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Radiocarbon dating of extinct fauna in the Americas recovered from tar pits

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Abstract

We have obtained radiocarbon dates by accelerator mass spectrometry on bones of extinct large mammals from tar pits. Results on some samples of *Glyptodon* and *Holmesina* (extinct large mammals similar to armadillos) yielded ages of >25 and >21 ka, respectively. We also studied the radiocarbon ages of three different samples of bones from the extinct Cuban ground sloth, *Parocnus bownii*, which yielded dates ranging from 4960 ± 280 to 11 880 ± 420 yr BP. In order to remove the tar component pretreat the samples sufficiently to obtain reliable dates, we cleaned the samples by Soxhlet extraction in benzene. Resulting samples of collagenous material were often small.

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1. Introduction

The extinction in the Americas of many large mammals (including proboscideans, Shasta ground sloths, giant peccary, and saber-tooth cats) at the end of the last ice age is a phenomenon of great interest. The cause or reasons for these mass extinctions has provoked considerable interest and discussion for many years [1]. In contrast to previous glacial–interglacial cycles which saw few losses of megafauna, the Late Pleistocene extinctions are characterized by their magnitude and rapidity, especially in the Americas. Many scientists have attributed the extinction to the inability of large animals to survive to the climatic changes of the Late Pleistocene or to changes in food availability. Martin and Diamond in Martin and Klein [1] and others have suggested that the late

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quaternary faunal extinctions, on the scale of the extinctions of many species reflected in American fauna, was due to the expansion and impact of early humans entering into the new world about the same time. Support for this hypothesis, can be found in the deadly synchroneity of later human colonization and faunal extinctions of large fauna on islands after the arrival of humans in various parts of the world, such as Madagascar, [1,2]. New Zealand, Madagascar, Cuba and other large islands are good places to study such extinctions.

An excellent example of this process is the report by Vartanyan et al. [3] that pygmy mammoths survived in an Arctic island refugium, Wrangel Island, until about 3700 radiocarbon years before present (yr BP).

Ho et al. [4] studied the radiocarbon ages of a number of extinct mammalian species found in the La Brea tar pits (Los Angeles, California). They used a pretreatment process including extraction with benzene to remove the contaminating tar. We applied these ideas and apply similar methods to the problem of dating large megafauna remains found preserved in Cuban and South American tar "pits" (seeps). In wet tropical climates, defensible radiocarbon dates are often difficult to obtain on bones of Late Pleistocene extinct faunas. We believe this dating problem may be solved in the case of deposits such as the ones reported here. We therefore hope that this paper will encourage the study of further faunal remains, which can be well preserved in tar pits around the world.

2. Methods and materials

We collected tar-pit bones from a variety of museum collections for this initial study. Bones were divided into small chips and fragments by cutting with a portable rotary cut-off tool and subsequent crushing. The bone fragments were treated in several different ways in order to determine the most effective pretreatment. We experimented with various solvents including toluene, dichloromethane, benzene and hexane. The best solvent for efficiently removing the tar was found to be benzene, similar to the conclusion of Ho et al. [4]. We finally decided to use a procedure using a Soxhlet extraction in benzene followed by a modified collagen-extraction procedure, based on the work of Longin [5]. We used a procedure modified from that of Brown et al. [6], where the ultrafiltration step was eliminated. The procedure is shown in Fig. 1.

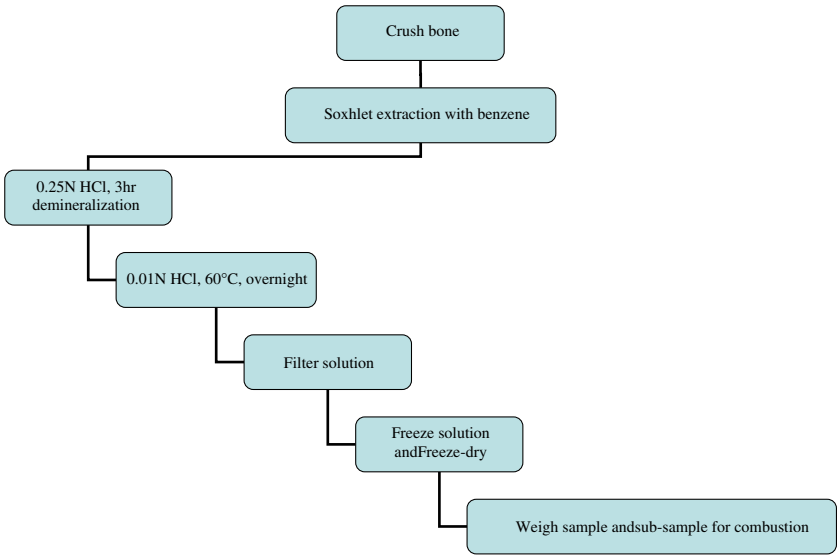

Fig. 1. Pretreatment protocol for tar-pit bone samples.

3. Results and discussion

Results of our measurements on various bones recovered from tar pits, as well as tar extracted from Venezualan tar pits are shown in Table 1. The results shown are for several known extinct species: *Glyptodon* (Glytopdontidae) and *Holmesina* (Pampatheriidae) – large armadillo-like mammals and *Parconus browni* I (Megalonychidae) – a species of Cuban Caribbean ground sloth.

Yields of both collagen and carbon were generally low, and the yields of carbon dioxide from combustion of the "collagen" were also low. This may be due to the poor preservation of collagen in these bones and also due to salts in the final collagen solution. However, the important point of this report is that radiocarbon dates can be obtained on the remaining organic material and this can be separated from the tar.

The tar seeps at Maricaibo in Venzuela are well-known as a repository of many Late-Pleistocene species. The Xenarthran armadillo species are thought to have become extinct at the end of the Pleistocene. The results we obtained so far tend to be older samples, the most recent sample so far observed was a *Glyptodon* of ~25 500 yr BP.

In Cuba, the asphalt seeps of Las Breas de San Felipe are the only known tar seeps in the Greater Antilles and they were first discussed in 1932 by a report from an oil-company geologist [7]. There was some evidence in Cuba for the survival of ground sloths into the Holocene [7], and MacPhee et al. [8] reported an age of 6250 ± 50 yr BP for a bone of *P. brownii* recovered from a cave deposit. Three new dates were obtained from *P. brownii* from San Felipe (4960 ± 280; 10 520 ± 440 and 11 800 ± 280 yr BP). These dates includes the oldest C14 date yet obtained for a Cuban fossil mammals, including humans (the oldest reliable C14 date from human remains is 5270 ± 20 [10]). These dates also suggest that ground sloth in Cuba postdate human population of the island, but more data is needed as the differences between the human and sloth dates are within the level of error of the dates. No ^{14}C dates on sloth remains from Puerto Rico more recent than ~33 ka [9] have yet been obtained, except that they are probably absent from cave deposits at ~5400 yr BP. With present dates one cannot test the

Table 1
Radiocarbon measurements on bones recovered from tar pits

Date no.	Sample	Location	Chemical pretreatment	Collagen yield (%)	Comb. yield (% C)	$\delta^{13}C$ (‰)	Fm	^{14}C age (yr BP)
AA33646T	Tar	Inciarte, Venezuela	Benzene-soluble component, combustion	–	36.4	−26.1	<0.0035	>45,400
AA33646A	Glyptodon c.f.	Inciarte, Venezuela	A, B: benzene extraction,	5.5	5.9	−26.1	0.0418 ± 0.0031	25 500 ± 600
AA33646B	Clavipes			4.7	7.3	−27.6	0.0307 ± 0.0014	27 980 ± 370
AA33647A	Holmesina	Inciarte, Venezuela	A: ABA*, benzene	–	10.5	−21.1	0.0060 ± 0.0010	41 000 ± 1300
AA33647B	Occidentalis		B: ABA*, toluene	–	10.5	−22.2	0.0029 ± 0.0009	46 900 ± 2600
AA33647C			C: ABA*, CH_2Cl_2	–	11.5	−23.1	0.0050 ± 0.0015	42 600 ± 2500
AA33647D			D: benzene	–	18.8	−15.6	<0.0653	>21 900
AA35290	*P. brownii*, humerus V626	Las Breas de San Felipe, Cuba	benzene, ABA*	1.5	1.5	−26.9	0.5395 ± 0.0186	4960 ± 280
AA35291	*P. brownii*, humerus V627	Las Breas de San Felipe, Cuba	Benzene, ABA*	3.4	0.7	(−25)	0.270 ± 0.015	10 520 ± 440
AA35292	*P. brownii*, femur V-649	Las Breas de San Felipe, Cuba	Benzene, ABA, collagen	2.9	1.2	−27.9	0.228 ± 0.012	11 880 ± 420

ABA: Conventional acid–base–acid pretreatment with 1 N HCl, 0.1% NaOH, 1 N HCl and finally distilled water.

hypothesis that human arrivals cause the extinction of ground sloth, as more data is needed.

These data give some credence to the effects of human arrival on the island as a possible cause of the extinction of this species of ground sloth. Macfarlane [11] has also discussed the extinction of rodents and insectivores on Puerto Rico which also support these conclusions. No dates on sloths from Puerto Rico more recent than ~33 ka [11] have yet been obtained, except that they are observed to be absent from cave deposits at ~5400 yr BP. In Hispaniola, there is a much younger date: 3755 ± 175 for taxonomically unallocated megalonychid bones reported by Woods [12]. However, we believe the date is possibly too young, as it was done before the advent of small-sample AMS measurements.

4. Conclusions

Dating of fossil bones of extinct Pleistocene fauna can be performed on material recovered from tar pits. Clearly, further work is needed to refine the methods used here. Since many of these pits and seeps have abundant fossil material, these methods may allow us to constrain the last occurrence of these species in various localities. There are sites, such as Talara (Peru), where there is evidence for human artifacts and extinct megafauna. This, coupled with the minimum age of first human contact, variously estimated to be up to 6000–7000 years ago, can be used to verify or reject various extinction hypotheses.

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