios of certain individual species are compared" (RUTTER *et al.*, 1990). Furthermore, and in reference to RUTTER *et al.* (1989) the authors say: "Prior to the present study, however, the amino acid ratios were judged to be Holocene in age ..." (emphasis by M.A.G.).

(c) At System III for the Caleta Valdés Locality,

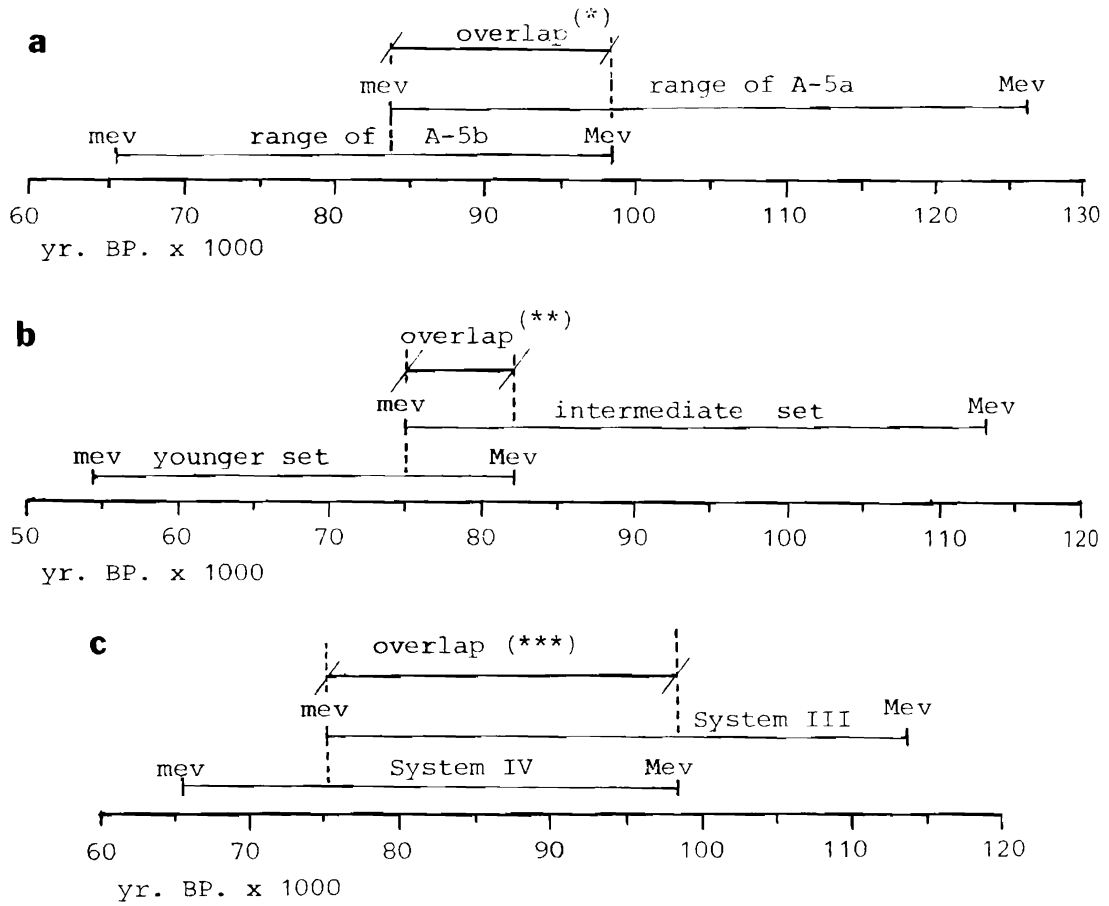

FIGURE 1. Range of dates to paleoshorelines of different localities, and their overlap. a. San Blas locality. (*) 44,21% concerning the entire range of A-5b; 34,57% concerning the entire range of A-5a. See values of mev and Mev in Table 1. b. San Antonio Oeste locality. (**) 24,22% concerning the entire range of younger set; 17,57% concerning the entire range of intermediate set. c. Caleta Valdes locality. (***) 68,38% concerning the entire range of System IV; 59,04% concerning the entire range of System III (see Table 1).

the ESR dates indicate a highly dispersed range of dates from Isotope Stage 2 (they indicate an age of 45,800 yr BP, with extreme values of 36,640 and 54,960 yr BP, only taking into account an error of 20%) to older than 5e (last Interglacial); but D/L ratios are relatively high and indicate penultimate or older interglacial. In this case, and according to some inverse and unexplained judgement to accept ESR dates for San Blas, D/L dates were unilaterally judged more reliable than ESR ones.

(d) At Bahía Bustamante, there is agreement between ESR and D/L results for terrace Systems I and III, but there aren't consistencies between D/L ratios and ESR dates for System II. The authors didn't accept the inconsistencies for System II; they attribute the differences between D/L and ESR results to original sampling problems, and they adopt only ESR dates. In the same way, they accept the agreement of the D/L ratios and ESR dates for Systems I and III. But, it is not clear that the quantitative dates support it. Moreover, the D/L ratios for terrace Systems I and II, ranging between 0.42 and 0.85 (their Figure 10) didn't permit us to establish any significant chronological difference between both systems of terraces.

(e) At the Puerto Deseado Locality, the ESR dates are clearly differentiated between terrace Systems IV and V, and the authors indicated that

TABLE 1. *Extreme values (Maximum = Mev, and minimum = mev) to paleoshorelines of San Blas, San Antonio Oeste and Caleta Valdes, according to the published dates of Rutter* et al., *1990, and their overlapped ranges (see Figure 1a, b and c).*

Locality	System of Terrace, Level, or Set of Dates	Published Dates (*) yr BP	Maximum Value (V) (*) + 20%	Minimum Value (v) (*) − 20%	Mean Extreme Values	
					Mev = x̄V	mev = x̄v
San Blas	A-5a	102,000	122,400	81,600	126,000	84,000
		108,000	129,600	86,400		
	A-5b	94,500	113,400	75,600	98,520	65,680
		79,600	95,520	63,680		
		72,700	86,640	57,760		
San Antonio Oeste	intermediate set	83,200	99,840	66,560	113,426	75,618
		86,500	103,800	69,200		
		88,600	106,200	70,800		
		90,200	108,240	72,160		
		91,000	109,200	72,800		
		96,000	115,200	76,800		
		97,300	116,760	77,840		
		107,000	128,400	85,600		
		111,000	133,200	88,800		
	younger set	66,800	80,160	53,440	82,260	54,840
		70,300	84,360	56,240		
Caleta Valdes	System III	45,800	54,960	36,640	113,680	75,787
		87,400	104,880	69,920		
		151,000	181,200	120,800		
	System IV	81,400	97,680	65,120	98,160	65,440
		82,400	98,640	65,760		

the amino acid ratios for System V are generally lower than System IV paleobeaches. But, in their Figure 12 there aren't differences between the D/L ratios of these paleobeaches. The deposits of System V originally were interpreted as last interglacial (RUTTER *et al.*, 1989), but "The ESR dates now cast doubt on this interpretation".

Concluding, for all the studied localities, most of the dates from both methodologies are inconsistent and highly suspect when they are compared. Their work, however, confirms the conclusions of KATZENBERGER (1988) and KATZENBERGER *et al.* (1988) concerning the need to carefully interpret ESR dates from mollusk (shell) samples. Even so, it is still dangerous to make correlations. In a similar way, it is not reasonable to judge or question the ^{14}C dates of the younger Late Pleistocene paleoshorelines, only with the presumption that "... a high pressure counter would have probably extended the dates beyond the limit of radiocarbon dating" (RUTTER *et al.*, 1990).

Concerning the ESR and Amino Acid Methodologies

Concerning ESR results and the spectral problems defined by KATZENBERGER (1988) and KATZENBERGER *et al.* (1988), the open system of the mollusk shells related to uranium, expressly pointed to by RUTTER and SCHNACK (1990), probably provides highly inhomogeneous samples. Moreover, such consideration is possible considering the different natural mineralogy of different mollusk species (different Calcite/Aragonite ratios and, thus, different diagenetic behaviour; see GONZALEZ *et al.*, 1988a); and, also, considering the differences in the amounts of natural organic compounds in different mollusk genera and species (Conchioline, as 'nacre', for instance, particularly abundant in shells of *Mytilus* sp., but relatively scarce in some other genera), leading to different uptakes of uranium in each case.

In this way, it is important to consider what RUTTER and SCHNACK (1990) have shown: "The open system uptake of uranium by mollusk shells makes analysis by either U series and ESR (Electron Spin Resonance) problematic. A U uptake history must be assumed. Furthermore, the possibility that U has been leached from, or deposited in the shell during diagenetic alteration requires that only shells in which the original mineralogy is preserved can be used for dating, but does not guarantee the ages derived will be correct" (emphasis by M.A.G.).

Concerning the amino acid results, RUTTER and

SCHNACK (1990) express: "Problems encountered that exhibit accurate interpretation of amino acid results are the variation in D/L ratios of different genera and species, variation of D/L ratios found within a single specimen of the certain species, and finally the same genera or species are not always found in all shorelines of varying age in all locations".

From the above comments, I admit that at least by means of ESR analysis on mollusk shells, perhaps it is difficult to know the true ages of the Argentinian Pleistocene shorelines.

But, in order to make a constructive contribution with these comments, I consider it possible to find corals in the Pleistocene littoral deposits of the Patagonian region. For instance, FARINATI (1989) described a species of Pennatulaceae (*Stylatula darwini*, Verril, 1864) in the Holocene beach ridges of Bahía Blanca (roughly 39°S); moreover, this Coelenterata lives in that area today (DARWIN, 1845; ELIAS, 1985; both in FARINATI, 1989).

I personally found some small cylindric, still unidentified fossils, in Late Pleistocene deposits of the southern part of the Buenos Aires province, which seem to be Pennatulaceae. It thus seems possible that such small corals could exist in the Pleistocene littoral deposits of North Patagonia. They could be dated by ESR and U series without the methodological problems associated with mollusk shells.

Concerning the D/L ratios, I believe that the Patagonian paleoshorelines (and also the northern ones), will provide more reliable dates with better taxonomic control and ecological knowledge of the several mollusk species recognized by FERUGLIO (1950) in these deposits.

Such knowledge would permit the collection of the same species in each paleoshoreline for each locality; but it would also provide an important parameter for the determination of reliable amino acid isochrones. True ecological knowledge of the malacological assemblages would indicate different thermal histories (related to different paleoclimatic and paleo-oceanographic conditions) of these fauna in different paleo-shorelines, as was already inferred by FERUGLIO (1950) for the Patagonian ones, and showed recently by AGUIRRE (1990a,b) for northern Argentinian littoral deposits.

FINAL COMMENTS

Finally, I wish to make some additional comments concerning the ^{14}C dates. I am not making them to "protect" our chronologies without arguments; on the contrary, I am attempting to reach a true state of serious analysis to correct our possible miscalculation.

For the past three decades, on world-wide littoral areas researchers have obtained ^{14}C dates ranging between 25,000 and 35,000 yr BP for a high paleoshoreline older than the mid-Holocene one (see GONZALEZ *et al.*, 1986, 1988a,b).

For the República Argentina, from 33°S to 40°/41°S, and also for southern (Patagonian) latitudes, similar ages were obtained. In addition to the Laboratory of INGEIS, ^{14}C age determinations were also performed in three other laboratories. Moreover, the samples were collected by at least five separate groups of researchers, perhaps with different field-work criteria: Laboratories of CNRS (CORTELEZZI and LERMAN, 1971); Groeningen University (CORTELEZZI, 1977); University of Miami (PARKER *et al.*, 1982); and INGEIS (CODIGNOTTO, 1983, 1984; GONZALEZ *et al.*, 1986, 1988a,b; GONZALEZ and GUIDA, 1990).

We know that ^{14}C dates older than 25,000 yr BP are considered to be uncertain (STUIVER *et al.*, 1975) because they approach the technical limit of detection of the standard liquid scintillation counters (see GONZALEZ *et al.*, 1988a). In this way, some contamination with 'young' ^{14}C may have affected the obtained dates (*i.e.*: an old carbonate without ^{14}C activity, considered a 'dead carbonate', with only the addition of 1% of modern ^{14}C, indicates an activity corresponding to an age of roughly 37,000 yr BP; see ANDREWS and MILLER, 1980; GONZALEZ *et al.*, 1988a).

Furthermore, it is widely accepted and we concur, that during the lapse between these dates, sea level could be at nearly −40 m (40 meters below the present one) according to paleoeustatic researches (BLOOM *et al.*, 1974; BLOOM, 1978; and others); or perhaps even at lower levels, according to the classic isotopic stages from deep sea cores.

With this basic knowledge, we still have an obligation to exhaustively analyze our dates before we exclude them. We have been working by means of several geochronological criteria. We published an extensive analysis of each possibility of error in our ^{14}C dates: methodological errors; contamination of the samples in the field (natural) or laboratory; problems of pre-treatment of the samples (these last ones, directly studied in GONZALEZ and RAVIZZA, 1987); diagenetic changes in the natural mineralogy of the mollusk shells; and some other possibilities, as natural isotopic fractioning

("vital effect"), for instance (see GONZALEZ *et al.*, 1988a).

Furthermore, we attempted to check our ^{14}C dates by means of magnetostratigraphy; and the obtained dates (GONZALEZ and GUIDA, 1990) were in agreement with our previous tentative correlations. In the studied locality, at the basal estuarine deposits tentatively correlated with the Sangamon (*i.e.* last interglacial), a reversal geomagnetic field event is recorded. The Virtual Geomagnetic Paleopole (VGP) would be in agreement with the VGP of the Blake Event in the Grand Pile deposits (Dr. Nils Axel Mörner, *written communication*) occurred at *ca.* 114,000 yr BP (SMITH and FOSTER, 1969; BUCHA *et al.*, 1969; NAKAJIMA *et al.*, 1973; MÖRNER, 1977).

Moreover, the younger estuarine deposits that overlay the previous ones have ^{14}C dates indicating a suggestive chronological difference between the basal part and the top. At its basal parts, articulated shells of *Tagelus* Gray have dates of 35,400 ± 1,800 yr BP; articulated ones of *Erodona mactroides* Daudin have dates of 32,700 ± 1,300 yr BP. Both dates indicate mean extreme values of 35,600 yr BP and 32,500 yr BP (Maximum = *Mev*, and minimum = *mev*, respectively). Furthermore, articulated shells of *E. mactroides* from the top of this sequence are dated as 26,600 ± 720 years before present.

In these younger estuarine deposits it appears that there was an 'excursion' of the geomagnetic field (GONZALEZ and GUIDA, 1990), which would be in agreement with the Lake Mungo Event at roughly 30,000 yr BP according to several authors (BUCHA, 1970; BARBETTI and MCELHINNY, 1972; NAKAJIMA *et al.*, 1973; among others). Notwithstanding, we are still attempting complementary works to definitively confirm or discard our ^{14}C dates by means of amino acid and some other methods. These analyses are still in laboratory.

I prefer to be considered as "suffering the Atlantic disease", as a friend has said to us, because our published dates do not agree with the 'present-day-knowledge', instead of hiding them, at least until the appearance of unquestionable dates.

I consider the work of Rutter *et al.* (1990) to be an important attempt at defining the true ages of the Patagonian terraces and, thus, the ages of paleoeustatism in our country. Their results are, however, still not conclusive. Furthermore, and according to the preceeding comments, at present day they are at least as suspicious as the ^{14}C dates.

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