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DID THE MEGAFAUNA RANGE TO 4300 BP IN SOUTH AMERICA?

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ABSTRACT. A date of 4300 ± 90 BP for extinct megafauna in Argentina is discussed. The fossil remains come from the Guerrero Member (area) of the Luján Formation near the city of Luján, Buenos Aires Province. The age of the top of the Guerrero Member is constrained by more than 60 radiocarbon dates obtained from the overlying Río Salado Member of Luján Formation, Las Escobas Formation, and Puesto Callejón Viejo Soil, most of them older than 4300 BP. In view of its low collagen content, the ^{14}C measurement of bone sample from Luján should not be accepted uncritically. Because of the poor bone preservation and the possible introduction of "young" contaminants that were not completely eliminated, the ^{14}C date of 4300 ± 90 BP is not reliable. Both biostratigraphic and ^{14}C dating evidence indicates that the date of 4300 BP for the last representative of extinct megafauna in South America is unsupported.

INTRODUCTION

Many large mammals that inhabited South American terrestrial environments became extinct at the end of the Pleistocene and beginning of the Holocene. To explain these extinction events, the youngest records of the involved taxa must be accurately dated, especially because the causes of the extinction are not completely elucidated (see different views in Martin and Klein 1984; MacPhee 1999).

Among those that disappeared were such important groups as glyptodonts and mylodonts (Cione and Tonni 1999; Cione et al. 1999). Recently, Rosello et al. (1999) reported a date of 4300 ± 90 BP for the putatively youngest remains of the glyptodont *Glyptodon clavipes* and indeterminate ground sloths of the family Mylodontidae. The material was processed in the Radiocarbon Laboratory of Department of Geology, National Taiwan University (Taipei, Taiwan). No number was reported for the date. In this contribution, we discuss this unusually young age for these extinct representatives of the South American megafauna.

Provenance of the Material

The material of *Glyptodon clavipes* (in situ) and mylodontids was found in sediments of the Luján Formation in the Río Luján valley near Mercedes, Buenos Aires province, Argentina (Rosello et al. 1999; Figure 1).

Rosello et al. (1999:106) only recognized the Luján and "Platense" Formations. Actually, the Luján Formation is formally divided into three members (Fidalgo et al. 1973; Dillon and Rabassa 1985): La Chumbiada, Guerrero, and Río Salado (from oldest to youngest; Figure 2). The Río Salado Member (area) is the "Platense" of old authors. According to the data given by Rosello et al. (1999), the material was obtained from levels of the Guerrero Member.

In the Pampean region, the Luján Formation was deposited in the river valleys while the late Pleistocene to Holocene La Postrera Formation was deposited in the divides (Fidalgo et al. 1973; Fidalgo 1979). The Guerrero Member is overlain by the Río Salado Member of Luján Formation but also by the marine Las Escobas Formation (Fidalgo et al. 1973; Figure 2). The marine mid Holocene sediments of the Las Escobas Formation crop out in eastern Buenos Aires Province 0–5 m above current sea level (Fidalgo et al. 1973; Fidalgo 1979, 1983). The Río Salado Member is correlated at least in part with the middle Holocene Las Escobas Formation marine beds (Fidalgo 1979). The tchernozoid Puesto Callejón Viejo Soil (Fidalgo 1983) frequently occurs at the top of the Guerrero Member.

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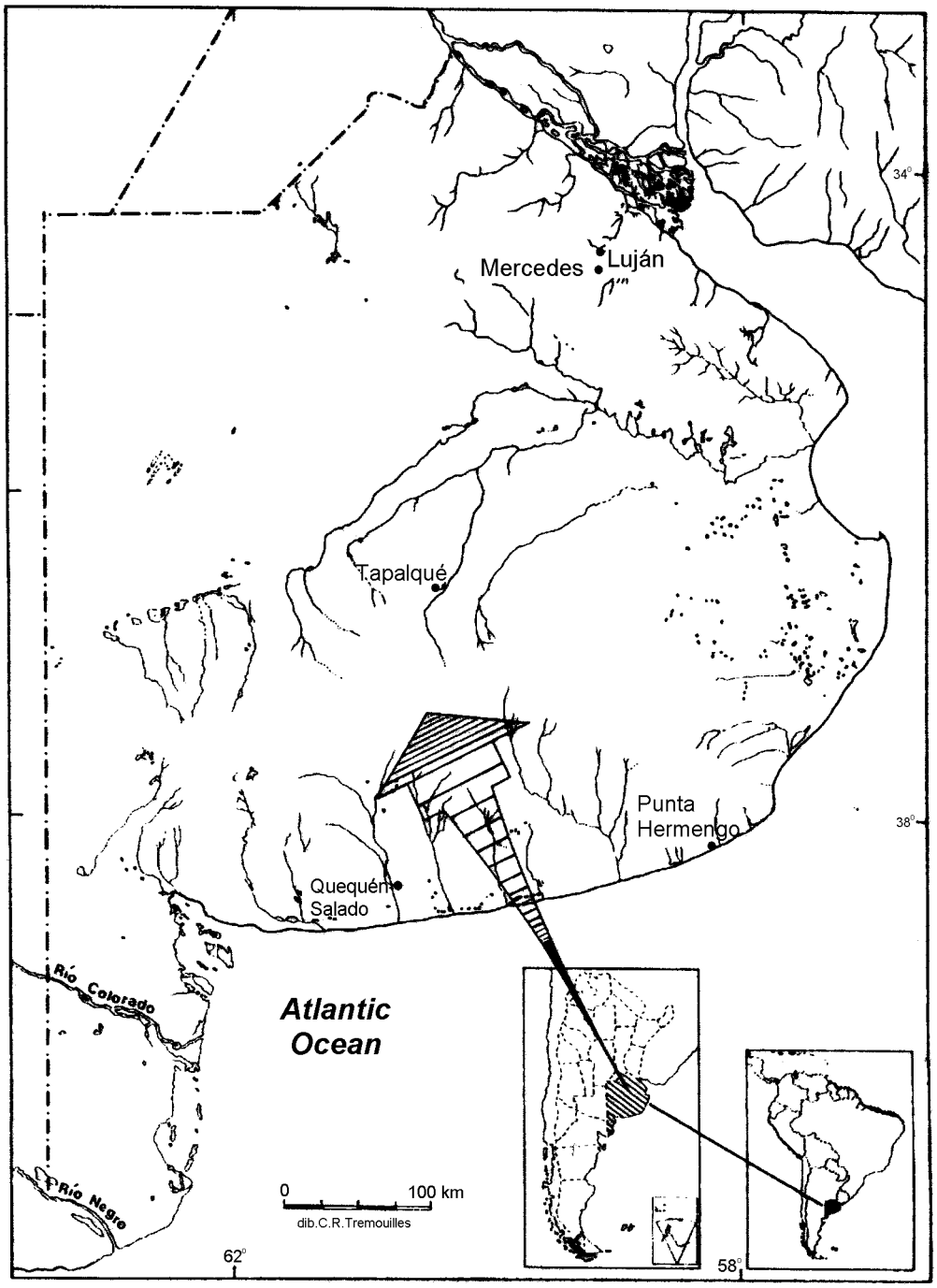

Figure 1 Map of Pampean area of Argentina depicting localities mentioned in text

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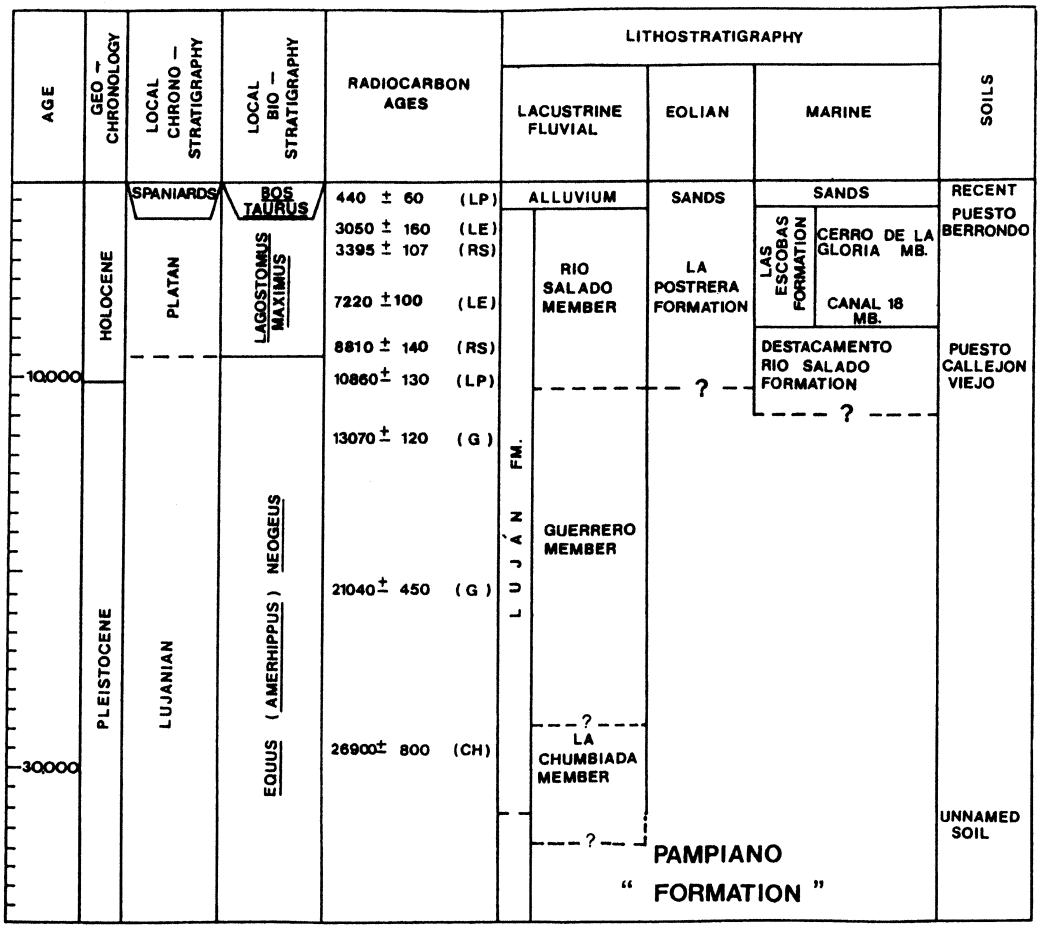

Figure 2 Diagram showing late Pleistocene and Holocene continental and marine lithostratigraphic units and paleosoils of the Pampean area (Fidalgo et al. 1991), the local time and biostratigraphic scales (Cione and Tonni 1995a,1995b) and some radiocarbon dates

Using the rich fossil record, and based on old local stratigraphic views, we have devised a biostratigraphic scheme for the Pampean area (Cione and Tonni 1995a, 1995b, 1996, 1999). The uppermost units are the *Equus (Amerhippus) neogeus* and *Lagostomus maximus* biozones (Figure 2).

The *Equus (Amerhippus) neogeus* Biozone is the local biostratigraphic basis for the recognition of the Lujanian Stage/Age (non Ameghino 1889; non Pascual et al. 1965; Cione and Tonni 1999). The biozone encompasses the La Chumbiada and Guerrero Members. We had suggested that the base of the biozone corresponded to the base of La Chumbiada Member. However, the occurrence of *Equus (Amerhippus) neogeus* in marine sediments assigned to the last interglacial (about 0.13 Ma) at the lower valley of the Río Quequén Salado (southern Buenos Aires province; Figure 1), showed that the base of the biozone was older (Pardiñas et al. 1996). In this biozone, the last representatives of the extinct megafauna were recorded.

The *Lagostomus maximus* biozone is the local biostratigraphic basis for the Platan Stage/Age (Cione and Tonni 1999). Their base coincides with that of the Río Salado Member and also encompasses

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more recent strata. Only living species are recorded in this biozone with the exception of some recently extinct mammal species (v.gr. *Dusicyon avus* extinct by 1450 BP).

Age of the Guerrero Member

The lower part of the Guerrero Member of the Luján Formation yielded six dates between 21040 ± 450 and 17,680 ± 400 BP, based on carbonate, collagen, and molluscan shells (Huarte et al. 1988; Figini et al. 1995). However, Figini et al. (1995) calculated that those dates obtained from molluscan shells are 1100 ± 140 too old due to the reservoir effect. This assumption may be correct, given that bone collagen from the upper beds has yielded a younger date (13070 ± 120 BP; Tonni 1990).

The age of the Guerrero Member is not only calculated by the dates from the unit but also is constrained by numerous dates obtained from the overlying Río Salado Member of Luján Formation, Las Escobas Formation, and Puesto Callejón Viejo Soil.

Eleven ^{14}C ages based on molluscan shells and total organic matter were obtained from the Río Salado Member in sections at the arroyo Tapalqué (central Buenos Aires province; Figure 1) ranging between 9710 ± 110 and 8810 ± 140 BP (Figini et al. 1995; Zárate et al. 1995). These dates seem too old in comparison with many other dates based on bone collagen from the lower part of the La Postrera Formation, which includes extinct mammals of the *Equus (Amerhippus) neogeus* Biozone. However, when corrected to account for the reservoir effect, these ages get closer to those of La Postrera Formation.

Fidalgo (1992) suggested that the Puesto Callejón Viejo Soil represents the Pleistocene-Holocene boundary in the Pampean region. One date from organic matter from the Puesto Callejón Viejo Soil yielded a date of 9000 ± 70 (Zárate et al. 1995). ^{14}C dates from dispersed organic matter, calcium and mollusc shells, from levels which are correlated with the Puesto Callejón Viejo Soil, gave dates ranging from 10070 ± 140 to 8940 ± 130 BP (Fidalgo et al. 1986; Bonadonna et al. 1995; Figini et al. 1998). However, the correlation of these beds with the paleosoil remains to be confirmed.

Forty-six dates were obtained from mollusc shells and marine mammal bones of the Holocene Las Escobas Formation. They range from 7890 ± 343 to 3050 ± 160 BP (Figini et al. 1978; Carbonari et al. 1980; Fidalgo et al. 1981; Huarte et al. 1983; Gómez et al. 1985, 1988; Carbonari et al. 1987; Fasano et al. 1987; Figini 1992; Colado et al. 1995). The youngest dates correspond to upper levels and the older to lower levels.

Quality of the Date of Rosello et al. (1999)

The chemical composition of a recent bone includes approximately 20% proteins, mainly collagen. Modifications in the organic matter composition in a fossil bone are occasioned by 1) the large surface (larger than 100 m^2/g) and porous structure that makes it an excellent medium for adsorption and precipitation of dissolved and colloidal particles of humic material and other molecules; this material, mobilized in groundwater, derives from modern soils and lacustrine-bog deposits (Arlanov and Svezhentsev 1993); and 2) protein content diminution due to collagen dissolution or destruction. In extreme cases fossil bones are stripped of their collagen.

Reliable ^{14}C dating using fossil bones (Hedges and van Klinken 1992) is based on samples with an adequate collagen fraction. Samples must fulfill the following conditions: no exogenous organic matter, enough material, and well-preserved bone with more than 4% collagen.

T K Liu (one of the co-authors of the paper by Rosello et al. 1999) communicated to us that samples from Luján weighted 1.8 kg. Using the methodology of Longin (1971), Rosello et al. (1999)

obtained "collagen" with an equivalent weight to 1.12 g of carbon. This means that the bone had approximately 0.12% of collagen.

However, a bone that includes less than 0.5% of collagen is very poorly preserved, may not include original collagen, and probably is highly contaminated (Staffort et al. 1987; Hedges and van Klinken 1992). A low collagen content in the sample implies that a larger quantity of material is needed to be processed and a larger exogenous organic matter needs to be eliminated. With the collagen loss, a larger chemical degradation of remnant protein will occur. This provokes problems in isolating, purifying, and characterizing bone collagen, and also makes it impossible to detect and characterize exogenous organic matter in the obtained "collagen." In this case, ^{13}C determination is not enough.

DISCUSSION AND CONCLUSION

The fossil remains described by Rosello et al. (1999) come from the Guerrero Member and are included in the *Equus (Amerhippus) neogeus* Biozone. They obtained a ^{14}C date of 4300 ± 90 BP. However, the age of the top of the Guerrero Member is constrained by more than 63 dates obtained from the overlying Río Salado Member of the Luján Formation, Las Escobas Formation, and Puesto Callejón Viejo Soil, most of them older than 4300 BP.

Additionally, in view of its low collagen content, the bone sample from Luján should not have been submitted for dating. The ^{14}C date of 4310 ± 90 BP is not reliable because of poor bone preservation and the possible introduction of "young" contaminants that were not completely eliminated in pretreatment (Arslanov and Svezhentser 1993). A small amount of "modern" organic matter (0 BP) can make an old specimen yielding little collagen appear much younger (Follestad and Omosi 1979). A sample with an actual age of 100,000 BP with a contamination of 1% of "modern" carbon gives a ^{14}C age of 37,000 BP.

Consequently, the biostratigraphic and the isotope dating evidence indicates that the date of 4300 BP for the last megafauna representation in South America is unsupported.

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