REVISITING AMEGHINO: NEW ^{14}C DATES FROM ANCIENT HUMAN SKELETONS FROM THE ARGENTINE PAMPAS

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Abstract
In South America, the chronology assigned to early human remains has been controversial since the middle of the 19th Century. Based on several human remains findings, Argentinean scientist Florentino Ameghino proposed not only the great antiquity of the peopling of this region, but also that modern humans and their forerunners originated in South America. In the early 1900's, physical anthropologist Aleš Hrdlička firmly distrusted any claim about ancient humans in the Americas and after a thorough examination of the available evidence, discounted all of Ameghino's conclusions. Although Hrdlička's authoritative criticism almost extinguished the debate about the existence of Late Pleistocene humans in the New World, none of his statements indicating that Ameghino's putative Plio-Pleistocene human remains were recent has ever been tested. The aim of this paper is to present new AMS radiocarbon data obtained from three human skeletons that Ameghino originally interpreted to be either Pliocene or Pleistocene in age. These skeletons comprise Arroyo de Frías, Arroyo La Tigra, and Arroyo Chocorí. We also include the Túmulo de Malacara site which was discovered shortly after the death of Ameghino but had relevance in the debates during the early 20th Century. The results presented here confirm the very Late Pleistocene age of the human occupation of the Pampas, since the Arroyo de Frias samples produced ages of 10,300 ± 60 and 9,520 ± 75 yrs BP. Moreover, the results from La Tigra (7,270 ± 60 yrs BP) and Arroyo Chocorí (7,010 ± 60 yrs BP) also confirm the Early Holocene human occupation of the current Atlantic seashore in the region. Finally, the Túmulo de Malacara sample gave a Late Holocene age (2,710 ± 40 yrs BP).

Résumé
En Amérique du Sud, la chronologie attribuée aux premiers restes humains a fait l'objet de controverses depuis le milieu du XIXe siècle. À partir de plusieurs découvertes de restes humains, le chercheur argentin Florentino Ameghino a proposé non seulement une grande ancienneté du peuplement de cette région, mais également que les Hommes modernes et leurs ancêtres étaient apparus en Amérique du Sud. Au début du XXe siècle, l'anthropologue Aleš Hrdlička s'est fermement opposé à l'idée de la présence ancienne de l'Homme en Amérique et, après un examen minutieux des données disponibles, il a écarté toutes les conclusions d'Ameghino. Bien que les critiques vigoureuses de Hrdlička aient presque clos le débat sur la présence de l'Homme en Amérique durant le Pléistocène supérieur, aucune de ses affirmations selon lesquelles les restes humains attribués au Plio-Pléistocène par Ameghino étaient récents n'a jamais été vérifiée. Le but de cet article est de présenter de nouvelles dates radiocarbone par AMS obtenues à partir de trois squelettes humains attribués par Ameghino au Plio-Pléistocène. Ces squelettes proviennent d'Arroyo de Frías, Arroyo La Tigra et Arroyo Chocorí. Nous avons également inclus les restes trouvés à Túmulo de Malacara, site découvert peu de temps après la mort d'Ameghino mais qui a sa place dans les débats du début du XXe siècle. Les résultats présentés ici confirment l'âge Pléistocène final des premières occupations de la pampa, puisque les échantillons de Arroyo de Frías ont livré les dates de 10 300 ± 60 et 9 520 ± 75 BP. De plus, les résultats issus de La Tigra (7 270 ± 60 BP) et Arroyo Chocorí (7 010 ± 60 BP) confirment également l'occupation dès l'Holocène ancien de l'actuel littoral atlantique de la région. Enfin, l'échantillon de Túmulo de Malacara a donné un âge de l'Holocène récent (2 710 ± 40 BP).

In southern South America, the chronology assigned to early human remains has been controversial since the middle of the 19th Century (Lund, 1842). Starting in the early 1870's, Florentino Ameghino (1854-1911) thoroughly investigated the geology and occurrence of human and animal fossils from both inland and coastal settings of the Pampas of Argentina (fig. 1). He acquired an international reputation based on his field and laboratory research, mainly in the field of vertebrate paleontology (Simpson, 1948). During his fieldwork at a number of sites in the province of Buenos Aires, Ameghino found stone tools that he interpreted as being associated with extinct mammal bones and human remains, some of which were deeply buried in what he interpreted as Quaternary and Tertiary sediments (Ameghino [1880-1881] 1915, [1889] 1916). He considered these discoveries as strong evidence for a great antiquity of those remains, and initially proposed a Pleistocene age for the human occupation of the Pampas. Later in his career, however, he became convinced not only of the great antiquity of the peopling of this region, but also that modern humans and their forerunners originated in South America (Ameghino, 1909, 1910; fig. 2).

In the early 1900's, the eminent Czech-born American physical anthropologist Aleš Hrdlička (1869-1943) became interested in Ameghino's discoveries and interpretations. Hrdlička firmly distrusted any claim about Tertiary-age humans and was especially skeptical of reports mentioning the presence of humans in the Americas before the end of the "Ice Age" (Meltzer, 1983). After a methodical examination of the available evidence, Hrdlička (1912) discounted all of Ameghino's conclusions. Although Hrdlička's authoritative criticism almost extinguished the debate about the existence of Late Pleistocene humans in the New World, none of his statements indicating that Ameghino´s putative Plio-Pleistocene human remains were recent has ever been tested.

The aim of this paper is to present new AMS radiocarbon dates obtained from three human skeletons that Ameghino originally interpreted to be Pleistocene in age. These are the very skeletons that Ameghino and other scientists have presented as evidence of the great antiquity of the human presence in the Argentine Pampas. The skeletons comprise Arroyo de Frías, Arroyo La Tigra, and Arroyo Chocorí (fig. 1). We also include the Túmulo

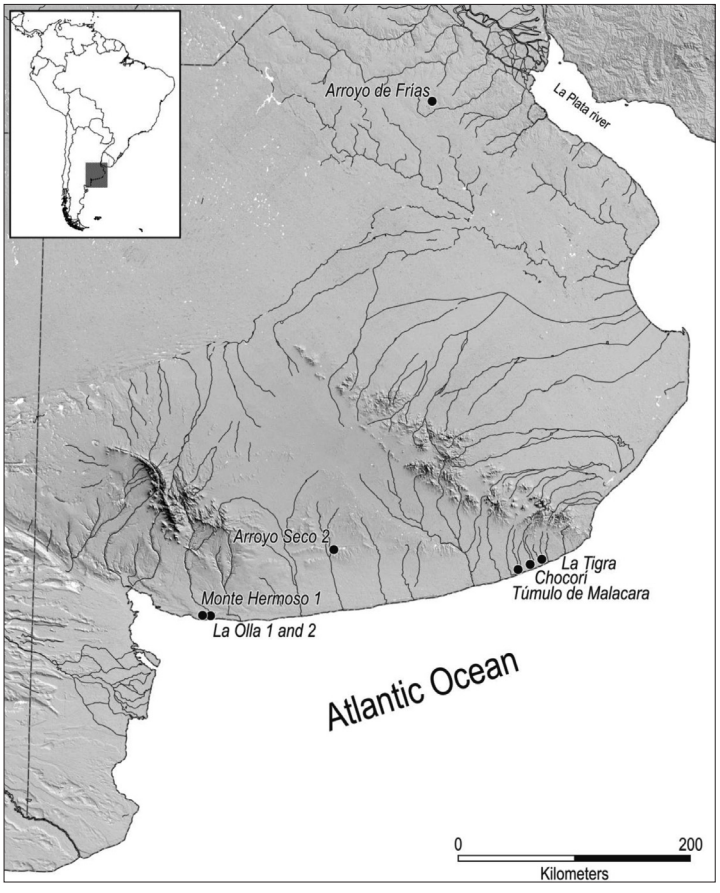

Figure 1. Map of the Eastern Pampean Region showing the sites discussed in the text

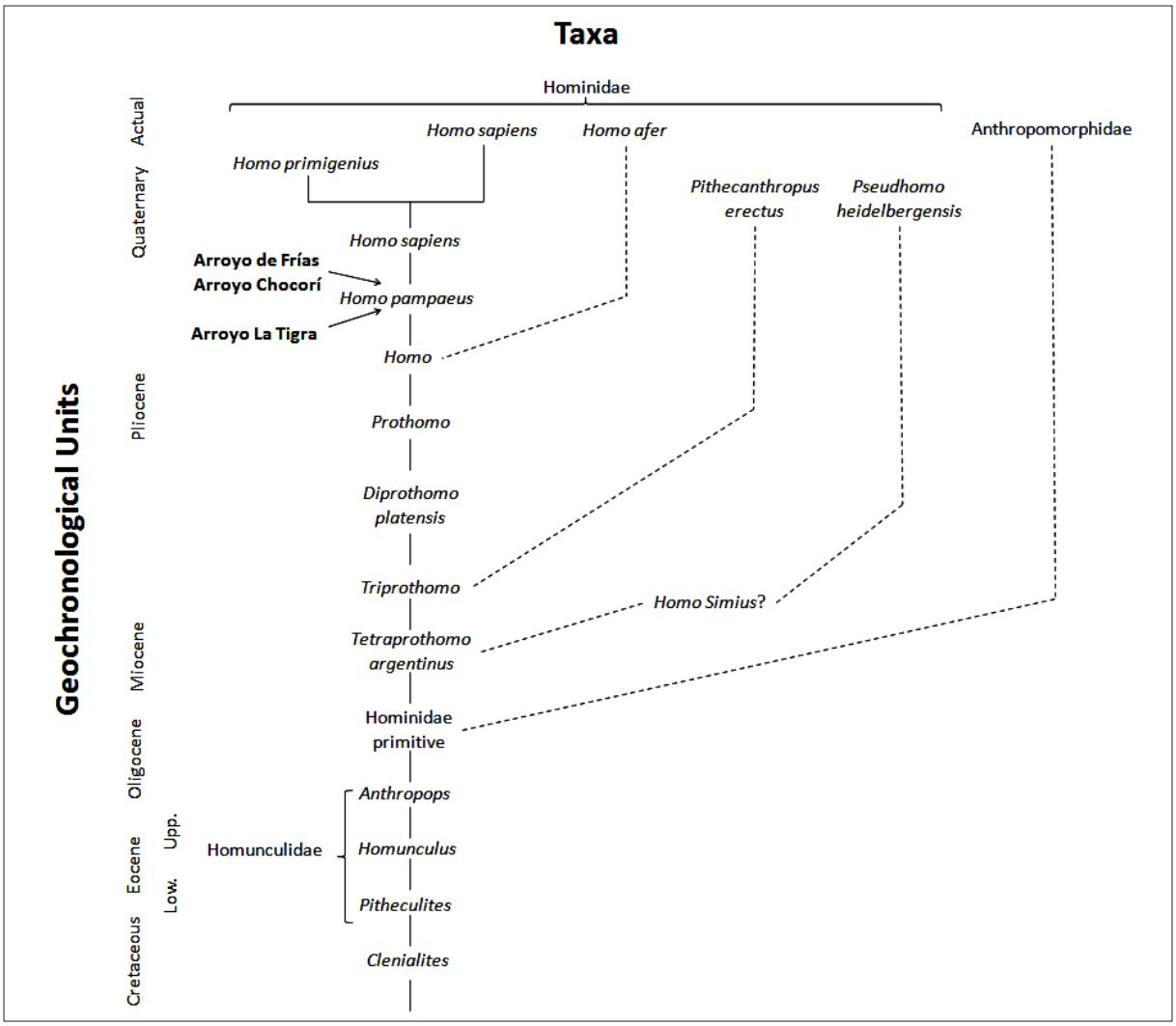

Figure 2. Florentino Ameghino´s scheme of human evolution (redrawn from Ameghino, 1909, and Hrdlička, 1912: 12-13). The putative geological ages of three of the cases discussed in the paper are indicated.

de Malacara site which was discovered shortly after the death of Ameghino but had relevance in the debates during the early 20th Century. On the basis of this new chronological information, we will discuss the importance of these human remains for the study the early peopling of South America.

AMS Radiocarbon Dating Program

To obtain new information about the geological ages of some of the most controversial human skeletal remains recovered during the late 1800's and early 1900's, we carried out between 1994 and 1998 an AMS radiocarbon dating program. Within this framework, we dated samples from four skeletons either studied by F. Ameghino himself or by other scientist in the context of the debate about "early man" in the Pampas (fig. 1, table 1). The first two samples were extracted from two skeletons studied by Ameghino himself: Arroyo de Frías and Arroyo La Tigra (Ameghino, 1880, 1898, 1915). The third sample is from skeletal remains recovered at Arroyo Chocorí, which were first reported in 1907 by the German anthropologist Robert Lehmann-Nitsche. All of these cases were considered as representing the earliest inhabitants of the Pampas and all three were extensively discussed by Hrdlička in his previously mentioned 1912 book.

The fourth sample is from a human skeleton recovered at the Túmulo de Malacara, a site excavated by Carlos Ameghino – the younger brother of Florentino – and Luis M. Torres in 1913. It was a burial site in the dunes of the Pampean seashore where a minimum of 13 individuals were recovered (Torres and Ameghino, 1913; Vignati, 1960). The excavators interpreted this site as a burial tumulus, although this interpretation is currently debated. Although this last finding was not discussed by either F. Ameghino or Hrdlička, we decided to include this sample in our dating program because of the intrinsic importance of the historical context in which the site was discovered (i.e. the post-Ameghinian debate on the antiquity of the human peopling of the Pampas), the outstanding and unusual nature of the archaeological context itself (i.e. multiple human burials in a supposedly funerary structure at a coastal setting), and the proximity of the site to other allegedly very ancient sites (Arroyo La Tigra and Arroyo Chocori).

All the skeletal remains included in this study belong to the anthropological collections of the Museo de La Plata, República Argentina, where more samples are available for further dating.

Samples from three sites (Arroyo de Frías, Arroyo La Tigra, and Arroyo Chocorí) were dated by one of the authors (T. S.) at the Laboratory for AMS Radiocarbon Research, University of Colorado, USA. A second sample from Arroyo de Frías was processed at the Radiocarbon Accelerator Unit, University of Oxford, UK. The sample from the Túmulo de Malacara was processed by the NSF-Arizona AMS Facility, University of Arizona, USA.

A Brief Description of Cases

Arroyo de Frías

Between 1870 and 1874, F. Ameghino recovered at Arroyo de Frías, near the town of Mercedes, ca. 100 km west from Buenos Aires, archaeological materials including the skeletal remains of one or possibly two individuals on the left bank of the creek (fig. 3), at a depth of 2.5 to 3 m below ground level. Ameghino mentioned this finding in several papers, which contain some contradictory data relating to the discoveries (Hrdlička, 1912; Orquera, 1970, 1971). The human remains were apparently associated with lithic artifacts, charcoal, fragments of ñandú eggs (*Rhea americana*), and bones of a number of different extant and extinct mammal species (e.g., *Neosclerocaliptus* sp.). Ameghino reported at this site the find of scutes of an extinct genus of glyptodont, *Haplophorus*. However, recent paleontological works show that this genus was never present in the region; it is probable that the specimens recovered by Ameghino actually belonged to the genus *Neosclerocaliptus*.

The best preserved individual, recovered in 1870 in the bed of the Arroyo de Frías during a drought period, was almost entirely articulated, laying in a flexed position on its right side (Ameghino, 1935). The position indicated an intentional, primary burial that had minor evidence of postdepositional disturbance. Three years after, in 1873, Ameghino returned to the spot and collected more human remains, which he interpreted as belonging to the same skeleton recovered in 1870. Paul Broca later examined

Figure 3. Approximate sector of the Arroyo de Frías (ca. 1970) where F. Ameghino made the findings of the human remains (photo courtesy Luis Abel Orquera)

these bones asserting that all of them corresponded to one aged, small-sized, female individual (Ameghino, 1915). However, on the basis of a morphometric study, H. Leboucq identified some of the bones (e.g. first metacarpal) as belonging to a second, taller, and more robust individual (Lehmann-Nitsche, 1907; Ameghino, 1935). Based on the stratigraphic profile reported by Ameghino, and on his original interpretations (Ameghino, 1915, 1916), the skeletal remains may have been buried in the upper part of the Guerrero Member of the Luján Formation (named "Lujanense" by Ameghino, 1916) or in the top of the Pampean Formation, and below the paleosoil that is between the Guerrero and Río Salado Members of the same formation (Puesto Callejón Viejo geosoil; Fidalgo *et al*., 1973; Fuchs and Deschamps, 2008), about 4 m below the current surface (see also a detailed discussion about the geology of the site in Orquera, 1971). The age of the upper part of the Guerrero Member is between 21,000 and 13,000 radiocarbon years BP (Figini *et al*., 1995; Tonni *et al*., 2003), and the fauna recovered in it suggests an arid to semiarid open steppe environment as well as a cooler climate than today (Tonni et al., 2003).

The skeleton (including the skull) recovered during the 1870 field season was donated in 1871 by a collectionist, Antonio Pozzi, to the Museo Civico di Storia Naturale of Milan, in Italy (Ameghino, 1935), and has been missing since the early 1890's (Lehmann-Nitsche, 1907). Regrettably, there is no detailed description of this skull other than the very brief and cursory one provided by Ameghino himself ([1889] 1916: 149), several years after the find: *"...muy dolicocéfalo, de frente angosta y muy deprimida, y dientes también muy gastados horizontalmente*". From this description alone it is impossible to infer if the skull was artificially deformed or it had any other traits of bioanthropological interest. The two samples selected for radiocarbon dating, consisting of two different hand phalanges, correspond to the fragmentary assemblage recovered in 1873 (Orquera, 1971).

Arroyo La Tigra

The skeleton from Arroyo La Tigra, also referred as "the Miramar skeleton", was recovered in 1888 by A. Canesa, a fossil collector working for the Museo de La Plata. The exact provenience of the remains is unknown; the approximate being a few kilometers from the village of Mar del Sur, in a place between two small creeks, called Arroyo La Tigra and Arroyo Seco, near the cliffs that face the Atlantic Ocean. The partial skeleton probably belongs to an adult male, and was first described by Ameghino (1898) ten years after its discovery. Further descriptions of these remains are in Ameghino (1906; 1909), Lehmann-Nitsche (1907), and Hrdlička (1912), and contemporary references are also found in Giuffrida-Ruggeri (1908), Sergi (1909), and Schwalbe (1910). Ameghino (1909) attributed the remains to the Pliocene, despite an original Quaternary assignment by S. Roth and R. Lehmann-Nitsche (Lehmann-Nitsche, 1907). On the basis of many allegedly primitive traits, Ameghino (1909) ascribed the remains to *Homo pampæus*, an ancestral species of *Homo* created by him to accommodate different finds of an attributed Pliocene age, that the remains from Arroyo La Tigra represented the earliest of this species (fig. 2).

Hrdlička himself (1912) undertook a detailed analysis of the cranial and postcranial remains from Arroyo La Tigra, concluding that the skeleton was of an adult male of advanced middle age, whose features were similar to those found in relatively recent skeletal remains from the Pampas and northern Patagonia. According to Hrdlička, the skull shows signs of both artificial and postdepositional deformation, both of which were ignored by Ameghino (1898, 1906, 1909), but recognized by Lehmann-Nitsche (1907). On the basis of features of the frontal and occipital bones, Hrdlička (1912) assigned the artificial deformation found in the Arroyo La Tigra skull to the Aymara or annular type, which is well documented in the Pampas and Patagonia with ages between ca. 8,000 and 2,000 radiocarbon years (Barrientos, 1997; Politis *et al*., 2010). However, a recent comparative geometric morphometric study carried out by Perez and Barrientos (2003), which was performed using the samples and methodology described in Perez (2007), found no strong similarities between the specimen from Arroyo La Tigra and those cases with undisputable annular cranial deformation, thus suggesting that if any artificial deformation is present in this skull, it is very slight and mostly undifferentiated.

Arroyo Chocorí

The Arroyo Chocorí skeleton was found in 1888 by F. Larrumbe, an employee of the Museo de La Plata. The skeleton was partially exposed on the ground surface at approximately 100 m from the beach, on the seashore near Mar del Sur, and few kilometers apart from Arroyo La Tigra. The skeleton was first reported by Lehmann-Nitsche (1907), who determined that the individual was a female with morphological affinities with the recent European crania (Mochi, 1910). In relation to its antiquity he was not very clear, although in a later publication (Lehmann-Nitsche 1910) he assigned the partial skeleton to the Upper Pampean Formation, which he rightly considered of Quaternary age. Ameghino (1909) included the Chocorí skeleton among the later representatives of the species *Homo pampæus*, and considered it of late Pliocene age.

Hrdlička (1912) also carefully examined this finding, concluding that the bones probably belonged to an adult male that had "no satisfactory geologic and no anthropologic claims to antiquity, to swell the rank of

Figure 4. Excavation of the Túmulo de Malacara made by Luis M. Torres and Carlos Ameghino in 1913 (photo courtesy Archivo Fotográfico del Museo de La Plata)

early Man in America". As for Arroyo La Tigra, the original reports contain no information about the type of burial. However, in both cases the recovered skeletal elements strongly suggest that the remains are from primary, individual burials that were affected by erosion and weathering. The macroscopic examination of the skull by one of the authors (G.B.) indicates that it lacks artificial cranial deformation, thus confirming the observation made by Hrdlička (1912).

Túmulo de Malacara

The Túmulo de Malacara was discovered on January 1913 by Carlos Ameghino and the archaeologist Luis M. Torres in the course of an intensive exploration of the most controversial areas of the Pampean coast, in search for new evidence regarding the early peopling of the Pampas (Torres and Ameghino, 1913) (fig. 4). The site is located about 190 m from the shoreline and 200 m from the confluence of the Arroyo Nutria Mansa and Arroyo del Pescado, two small creeks whose mouth is situated approximately 17 km SW from the place where the Arroyo Chocorí skeleton was found. The description of the findings, which remained unpublished for almost 50 years, was made by M. A. Vignati (1960), who accompanied the text with several drawings and photographs depicting the findings. The site was in the seashore dunes, very close to a big and dense concentration of lithic artifacts. The excavators interpreted it as an anthropic construction 2 m high, 22 m length, and 18 m wide, inside which a minimum of 13 individuals were interred as both primary and secondary burials. Some of the skeletons were associated with rectangular shell beads that were deposited as funerary goods (Vignati, 1960). On the basis of several features, Torres and Ameghino (1913) concluded that the site was relatively recent.

The examination of the photographs published by Vignati (1960), and of two partially complete crania housed at the Museo de La Plata, allowed Barrientos (1997) to determine that at least part of the skulls were artificially deformed, all corresponding to the tabular oblique (fronto-occipital) variety (Dembo and Imbelloni, 1938). Crania with this kind of deformation had been radiocarbon dated both in the Pampas and northern Patagonia, yielding ages of 2000 to 3000 radiocarbon years BP (Bernal *et al.*, 2008; Favier Dubois *et al.*, 2009; Gómez Otero and Dahinten, 1997-1998; Madrid and Barrientos, 2000). The skeletal remains sampled in this study, registered in the collections of the Museo de La Plata with the number 6419, belong to a male individual, with an age of death estimated at 20-30 years (Barrientos, 1997).

Sample Pretreatment

Laboratory for AMS Radiocarbon Research, University of Colorado (1994)

Samples CAMS-16598, CAMS-16173, CAMS-16593 were pretreated, and bone collagen was extracted by Stafford, graphitized samples were submitted to the Lawrence Livermore National Laboratory's Center for Accelerator Mass Spectrometry, for AMS radiocarbon analysis. Bone dated as "XAD-KOH Gelatin Hydrolyzate" is the XAD-purified hydrolyzate of gelatin from KOH-extracted collagen. The bone was broken into approximately 5 mm fragments that were soxhlet extracted sequentially with methanol and acetone. After decalcification in 4°C, 0.2*N* HCl, the acid insoluble collagen was extracted

overnight in 0.1 % KOH and the residue acidified and freeze dried to obtain weight percent yields. The base-extracted collagen was gelatinized by heating the KOH-treated collagen for 24 hr in pH2 HCl. The solution was filtered through a 0.45 µm Durapore filter and the eluate freeze dried. Approximately 10 to 20 mg of gelatin were hydrolyzed in 6*N* HCl at 110°C for 24 hr. The hydrolyzed collagen solution was purified by passing the solution through a 1ml volume of XAD-2 resing in a column having a 0.45 µm Durapore filter at the end. The XAD-purified hydrolyzate was dried to a syrup under N_2 at 50°C, and approximately 10 mg of amino acids were combusted and graphitized.

Oxford Radiocarbon Accelerator Unit (1998)

Sample OxA-8545 was submitted in powder form with a note regarding the presence of glue on the bones. The bone was therefore given a solvent rinse (50 % V/V methanol/chloroform) to remove additives during museum conservation. Afterwards, the sample was given a routine AG pretreatment: a) decalcification in HCl (0.5*M*), b) washed in 0.1*M* NaOH to remove humic acids, c) gelatinization of the insoluble collagen in pH 3 water at 75 degrees C for 20 hours, d) filtering, e) recovering of the supernatant, f) freezing dried, g) combustion, and h) graphitization. The collagen yield was 101 mg collagen per gram of bone. Taking into account that modern bone yields approximately 200 mg of collagen per gram of bone, this sample can be considered as well preserved chemically. To assess the chemical integrity of the collagen in the date reported in this paper, the ratio of carbon to nitrogen (C:N) was measured. The result obtained (3.00) indicates that we can be confident that non-protein contamination is not present in this sample, since normal C:N values are between 2.9 to 3.6.

Results and Discussion

As expected, the obtained results do not support the claims raised by F. Ameghino and some his contemporaries that attributed an exceedingly great antiquity to these skeletons. However, putting aside the case of the Túmulo de Malacara, it is clear that they also do not support Hrdlička's assumptions that the skeletal remains are recent. In fact, the radiocarbon data presented here are an indication that the dated samples correspond to three different periods presently accepted for the time-span of human occupation of the region: the Pleistocene-Holocene transition (Arroyo de Frías), the Early-Middle Holocene transition (Arroyo La Tigra and Arroyo Chocorí), and the first half of the Late Holocene (Túmulo de Malacara) (table 1; fig. 5).

For Arroyo de Frías, the observed discrepancy between the two dates has an unknown origin. The likely sources of variation may include differences in collagen content between the two samples, differential diagenesis, and a disparity between purification methods used by different laboratories. It is also possible that the bones dated at Colorado and Oxford were from individuals of different geological ages. However, the latter possibility seems unlikely because the skeletal elements from the two individuals whose presence is recognized at this site can

Site	Sample Code	Chemical Fraction Dated	Skeletal Element	Conventional age (^{14}C years BP)	Calibrated age (Cal years BP; $2\sigma^*$)
Arroyo de Frías	CAMS-16598	XAD-KOH Gelatin Hydrolyzate	Phalange	10,300 ± 60	12,750-11,750
	OxA-8545	Purified Gelatin	Phalange, right hand	9520 ± 75	11,200-10,550
Arroyo La Tigra	CAMS-16173	XAD-KOH Gelatin Hydrolyzate	Radius (fragment)	7270 ± 60	8180-7960
Arroyo Chocorí	CAMS-16593	XAD-KOH Gelatin Hydrolyzate	Tibia (fragment)	7010 ± 60	7932-7673
Túmulo de Malacara	AA-24049	Bone Collagen	Vertebra	2710 ± 40	2854-2724

Table 1. Radiocarbon Age Measurements on human skeletal remains from Argentina
Calibrations performed with the Calib Rev 5.1 beta program (Stuiver *et al*., 2005), using the decadal Southern Hemisphere atmospheric dataset (McCormac *et al*., 2004).

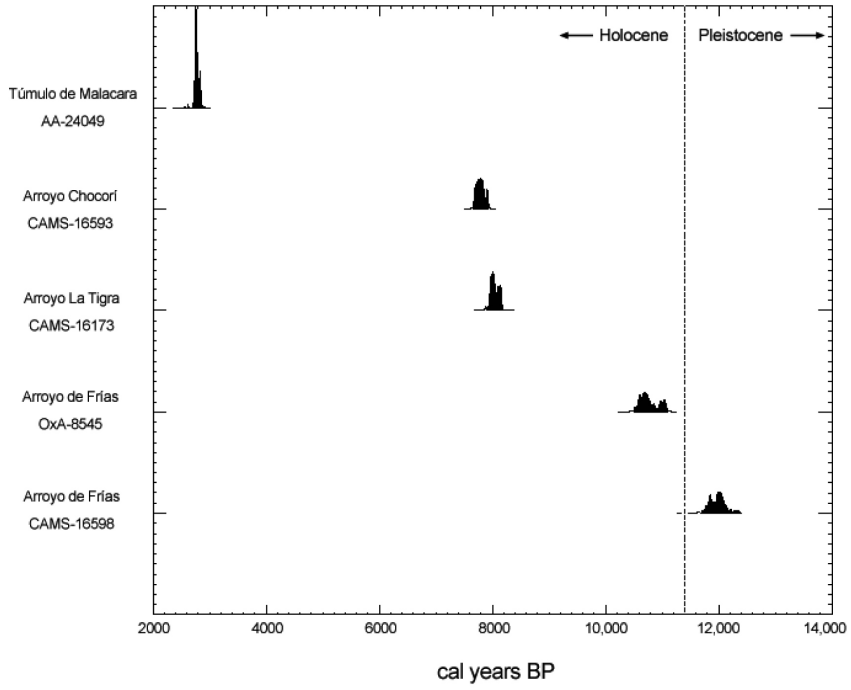

Figure 5. Probability plot of the calibrated radiocarbon dates of the four cases discussed in this paper. Calibrations performed with the Calib Rev 5.1 beta program (Stuiver *et al*., 2005), using the decadal Southern Hemisphere atmospheric dataset (McCormac *et al*., 2004)

be confidently identified, and we took special care in sampling skeletal elements (i.e., phalanges) that matched each other as closely as possible in size, form, and texture. This approach enabled us to be reasonably certain that both samples were from the same adult female individual. In spite of the yet unexplained nature of the difference between the two radiocarbon dates, they clearly demonstrate that these bones date to the Pleistocene-Holocene boundary, and place the remains among the oldest human remains recorded in South America.

Stable isotope data from bone collagen obtained for the Arroyo de Frías skeleton at the Oxford laboratory ($\delta^{13}C_{col}$ = –18.7 ‰; $\delta^{15}N$ = 7.27 ‰) are close to those of late Holocene skeletons from the same area ($\delta^{13}C_{col}$: n = 7, median = –19.34 ‰, interquartile range = –20.17 ‰ to –18.51 ‰; $\delta^{15}N$: n = 4, median = 8.91 ‰, interquartile range = 8.53 ‰ to 9.28 ‰; Loponte and Acosta, 2007). This indicates a very persistent local subsistence characterized by a continental diet with a relatively high content of C_3 plants. The relatively low trophic level of this individual, as indicated by the low $\delta^{15}N$ value, indicates a diet containing a moderate amount of meat. This evidence is consistent with that from diverse environmental settings in South America (e.g., humid tropical and cold temperate forests; Dillehay, 1997; Roosevelt *et al*., 1997), which suggest the existence among the early inhabitants of the continent of a subsistence economy of a broader spectrum than previously thought (Neves and Cornero, 1997).

The samples from Arroyo La Tigra and Arroyo Chocorí yielded very similar radiocarbon ages, although they are statistically different at the 95 % confidence level as calculated with the Calib Rev 5.1 beta program (Stuiver *et al*., 2005). Both skeletons date from the Early-Middle Holocene transition, and are roughly contemporary with two other skeletons also recovered on a coastal environment at Monte Hermoso 1 site (fig. 1), in the southern Pampean coast (Bayón *et al*., 2007). The radiocarbon ages of these skeletal remains are 7866 ± 75 and 6606 ± 79 radiocarbon years BP (8417-8973 and 7294-7582 cal years BP, respectively), and their $\delta^{13}C_{col}$ are –13.2 ‰ and –13.6 ‰ respectively, indicating a mostly marine diet (Politis *et al*., 2009). Other evidence of an early use of the actual coastal line comes from La Olla 1 and 2 sites, both situated at a short distance from Monte Hermoso 1, which have been dated between 7400 ± 95 and 6640 ± 90 radiocarbon years BP (8355-7979 and 7620-7307 cal years BP, respectively) (Bayón and Politis, 1996, Johnson *et al*., 2000). All these chronological data are slightly older than the oldest recorded Patagonian coastal site, Cabo Tres Puntas (Castro and Moreno, 1996/1998), thus suggesting an earlier coastal exploitation.

As noted above, the skull from Arroyo La Tigra has some evidence of artificial deformation, likely of the annular type, although slightly expressed. This kind of artificial cranial deformation was present in the area

during Early and Middle Holocene times, as it is showed by several cases recorded at the Arroyo Seco 2 site (fig. 1). This is an inland, open air, and multicomponent site located at about 60 km from the Atlantic coast, and 200 km west from Arroyo La Tigra and Arroyo Chocorí, which was intensively but intermittently used between ca. 8000 to 4500 radiocarbon years BP (ca. 9000-4800 cal years BP) for the inhumation of at least 44 individuals (Politis *et al*., 2009). It is significant that all but one of the 31 skeletons for which stable isotope information is available ($\delta^{13}C_{col}$, $\delta^{13}C_{ap}$, $\delta^{15}N$) had diets based on the consumption of terrestrial C_3 herbivores, with a minor contribution of marine and C_4 plant (Politis *et al*., 2009). The mostly continental diet inferred for this sample of human remains from a site situated not so far from the coast, as well as the predominantly marine diet inferred for two skeletons recovered at the seashore, points to a rather complex relationship between inland and coastal areas at the Early-Middle Holocene from a cultural point of view, notwithstanding the fact that there are significant evidences showing that both environments were used by the same populations over time (Politis *et al*., 2003 and 2009). Unfortunately, there are yet no isotopic data for Arroyo La Tigra and Arroyo Chocorí which certainly would shed some light on this problem.

The sample from the Túmulo de Malacara gave a Late Holocene age that is compatible with previous age estimates made on the basis of the kind of artificial cranial deformation present at this site, tabular oblique, which is shared with individuals recovered at other sites from the Pampas, and dated between ca. 2500 and 2000 radiocarbon years BP (ca. 2700-1700 cal years BP) (i.e. Laguna Tres Reyes 1, and La Toma; Barrientos, 1997; Madrid and Barrientos, 2000; Madrid and Politis, 1991). AMS radiocarbon dating of skeletal remains with this same kind of cranial deformation recovered at different localities in northern Patagonia also yielded comparable results (Bernal *et al*., 2008; Favier Dubois *et al*., 2009; Gómez Otero and Dahinten, 1997-1998), thus indicating the likely existence of some kind of relationship between both neighboring regions during the first half of the Late Holocene.

The date from the Túmulo de Malacara is also evidence for the persistent use of the Pampean coast as a burial place throughout the Holocene. However, unlike the two already mentioned skeletons from the earlier coastal site of Monte Hermoso, stable isotopes of C and N measured at Oxford on a different sample of the same individual from the Túmulo de Malacara suggest a continental diet, only marginally complemented with seafood ($\delta^{13}C_{col}$ = –17.8 ‰; $\delta^{15}N$= 12.0‰). This is in agreement with the generally accepted model of the use of the Atlantic coast and the inland areas by the same human groups (Politis *et al*., 2003).

Concluding Remarks

Decades of archaeological and paleoanthropological research had demonstrated that both Ameghino and Hrdlička were wrong in fundamental aspects of their respective theses about the human peopling of the Americas in general, and of the Pampas in particular. It is clear now that this process was neither as ancient as Ameghino proposed, nor as recent as Hrdlička once thought. However, these revised interpretations do not detract from the outstanding importance of the ground-breaking work of both of these pioneering scientists. Both these outstanding researchers deserve recognition that at least some of their still untested propositions can be evaluated to test their interpretations. Such research will enable us to gain new information that will be relevant and crucial to the current discussion about the peopling of the Southern Cone of South America. This has proved to be the case with at least one of the human skeletons, Arroyo de Frías. What had been bones of contention between scientists almost a century ago are now resolved issues.

The results presented here confirm the very Late Pleistocene age of the human occupation of the Pampas, which has already been proposed on the basis of several archaeological evidence (Flegenheimer, 2003; Martínez, 2006; Mazzanti, 2003; Politis and Madrid, 2001; Steele and Politis, 2009), but not corroborated by the direct dating of human skeletal remains until now. Moreover, the results from La Tigra and Arroyo Chocorí also confirm the late Early Holocene human occupation of the current Atlantic seashore in the region.

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