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Argentinian Holocene Transgression: Sidereal Ages

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ABSTRACT

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Chronological analyses identify Holocene transgressive episodes on some South American mid-latitudinal littorals, mainly in Argentina. ^{14}C dates corrected to sidereal ones, are grouped in histograms, or bar diagrams, and define dominant transgressive episodes. The histograms indicate a weighting of dates to the maximum Holocene transgression around of 5500 yr BP, with major peaks up to the present. The warming hemicycle seems to be more extended than the colder one.

Furthermore, a possibly time-transgressive eustatic 'wave' from south to north is suggested for the maximum Holocene transgression. That eustatic episode seems to have a differential shift in certain areas; in the Patagonian and Pampean regions, that transgressive 'wave' seems to be shifted at similar rate; meanwhile, Brazilian coasts show an almost-instantaneous rate of transgression at every latitude.

ADDITIONAL INDEX WORDS: *Argentina, eustasy, Holocene, geochronology, ^{14}C carbon, sidereal dates.*

INTRODUCTION

In previous works, WEILER and GONZALEZ (1990) and GONZALEZ and WEILER (in press), attempted to interpret the meaning of Holocene chronologies (mainly ^{14}C) on certain South American Atlantic littorals. But their results were not conclusive because of the changeable ^{14}C flux during the Holocene affected the measured ^{14}C activity in the samples, masking the true ages.

FAIRBRIDGE (1990 and *written communication*) suggested a comparison of sidereal ages from transgressive evidence and solar activity, in order to interpret the regional transgressive/regressive behaviour during the Holocene. The ^{14}C dates are related to geological (geomorphological, stratigraphical) evidence of the Holocene transgressive/regressive cycle on mid-latitudinal South American Atlantic littorals. The dates were calculated to sidereal ones, employing the calibration program of STUIVER *et al.*, (1986).

The paleoeustatic researches were made along shorelines located between 33° and 41°S, and associated with five major structural units, which have varied crustal behaviour (GONZALEZ *et al.*, 1988). In spite of having our own dates for these latitudes, only the dates for the Colorado Basin (38°40'S) were employed to make the analyses, because three of its localities have been studied in detail over several years: Pehuencó beach, Bahía Blanca estuary and Colorado River delta (Figure 1). Thus, most of the dates are from this sedimentary basin (93 dates, out of a total of 109 ones at all these latitudes). Moreover, it is not appropriate to compare the dates of all these latitudes as a single unit because of the different crustal behaviour of the different structural units which could confuse the eustatic signals.

Samples for ^{14}C analyses were all mollusk shells, coming from:

(a) High energy deposits, such as beach ridges of coarse sediments. In this case, mollusk shells are liable to be re-worked and redeposited: their ^{14}C ages were considered as not representative of the sampled deposits. Thus, the *Probable Geological Age* (PGA) criteria (GONZALEZ, 1989) was employed. PGA is the lowest ^{14}C age obtained from a deposit of high energy; this deposit could be younger, but it could not be older than its PGA. Thus, PGA is also a *Maximum Age.*

As indicated by FAIRBRIDGE (1990) in Florida beach ridges, the origin of our dated beach ridges are a consequence of: (a) rising sea-level episodes; and (b) changes of wind systems. In our littorals, generally open to the east, the Easterlies were most frequent during warming episodes (GONZALEZ, 1990; GONZALEZ and GALAN, 1990) which lead to enhanced building of beach ridges, at the same time as a rise of sea level.

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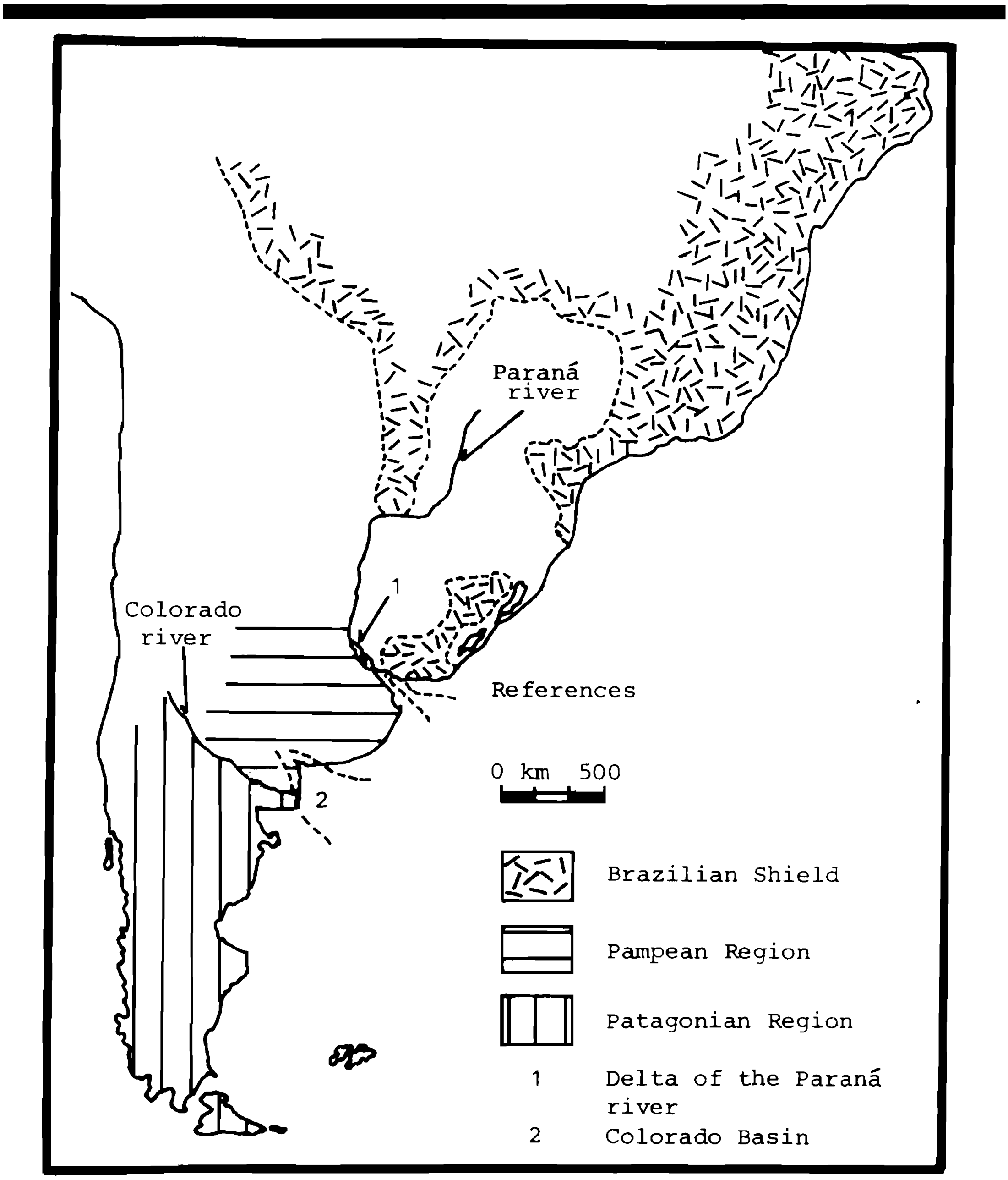

Figure 1. General Location map.

(b) Low energy deposits, such as tidal flats and lagoons; in this case, mollusk shells in "life position" were sampled, and their respective ^{14}C ages were considered as truly representative of the deposits.

^{14}C analyses were made at the Laboratory of INGEIS (CONICET, Argentina). We still have no reliable date concerning the reservoir effect along our coast; nevertheless, we assumed a mean value of 400 years for it, following data

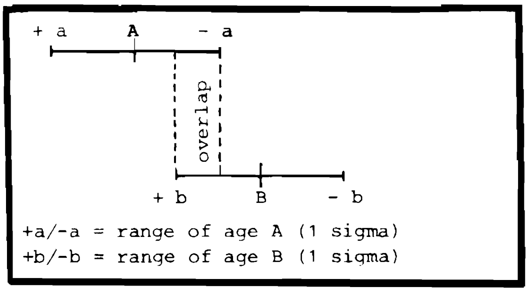

Figure 2. Ages (^{14}C) of the same group.

by several researchers of the global oceans. In spite of this, as was pointed out by GONZALEZ and WEILER (1983) and suggested by FAIRBRIDGE (*written communication*), it is possible that Argentinian littorals do not have a large 'reservoir effect', because of the width of the Atlantic shelf, major wave action, tidal exchange and fluvial inflow.

DATA

Several different analyses were made. First, ^{14}C dates were grouped according to the overlap of their respective methodological errors (Figure 2). To judge the meaning of the methodological errors of each ^{14}C date in its own group, we calculate the *mean extreme values* (*maximum* = *Mev*, and *minimum* = *mev;* see GONZALEZ, 1992) of each group. Then, the mean age of each group was obtained and, finally, these ages were calibrated to sidereal ones (Table 1 and Figures 3 and 4).

Second, each ^{14}C date was individually calibrated to a sidereal one, and these ages were grouped on a histogram with intervals of 250 years (Figure 5). An attempt was made to prepare a histogram with intervals of 100 years, as was suggested by FAIRBRIDGE (1990) (Figure 4). Unfortunately, the number of dates was not adequate for this. In any case, the histogram with intervals of 250 years turned out to be highly interesting and, perhaps, representative of the probable Holocene eustatic behaviour.

Third, a comparison was made between latitude and sidereal ages of ^{14}C dates for the maximum Holocene transgression along the entire South American Atlantic littorals south of the Equator, as proposed by WEILER and GONZALEZ (1990) and GONZALEZ and WEILER (in press). These results seem to be highly significant.

DISCUSSION

The histogram with the groups of ^{14}C dates calibrated to sidereal ones (Figure 3), indicates a weighting of dates for the maximum Holocene transgression around 5,500 yr BP. Also indicated are minor peaks extending up to the present, but with much less significance.

The histogram (intervals × 250 years, Figure 5) with the ^{14}C dates individually calibrated, also

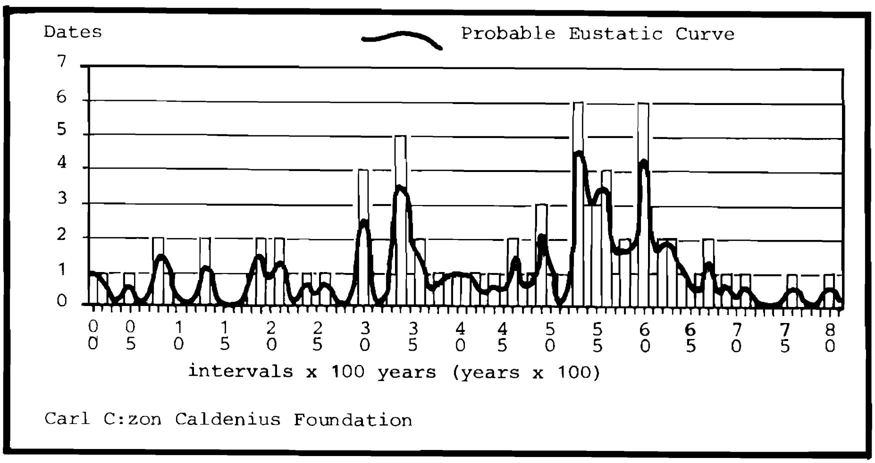

Figure 3. Eustatism at Colorado Basin. Sidereal ages (histogram) and probable eustatic trend (curve) to the Holocene (interval of the bar × 100 years).

Table 1. *Groups of ¹⁴C dates, mean extreme values (Maximum and minimum) and sidereal ages to Colorado Basin, Atlantic littoral, Republic of Argentina.*

Sample No.	Age (yr BP)	Mev (yr BP)	mev (yr BP)	Mean Age of the Group	Sidereal Ages (yr BP)
AC-120	11,300 ± 180	11,480	11,120	11,300 ± 180	—
AC-0053	9,460 ± 120	9,580	9,340	9,430 ± 135	—
AC-0252	9,420 ± 150	9,570	9,270		
AC-0934	9,400 ± 130	9,530	9,270		
AC-0245	8,720 ± 140	8,860	8,580	8,620 ± 140	—
AC-1217	8,660 ± 110	8,770	8,550		
AC-0244	8,590 ± 135	8,725	8,355		
AC-1020	8,570 ± 120	8,690	8,450		
AC-0253	7,850 ± 130	7,980	7,720	7,705 ± 160	7,724 (7,909–7,569)
AC-0252	7,560 ± 190	7,750	7,370		
AC-0046	6,990 ± 130	7,060	6,800	6,845 ± 115	6,925 (7,089–6,789)
AC-0055	6,760 ± 100	6,860	6,660		
AC-0312	6,600 ± 120	6,720	6,480	6,580 ± 125	6,639 (6,759–6,469)
AC-1021	6,560 ± 130	6,690	6,430		
AC-0390	6,420 ± 135	6,555	6,285	5,652 ± 111	5,616 (5,719–5,489)
AC-0314	6,350 ± 110	6,460	6,240		
AC-0935	6,260 ± 100	6,360	6,160		
AC-1021	6,190 ± 110	6,300	6,080		
AC-1129	6,130 ± 120	6,250	6,010		
AC-0313	6,100 ± 120	6,220	5,980		
AC-0933	6,080 ± 100	6,180	5,980		
AC-0382	6,000 ± 110	6,110	5,890		
AC-0391	6,000 ± 105	6,105	5,895		
AC-0029	6,000 ± 150	6,150	5,850		
AC-0311	5,990 ± 115	6,105	5,875		
AC-1013	5,980 ± 90	6,070	5,890		
AC-1065	5,960 ± 120	6,080	5,840		
AC-0054	5,900 ± 100	6,000	5,800		
AC-0463	5,820 ± 110	5,930	5,710		
AC-0068	5,750 ± 170	5,920	5,580		
AC-0381	5,720 ± 100	5,820	5,620		
AC-1202	5,630 ± 170	5,800	5,460		
AC-0240	5,590 ± 110	5,700	5,480		
AC-0338	5,580 ± 130	5,710	5,450		
AC-1014	5,570 ± 120	5.690	5,450		
AC-0251	5,510 ± 110	5,620	5,400		
AC-0384	5,470 ± 100	5,570	5,370		
AC-0317	5,460 ± 105	5,565	5,355		
AC-0558	5,440 ± 150	5,590	5,290		
AC-0380	5,420 ± 100	5,520	5,320		
AC-0316	5,400 ± 140	5,540	5,260		
AC-0346	5,350 ± 130	5,480	5,220		
AC-0322	5,320 ± 100	5,420	5,220		
AC-1013	5,310 ± 110	5,420	5,200		
AC-0045	5,310 ± 120	5,430	5,190		
AC-0240	5,305 ± 165	5,470	5,140		
AC-0315	5,280 ± 105	5,385	5,175		
AC-1017	5,200 ± 110	5,310	5,090		
AC-0239	5,140 ± 110	5,250	5,030		
AC-0246	5,100 ± 100	5,200	5,000		
AC-0363	5,050 ± 100	5,150	4,950		
AC-0388	4,950 ± 100	5,050	4,850		
AC-0052	4,850 ± 90	4,940	4,760	4,785 ± 100	4,522 (4,688–4,406)
AC-0250	4,830 ± 110	4,940	4,720		
AC-0362	4,820 ± 100	4,920	4,720		
AC-0248	4,640 ± 100	4,740	4,540		

Table 1. *Continued.*

Sample No.	Age (yr BP)	Mev (yr BP)	mev (yr BP)	Mean Age of the Group	Sidereal Ages (yr BP)
AC-0350	4,520 ± 110	4,630	4,410	4,400 ± 95	3,989 (4,135–3,868)
AC-0349	4,470 ± 90	4,560	4,380		
AC-0389	4,460 ± 100	4,560	4,360		
AC-1205	4,455 ± 80	4,535	4,375		
AC-0930	4,450 ± 100	4,550	4,350		
AC-0464	4,380 ± 80	4,460	4,300		
AC-1216	4,350 ± 90	4,440	4,260		
AC-0932	4,320 ± 90	4,410	4,230		
AC-0337	4,220 ± 100	4,320	4,120		
AC-0931	4,060 ± 100	4,160	3,960	3,880 ± 95	3,358 (3,455–3,254)
AC-0387	3,950 ± 90	4,040	3,860		
AC-0067	3,920 ± 60	3,980	3,860		
AC-0348	3,920 ± 90	4,010	3,830		
AC-0247	3,860 ± 105	3,955	3,765		
AC-0511	3,850 ± 120	3,970	3,730		
AC-0351	3,810 ± 120	3,930	3,690		
AC-0241	3,740 ± 90	3,830	3,650		
AC-0467	3,600 ± 100	3,700	3,500	3,570 ± 95	2,946 (3,089–2,832)
AC-0049	3,580 ± 90	3,670	3,490		
AC-0386	3,570 ± 100	3,670	3,470		
AC-0512	3,560 ± 100	3,660	3,460		
AC-1224	3,550 ± 80	3,630	3,470		
AC-0170	3,220 ± 95	3,315	3,125	3,220 ± 95	2,589 (2,712–2,377)
AC-0047	3,060 ± 120	3,180	2,940	3,060 ± 120	2,329 (2,479–2,189)
AC-0050	2,850 ± 80	2,930	2,770	2,820 ± 85	2,046 (2,143–1,939)
AC-0242	2,790 ± 90	2,880	2,700		
AC-0243	2,620 ± 85	2,705	2,535	2,603 ± 95	1,802 (1,896–1,688)
AC-0468	2,600 ± 90	2,690	2,510		
AC-0027	2,590 ± 110	2,700	2,480		
AC-0249	2,170 ± 85	2,255	2,095	2,165 ± 100	1,294 (1,388–1,227)
AC-0026	2,155 ± 115	2,270	2,040		
AC-0171	1,680 ± 85	1,765	1,595	1,640 ± 100	762 (895–674)
AC-0048	1,640 ± 80	1,720	1,560		
AC-0044	1,600 ± 95	1,695	1,505		
AC-0051	1,240 ± 80	1,320	1,160	1,240 ± 80	471 (514–410)
AC-0476	870 ± 80	950	790	870 ± 80	40-0 (149–0)
AC-0028	407 ± 100	507	307	407 ± 100	0 (0–0)

seems to indicate minor peaks of dates. Previous works supported by field evidence and ^{14}C analyses (WEILER and GONZALEZ, 1990; GONZALEZ and WEILER, in press) suggested the existence of three transgressive peaks in the Holocene eustatic behaviour.

The ages for the respective peaks (previous ^{14}C ages and sidereal peaks of Figure 5) are not very different. Moreover, and as suggested by FAIRBRIDGE (1990), at least with respect to the maximum Holocene transgressive episode and, perhaps, also to the younger ones, the warming hemicycle seems to be more extended than the colder one. That is possible also for the intermediate ones, but in this case they might be masked by the existence of more older dates.

In an other matter, according to previous works and mainly related to ^{14}C dates (and only few ESR ones), a possible time-transgressive eustatic 'wave' from south to north was suggested for the maximum Holocene transgression. Furthermore, that transgressive episode seems to occur at different rates along various parts of these littorals; with a delayed rate at higher latitudes (Patagonian region); an intermediate rate at mean latitudes (Pampean region); and a high, almost-instantaneous rate, at lower ones (Brazilian coasts; see GONZALEZ and WEILER, in press).

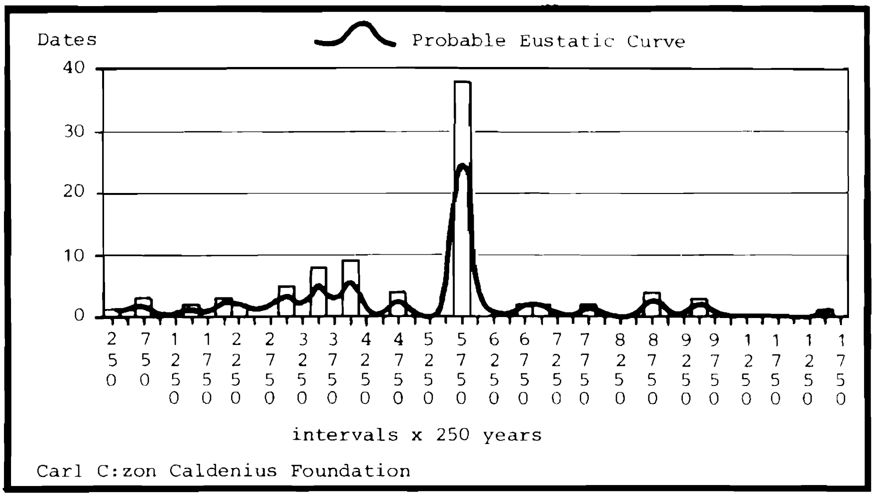

Figure 4. Eustatism at Colorado Basin. Groups of ^{14}C ages corrected to sidereal ones (see text) to the Holocene.

According to the same ^{14}C dates, but now calibrated to sidereal ones, there also appears a similar time-transgressive eustatic south-to-north 'wave'. But now, in the Patagonian and Pampean regions, that transgressive 'wave' seems to be shifted at similar rate; nevertheless, Brazilian coasts show an almost instantaneous behaviour (Figure 6).

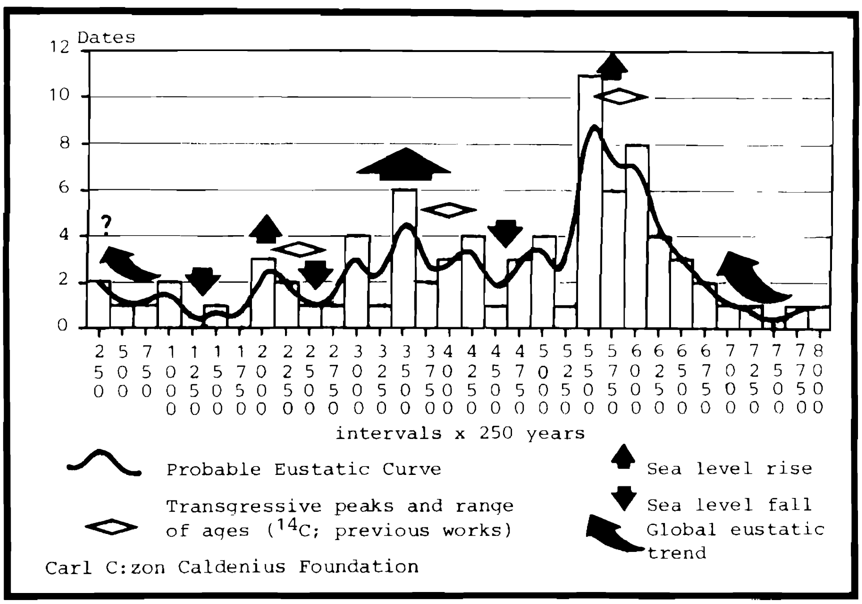

Figure 5. Eustatism at Colorado Basin. Histogram of sidereal ages; transgressive peaks (^{14}C); possible eustatic curve.

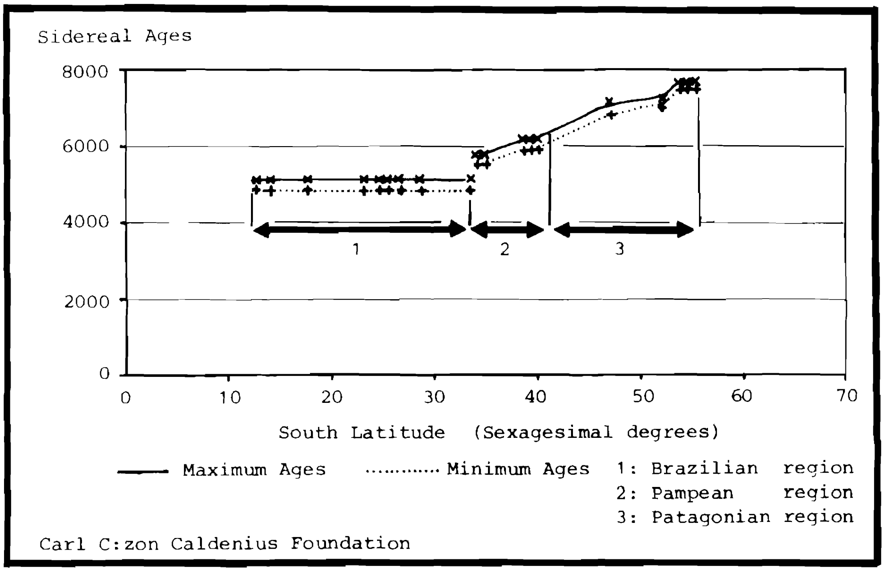

Figure 6. Mid-Holocene transgression. Time-transgressive 'wave' to South American Atlantic littorals.

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