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Late Pleistocene Littoral Deposits from 33° to 40° S, Argentine Republic: Blake and Probable Lake Mungo Events—Magnetostratigraphic Geochronology

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ABSTRACT

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Geochronological data are presented on a basis of magnetostratigraphic evidence from old lagoonal deposits and younger estuarine deposits from Irazusta Quarry (33° S and 58° W). The Virtual Geomagnetic Pole Position (VGP) recorded in the lagoonal deposits, corresponds to the Blake Event and confirms its previous tentative correlations with the Sangamon (Eemian) Interglacial.

An "excursion," or "transition interval" of the earth's magnetic field recorded in the younger estuarine deposits, previously dated between 35,400 ± 1800 BP and 26,600 ± 720 BP (^{14}C ages), could indicate the Lake Mungo Event. On the other hand, littoral deposits from 38° S, dated in 30,500 ± 1400 BP, also recorded an "excursion" that could coincide with the Lake Mungo Event. If this Lake Mungo Event is confirmed, then the reliability of the ^{14}C ages for these estuarine and littoral deposits from 33° to 40° S at the present time above modern mean sea level will be definitively supported.

ADDITIONAL INDEX WORDS: *Blake Event, Brunhes Magnetic Epoch, Earth's magnetic field, eustasy, global sea level changes, Lake Mungo Event, paleoclimate.*

INTRODUCTION

Littoral deposits from two high sea level episodes, both well differentiated from middle Holocene transgressive deposits (GONZÁLEZ *et al.*, 1986) were found during field work between 33° and 40° S (Argentine Republic). According to the stratigraphic relations, both deposits are late Pleistocene. Several ^{14}C ages for the younger of them, range between 38,500 ± 3000 BP and 25,700 ± 650 BP, supported this correlation (GONZÁLEZ, 1984; GONZÁLEZ *et al.*, 1983a-b, 1986, 1988a and 1988b; GONZÁLEZ and RAVIZZA, 1987; GUIDA and GONZÁLEZ, 1984; WEILER *et al.*, 1987; WEILER and GONZÁLEZ, in press).

The younger high sea level episode was correlated at first with Mid-Wisconsin Interstadial and the other one, older than the first one, was correlated with the Sangamon Interglacial. Since the ^{14}C reliability is poor for ages older than 25,000 BP, both correlations were considered as tentative.

The correct age for the younger high sea level episode is in doubt, however, because these deposits are some meters above the present mean sea level and, also, are similar in height to the Sangamon deposits. For this time interval, the classic global eustatic curve indicates a sea level near 40 meters below the present mean sea level (BLOOM, 1978; BLOOM *et al.*, 1974). Furthermore, most of these deposits are in relatively stable tectonic areas (GONZÁLEZ *et al.*, 1988a and 1988b).

GONZÁLEZ *et al.* (1988a) analyzed all the possibilities of error in the ^{14}C method for each sample. They concluded that the dates presented have a high reliability. Therefore, we

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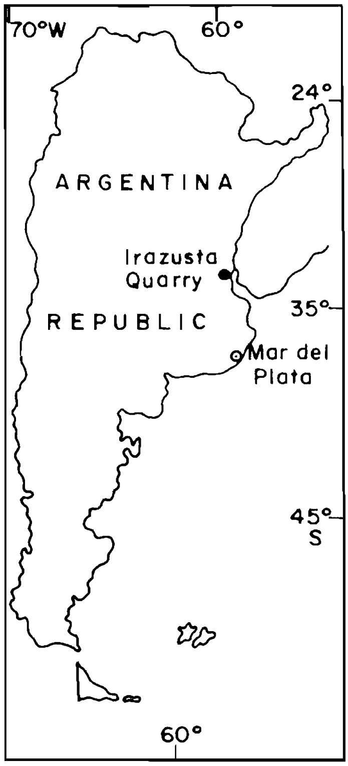

Figure 1. General location.

attempted to verify the reliability of these isotopic chronologies by means of magnetostratigraphic data; samples were taken from two localities, and measured in two paleomagnetism laboratories, respectively.

Oriented samples taken from littoral deposits near the Mar del Plata harbor (38° S; Figure 1), were dated at 30,500 ± 1400 BP (GONZÁLEZ *et al.*, 1986) and measured in the Paleomagnetism Laboratory of the Buenos Aires University. The Paleomagnetism Laboratory of the Stockholm University (Sweden) was sent the samples from Irazusta Quarry (33° S; Figure 1). The second group included lagoonal deposits tentatively correlated with the Sangamon Interglacial, as well as the estuarine deposits dated between 35,400 ± 1800 BP and 26,600 ± 720 BP (GONZÁLEZ *et al.*, 1986; GUIDA and GONZÁLEZ, 1984).

In this paper, we only show the paleoeustatic implications of the magnetostratigraphic results from Irazusta Quarry.

FIELD DATA

Two vertical sets of samples were collected at the Irazusta Quarry. Figure 2 shows the local stratigraphic sequence and the sets of samples. Each one was taken by means of a copper cylinder 2.54 cm long and 2.54 cm diameter. These samples were oriented by means of a clinometer and magnetic compass, with an estimate error of ± 1°.

The geological and geochronological description (after GUIDA and GONZÁLEZ, 1984; GONZÁLEZ *et al.*, 1986, 1988, 1988a and 1988b), is presented below for each set of samples.

Sample Group N° 1 (Figure 2, right)

Samples 01 to 09: Greenish to yellowish silts and sandy silts, with abundant small root channels and MnO-Fe_2O_3 stains (hydromorphism); silty sand toward the basal part and silty clays toward the top. Some concretions of $CaCO_3$, may appear. These are all paleosols of a poorly drained area (gley soil), with no fossil calcareous invertebrates (mollusk shells, ostracods or foraminifers). According to their lithological, paleopedological and paleogeographical characteristics, these deposits correspond to a paleolagoonal environment, and are correlated tentatively with the Sangamon Interglacial (GONZÁLEZ *et al.*, 1986, 1988a and 1988b).

Samples 10 to 12: greenish-brown sandy silts, with some small calcareous and siliceous pebbles and some larger intraclasts of the underlying lagoonal deposits. Articulated shells of *Tagelus* Gray (^{14}C age = 35,400 ± 1800 BP) and *Erodona mactroides* Daudin (^{14}C age = 32,700 ± 1300 BP) in their life positions, appear. Both mollusks are characteristic of brackish, estuarine environments. Both ages can be considered as similar, according to it errors, and could suggest a mean age, $\bar{x}$ = 34,050 BP for the basal part of these deposits, and thus, could be considered to correspond to a Mid-Wisconsin Interstadial.

Samples 12-b to 26: Brown to greenish-brown fine sandy silts, with some articulated shells of *E. mactroides* Daudin in life position. Some small quartz pebbles, also occur.

Sample 27: Similar sediments to the samples 12-b to 26. This horizon contains the youngest shells of *E. mactroides* Daudin (^{14}C age =

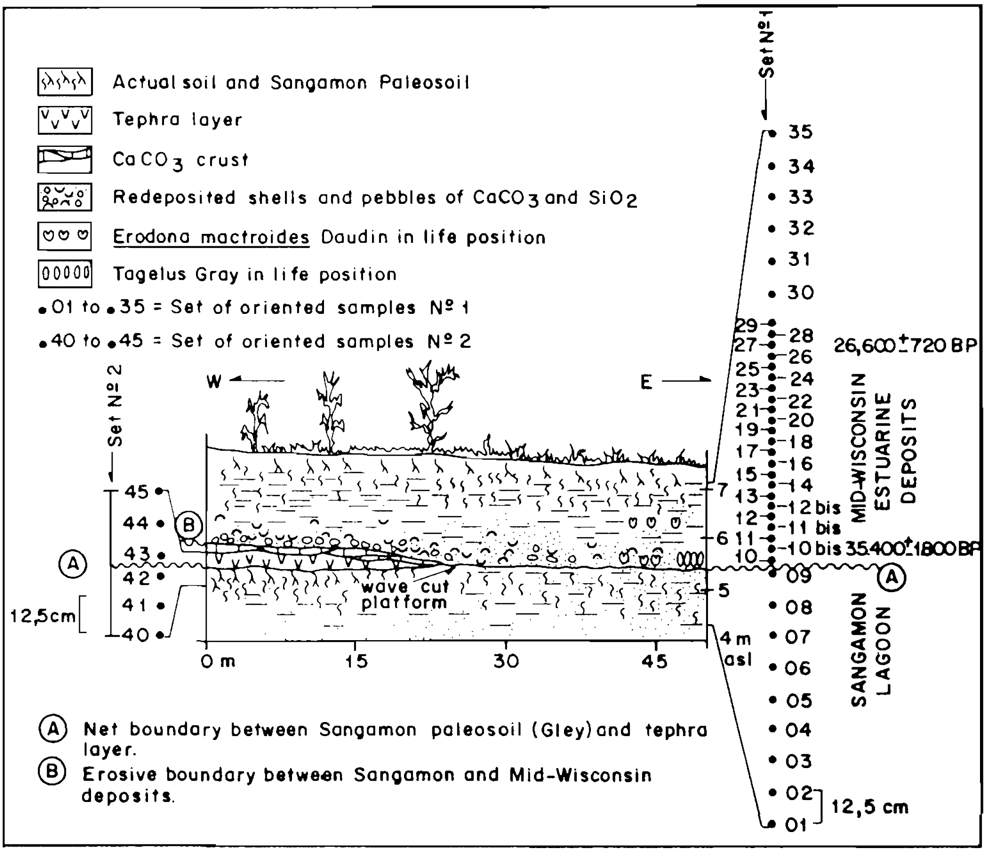

Figure 2. Irazusta Quarry (33° S, 58° W), sample sites.

26,600 ± 720 BP), and the youngest quartz pebbles.

Samples 28 to 35: Brown to reddish-brown silts (loess and loess-like sediments), with abundant little root channels with *cutans*. Also, some small calcrete concretions, appear. The sample 35 was taken from the "B horizon" of the present day soil.

Sample Group N° 2 (Figure 2, left)

Samples 40, 41 and 42: Greenish-brown sandy silts to silty clays, similar to the sediments of the samples 01 to 09 (Sample Group N° 1). Abundant little root channels with MnO and Fe_2O_3 stains, appear. Also, some calcrete concretions and veins, appear. It is believed that these sediments represent the upper part of the Sangamon lagoonal deposits.

Samples 43, 44 and 45: Near the boundary above the previous deposits, there is a greyish to greenish fine volcanic ash, or tephra, forming a porous bed. Toward the upper part there are thin calcareous crusts (caliche or calcrete). In erosive discordance over this calcareous crust, follow what are believed to be estuarine Mid-Wisconsin Interstadial deposits. They begin with a basal stratum with abundant redeposited *Erodona mactroides* Daudin shells, some *Tagelus* Gray shells (also redeposited) and abundant calcareous and quartz pebbles in a light-brown silty sand matrix. This deposit corresponds with the samples 10 to 27 of the Sample Group N° 1.

PALEOMAGNETIC DATA

All the samples of both groups were sent to the Paleomagnetism Laboratory of the Stock-

Table 1. *Cantera Irazusta — NRM values.*

Sample	Int. (emu/cm^3)	DEC	INC
1	1.13	85.1	- 64.8
2	0.82	71.7	- 38.7
3	2.52	266.8	21.5
4	5.23	8.1	- 44.9
5	2.59	34.0	- 66.5
6	1.12	22.2	- 4.6
7	2.72	301.8	- 40.3
8	8.09	355.7	- 37.3
9	2.37	19.6	14.8
40	6.75	325.5	5.5
41	34.32	307.7	5.3
42	12.45	310.4	6.5
43	48.11	261.7	- 24.8
44	22.09	286.9	17.8
45	14.90	301.7	9.7
10	6.49	13.4	- 57.4
10b	20.84	6.8	- 14.9
11	9.21	12.5	- 37.4
11b	8.08	55.5	- 45.1
12	18.70	16.9	- 24.8
12b	11.90	53.2	- 61.3
13	9.52	32.7	- 67.4
14	24.19	22.7	- 28.4
15	20.16	7.3	- 33.8
16	23.98	14.3	- 24.9
17	26.77	0.5	27.4
18	19.02	17.1	- 49.5
19	40.89	2.6	- 28.7
20	25.74	349.3	- 41.9
21	25.80	10.8	- 40.5
22	14.74	23.4	- 62.8
23	8.74	30.3	44.3
24	12.86	20.5	- 38.6
25	12.86	36.6	- 28.0
26	19.58	351.4	- 46.2
27	23.35	15.3	- 28.0
28	16.51	25.5	- 38.4
29	7.32	28.9	- 50.8
30	36.29	37.3	- 56.2
31	6.56	12.5	- 39.2
32	12.93	38.4	- 30.7
33	16.88	41.1	- 21.3
34	18.13	17.5	- 25.8
35	18.85	7.0	- 34.0

Table 2. *Cantera Irazusta — Values after demagnetization (*).*

Sample	DEC	INC	Demag. (Oe)
3	265.1	21.5	200
4	356.1	- 60.4	200
5	290.4	- 50.4	300
6	343.2	38.2	200
7	334.4	20.6	300
8	328.7	- 32.8	300
9	10.3	- 2.2	300
41	7.0	50.4	300
42	84.3	11.3	150
43	25.2	49.7	300
44	28.7	7.0	200
45	6.4	39.5	200
10	343.9	- 60.4	200
10b	11.2	- 57.0	300
11	349.9	- 45.4	200
11b	60.9	61.5	200
12	1.3	- 34.9	200
12b	347.2	- 54.8	200
13	353.2	45.1	200
14	115.0	- 46.3	400
15	9.3	- 34.9	200
16	2.4	- 35.2	200
17	347.5	- 49.0	200
18	356.7	- 45.6	200
19	5.1	49.3	200
20	349.1	- 43.1	200
21	13.9	- 45.9	200
22	357.1	- 60.4	200
23	343.5	- 34.6	200
24	11.1	- 41.4	100
25	18.2	- 50.6	200
26	310.5	- 41.6	200
27	356.1	- 41.1	200
28	350.4	- 59.3	200
29	12.3	- 68.3	200
30	17.1	- 53.9	200
31	5.5	73.2	200
32	17.8	- 48.0	200
33	8.1	- 45.9	200
34	8.1	- 40.5	200
35	343.8	- 58.0	200

(*)—After demagnetization the values of samples 1, 2 and 40 diminished in such a form that they became smaller than the magnetometer's error.

holm University (Sweden), where remanent magnetism was measured by Dr. Nils Axel Mörner and Lic. Claudio Sylwan. Table 1 shows the NRM (Normal Remanent Magnetism) and intensity values for all the samples. Table 2 shows the values after demagnetization. Table 3 shows the Virtual Geomagnetic Pole (VGP) position for each sample. Figure 3 shows the graphical values of NRM and demagnetization; the magnetic intensity values are shown in Figure 4; Figures 5, 6, 7, 8 and 9, show the VGP values for the different samples.

DISCUSSION

The paleomagnetic records from the basal part of the Sample Group N° 1 (samples 01 to 09) indicate a magnetic excursion. The values from the Sample Group N° 2 (samples 41 to 45), also indicate an excursion of the magnetic field. "This double excursion may represent the 'Blake Excursion' and my 'H + I' Excursions in

Table 3. *Cantera Irazusta—Virtual Geomagnetic Pole Position (VGP).*

Sample	Lat.	Long.
3	- 10.1°	218.2°
4	81.2°	141.0°
5	34.6°	236.6°
6	33.0°	282.7°
7	39.8°	267.9°
8	58.0°	232.3°
9	56.5°	- 39.5°(*)
41	25.3°	51.8°
42	1.6°	23.6°
43	22.0°	- 35.1°
44	44.3°	- 16.3°
45	34.1°	- 51.3°
10	74.8°	174.1°
10b	79.8°	60.5°
11	79.8°	247.0°
11b	42.0°	61.5°
12	76.0°	- 56.4°
12b	79.0°	196.4°
13	81.2°	257.6°
14	73.2°	- 8.7°
15	73.7°	- 25.3°
16	76.1°	49.0°
17	78.8°	225.1°
18	83.2°	275.6°
19	84.7°	1.6°
20	77.5°	249.0°
21	76.6°	9.0°
22	81.4°	136.3°
23	69.3°	251.8°
24	80.0°	16.9°
25	74.5°	29.6°
26	45.9°	210.2°
27	79.8°	280.8°
28	79.3°	163.0°
29	69.6°	99.1°
30	75.7°	41.3°
31	64.0°	115.0°
32	74.2°	21.1°
33	80.8°	- 6.3°
34	77.6°	21.0°
35	71.9°	- 16.8°

(*)—When longitude has negative sign it means that the value should be counted in the opposite direction; *i.e.*: Long. − 15.0° is the same that 345°.

Grande Pile or the 'F' Excursion as this has similar VGP as set 5.[1] This confirms your Sangamon ? age." (N.A. Mörner, *written comm.* of Sept. 26, 1985; see Figures 4 and 5). Thus, the indication of the Blake Event suggests an age of nearly 114,000 BP for these lagoonal deposits, according to the ages published for this geomagnetic event (SMITH and FOSTER, 1969; BUCHA *et al.*, 1969; NAKAJIMA *et al.*, 1973; MÖRNER, 1977).

Concerning the younger deposits (samples 10 to 35), the VGP lesser than 50° for the sample 11-b (VGP = 42°) and for the sample 26 (VGP = 45,9°), would indicate the probable existence of "transition intervals" (according to WILSON *et al.*, 1972). Therefore, considering that the Blake Event also appears in the basal part of this same locality, these younger "transition intervals" could indicate another younger reversal event. According to the ^{14}C ages from sample 10 to sample 27, ranging between 35,400 ± 1800 BP to 26,600 ± 720 BP, this probable younger event could be considered as the Lake Mungo Event, dated in nearly 30,000 BP (BUCHA, 1970; BARBETTI and McELHINNY, 1972; NAKAJIMA *et al.*, 1973; FREED and HEALY, 1974; OPDYKE *et al.*, 1974; MÖRNER, 1977; PIERCE and CLARK, 1978).

Furthermore, the littoral deposit from the Mar del Plata harbor, with a date of 30,500 ± 1400 BP has recorded a reversal episode, assigned to the Laschamp Event (Valencio and Orgeira, 1983 and *personnal comm.*). This deposit has a stratigraphic position similar to sample 10 to 27 from Irazusta Quarry, and their ^{14}C age is also similar. Thus, it may be appropriate to assign the reversal episode recorded in the Mar del Plata harbor deposit to the Lake Mungo Event, rather than to the Laschamp Event; the age of the latter has been reported as ranging between 7000 BP to 17,000 BP (FREED and HEALY, 1974; NOEL and TARLING, 1975).

The Blake Event appears to be recorded in the basal deposits of Irazusta Quarry, and that would tend to confirm its previous correlation with the Sangamon Interglacial, especially in the light of the ^{14}C ages from the overlying estuarine deposits. The absolute reliability of those ^{14}C ages would be enhanced if their reversed field is confirmed as the Lake Mungo Event.

Geochronological research in order to confirm the age of this younger late Pleistocene high sea level episode, should be continued. But the present dates could indicate that during this Mid-Wisconsinan Interstadial (*ca.* 35,000/25,000 BP), the sea level could have reached, and even exceeded the present level, at least in this part of South America.

1. The Sample Group N° 2 of the present paper, was sent initially as "set 5" to Mörner's Laboratory.

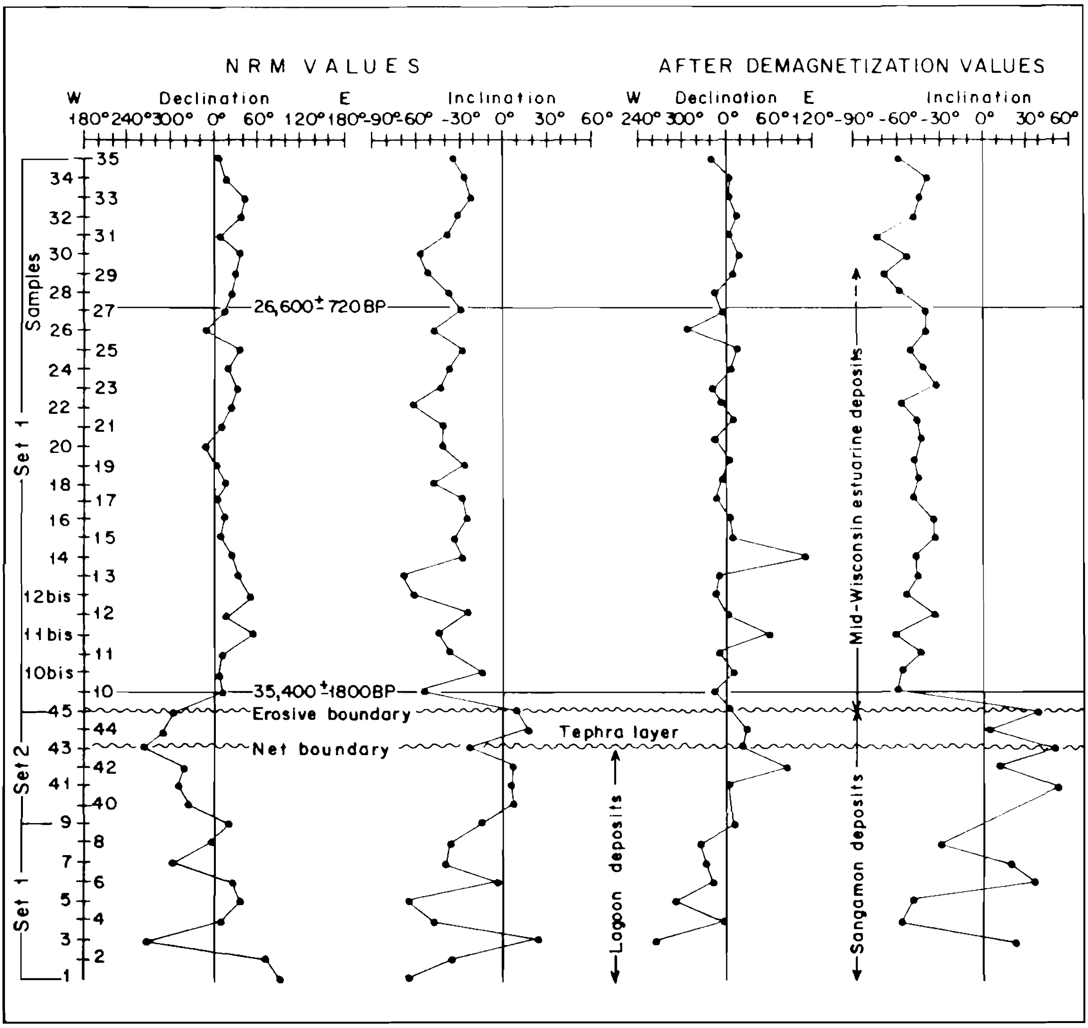

Figure 3. Irazusta Quarry, NRM and demagnetization values.

CONCLUSIONS

(1) The record of the Blake Event geomagnetic field reversal in the lagoon deposits from Irazusta Quarry confirms its tentative correlation with the Sangamon Interglacial.

(2) Littoral deposits that, between 33° S to 40° S, overly Sangamon deposits, must be younger. This fact gives greater credence to the ^{14}C ages, ranging between 38,500 ± 3000 BP and 25,700 ± 650 BP, obtained for these younger deposits.

(3) The probable record of the Lake Mungo Event in these younger littoral deposits that overlie Sangamon deposits, would appear to confirm the reliability of these ^{14}C ages. Moreover, this conclusion would imply that sea level around 35,000/25,000 BP, was similar to the Sangamon Interglacial, and also was greater than the present mean sea level. [Editorial Note: This reasoning is highly controversial, and clearly calls for chronologic confirmation.]

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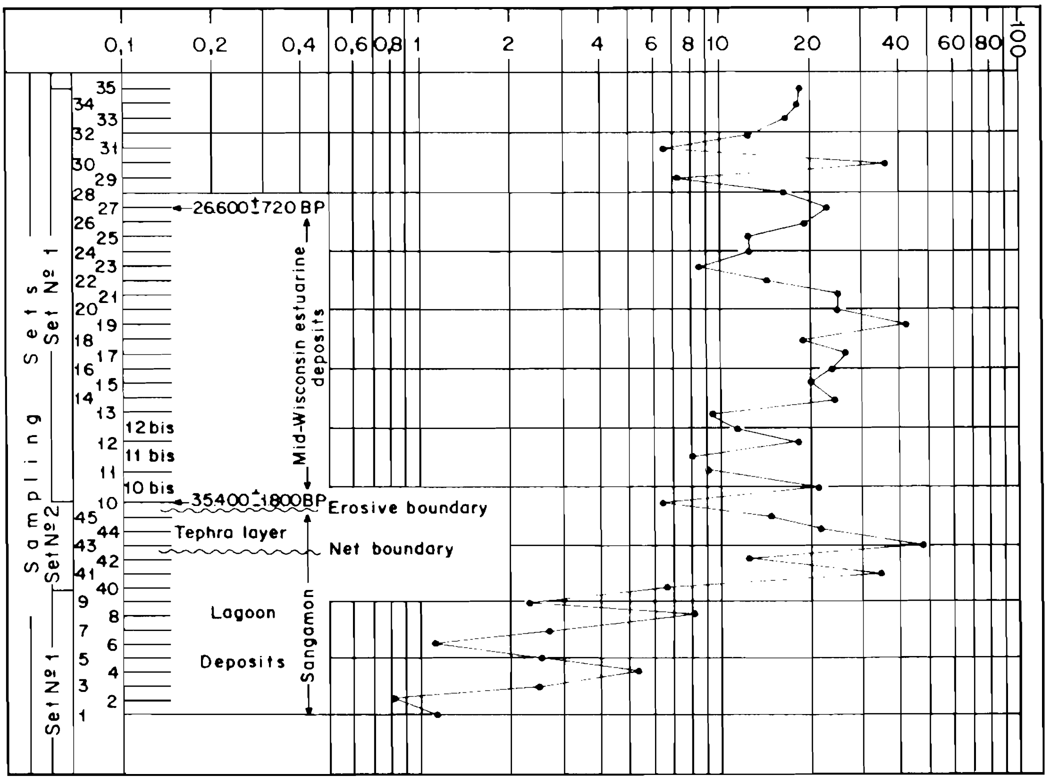

Figure 4. Irazusta Quarry, magnetic intensity (10^{-6} emu/cm^3).

University, for the measurement of the samples and for their important comments concerning the paleomagnetic dates; to the staff of the ^{14}C Laboratory of INGEIS; to Lic. Patricia Galán and Lic. Nora Franco for their critical reading of the manuscript; to the Carl C:zon Caldenius Foundation for its aid. Special appreciation is due to Dr. Rodolfo Casamiquela (CONICET and F. Ameghino Foundation), without whose support we could have never developed our investigation project, and to Dr. R.W. Fairbridge for his important comments, and patient manuscript correction. The present work was made as part of the Major Investigation Project N° 03919608/85 of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), named: "Paleoclimate and geochronology of the late Pleistocene and Holocene in middle latitudes of the Argentine Republic", which is sponsored by the CONICET.

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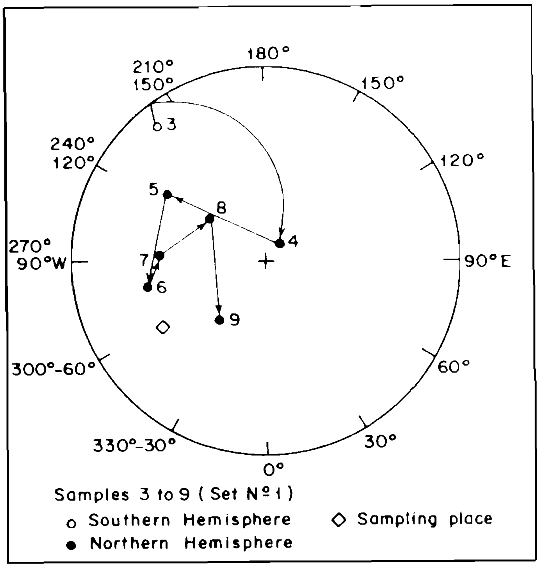

Figure 5. Virtual Geomagnetic Pole Position (VGP), samples 03 to 09, Irazusta Quarry.

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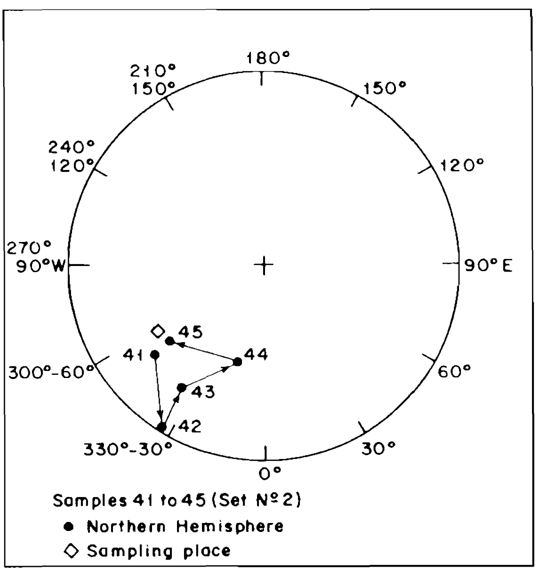

Figure 6. Virtual Geomagnetic Pole Position (VGP), samples 41 to 45, Irazusta Quarry.

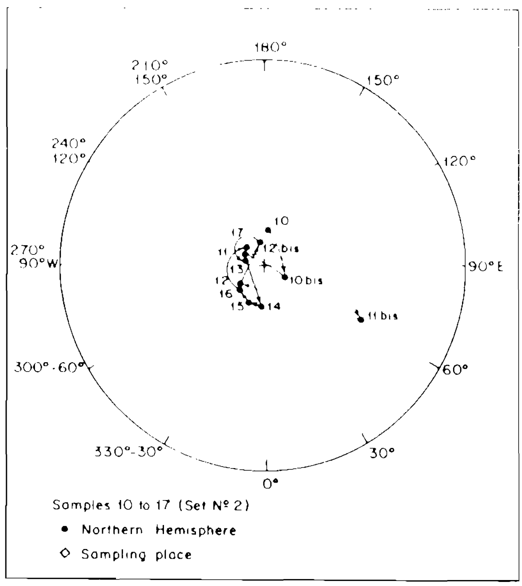

Figure 7. Virtual Geomagnetic Pole Position (VGP), samples 10 to 17, Irazusta Quarry.

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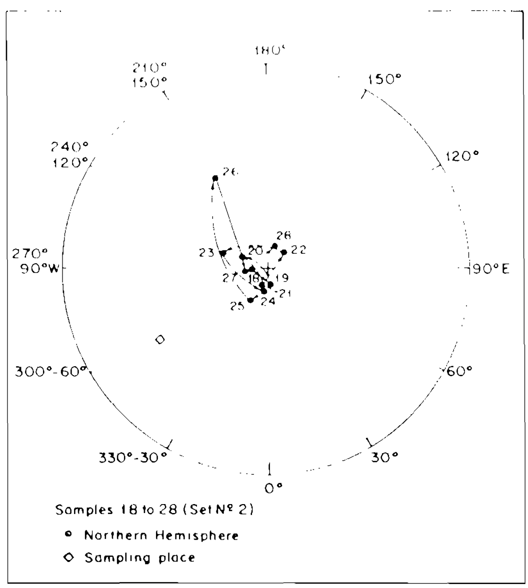

Figure 8. Virtual Geomagnetic Pole Position (VGP), samples 18 to 28, Irazusta Quarry.

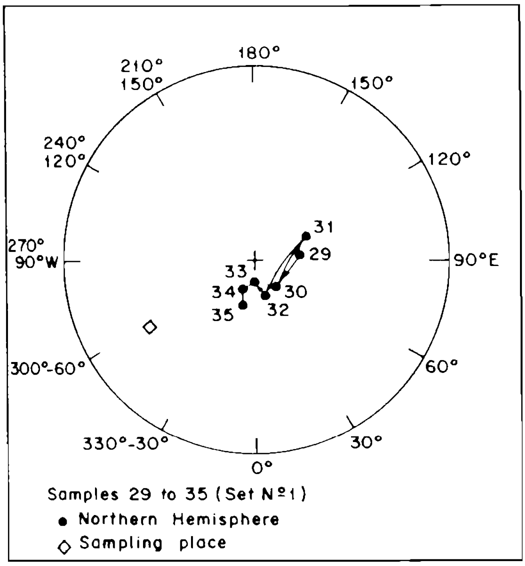

Figure 9. Virtual Geomagnetic Pole Position (VGP), samples 29 to 35, Irazusta Quarry.

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□ RESUMEN □

Se presentan datos geocronológicos basados en evidencias magnetoestratigráficas registradas en depósitos de albúfera antíguos y en depósitos estuáricos más jóvenes, ambos vinculados a dos transgresiones distintas, ocurridas durante el Pleistoceno tardío, presentes en Cantera Irazusta (33° S y 58° W).

La posición del Polo Geomagnético Virtual registrado en los depósitos de albúfera corresponde al Evento Blake de reversión del campo magnético terrestre (c.m.t.) y confirma su previa correlación tentativa con el Interglacial Sangamon (Eemian).

Una "excursión", o "intervalo de transición" del c.m.t. registrado en los depósitos estuáricos más jóvenes, datados previamente entre 35,400 ± 1800 BP y 26,600 ± 720 BP (cronologías basadas en análisis de ^{14}C), podría indicar la presencia del Evento Lago Mungo de reversión del c.m.t., ocurrido en alrededor de 30,000 BP. Por otra parte, depósitos litorales vinculados a los mencionados

depósitos estuáricos, presentes en 38° S y datados en 30,500 ± 1400 BP, también tienen registrada una "excursión" del c.m.t., la cual, de acuerdo a la mencionada edad (^{14}C), podría coincidir con el Evento Lago Mungo.

Si se confirma la presencia del Evento Lago Mungo en estos depósitos, sería definitivamente sustentada la confiabilidad de las edades ^{14}C obtenidas para los depósitos estuarinos y litorales presentes entre 33°y 40° S, ubicados por encima del actual nivel marino medio.

□ RÉSUMÉ □

Présente une géochronologie obtenue à partir de données magnétostratigraphiques sur des lagunaires anciens et des dépôts marins plus récents situés à Irazusta Quarry (33°S, 58°W). La position virtuelle du pôle magnétique (VGP) enregistrée dans la lagune correspond au phénomène de Black Event et confirme ses précédentes tentatives de corrélation aveac l'interglaciaire éémien de Sangamon. L'excursion (ou l'intervalle de transition) du champ magnétique terrestre enregistrée dans les dépôts estuariens les plus récents avait été datée 35400 ± 1800 BP et 26600 ± 720 BP (au ^{14}C). Elle pourrait correspondre au phénomène du lac Mungo. Les dépôts littoraux du 38°S, datés 3500 ± 1400 BP présentent aussi une excursion qui pourrait aussi coïncider avec le phénomène du lac Mungo. Si ceci est confirmé, la validité des datations au ^{14}C de ces dépôts situés entre 33° et 40° S et à l'heure actuelle au dessus du niveau moyen de la mer, pourrait être définitivement établie.—*Catherine Bressolier (Labo. Géomorphologie E.P.H.E., Montrouge, France).*