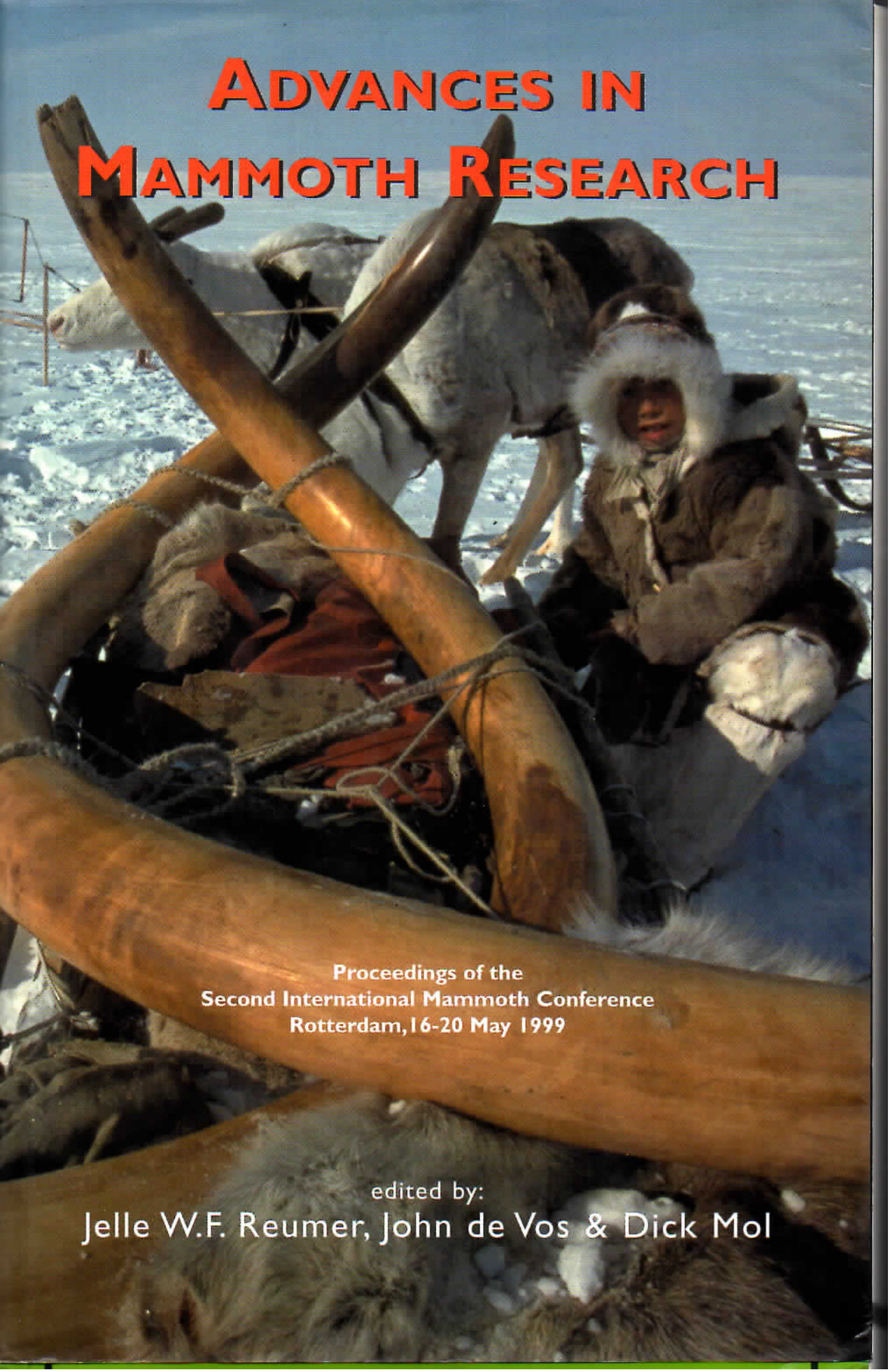
Advances in Mammoth Research



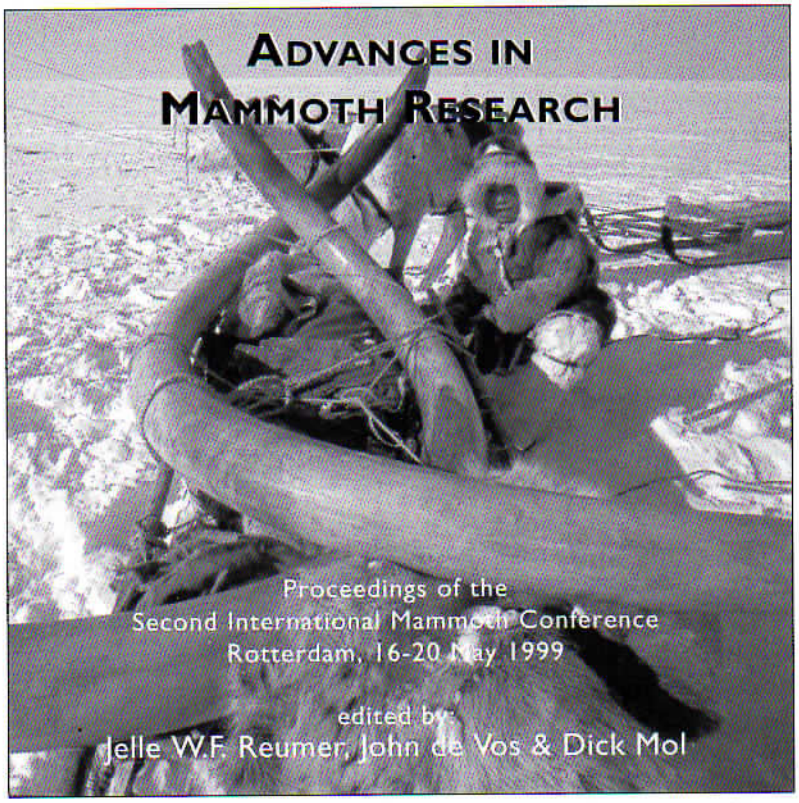
Proceedings of the
Second International Mammoth Conference
Rotterdam, 16-20 May 1999

edited by:
Jelle W.F. Reumer, John de Vos & Dick Mol

DEINSEA

JAARBERICHT VAN HET NATUURMUSEUM ROTTERDAM

ISSN 0923-9308



ANNUAL OF THE
NATURAL HISTORY MUSEUM ROTTERDAM

9

2003

Luis A. Morett[1], Silvia González [2] Joaquín Arroyo-Cabrales[3], Oscar J. Polaco[3], Graham J. Sherwood[2] & Alan Turner[2]
[1]Museo Nacional de Agricultura, Universidad Autónoma Chapingo
[2]School of Biological and Earth Sciences, Liverpool John Moores University
[3]Laboratorio de Paleozoología, Instituto Nacional de Antropología e Historia

The Late Pleistocene paleoenvironment of the Basin of Mexico - evidence from the Tocuila mammoth site

Morett A.L., González, S., Arroyo-Cabrales, J., Polaco, O.J., Sherwood, G.J. & Turner, A., 2003 - The Late Pleistocene paleoenvironment of the Basin of Mexico - evidence from the Tocuila mammoth site - in: Reumer, J.W.F., De Vos, J. & Mol, D. (eds.) - ADVANCES IN MAMMOTH RESEARCH (Proceedings of the Second International Mammoth Conference, Rotterdam, May 16-20 1999) - DEINSEA 9: 267-272 [ISSN 0923-9308] Published 24 May 2003

One of the most interesting and newest mammoth sites in Mexico is found in Tocuila, State of Mexico, east of Mexico City. Remains of at least five Plains mammoths (*Mammuthus columbi*), and other animals were found in deposits dated at approximately 11,200 yBP. The matrix in which the bones are embedded consists of a sandy silty sediment with pumice fragments associated with a catastrophic mud flow of volcanic origin.

Correspondence: Luis A. Morett, Museo Nacional de Agricultura, Universidad Autonoma Chapingo, Edificio Principal Planta Alta, Km. 38.5 Carr. México-Texcoco, 56230 Chapingo, Estado de México; email: morett@taurus1.chapingo.mx; Silvia González, Graham J. Sherwood & Alan Turner, School of Biological and Earth Sciences, Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF, United Kingdom; e-mail: bessgonz@livjm.ac.uk; Joaquín Arroyo-Cabrales & Oscar J. Polaco, Laboratorio de Paleozoología, Subdirección de Laboratorios y Apoyo Académico, Instituto Nacional de Antropología e Historia, Moneda # 16, Col. Centro, 06060 México, D.F.; e-mail: arromatu@prodigy.net.mx

Keywords: Tocuila, *Mammuthus columbi*, Late Pleistocene, Tephra

INTRODUCTION

It has been more than 100 years since the presence of mammoth remains in the Basin of Mexico was first documented. In fact, for the past 30 years, the written reports have increased to dozens (Lorenzo & Mirambell 1986). However, most of the mammoth remains have just been the subject of salvage excavations, without further research on their importance. Here we report on a mammoth-bearing that has received much attention over the past seven years, both from the general public and academics from a range of institutions and disciplines.

The paleontological site of Tocuila is located about 40 km east of Mexico City, downtown at the small village of San Miguel Tocuila, Municipality of Texcoco, State of Mexico (Fig. 1). Construction of a water cistern for a cafeteria in July 1996 brought to light one of the most important Quaternary sites in Mexico (Morett *et al.* 1998a, 1998b). At the time, laborers found some large bone fragments when they struck a complete mammoth skull. Fortunately one of the co-owners of the property, Mr. Celso Ramírez one of decided to request advice from a nearby university museum. It was decided to undertake a detail-

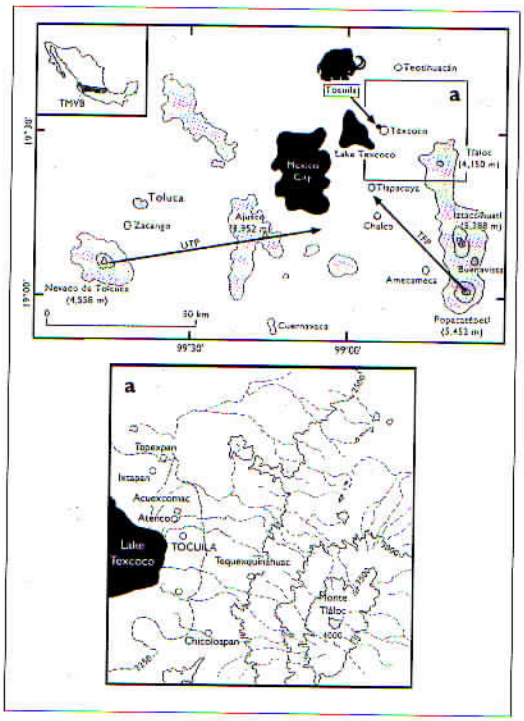


Figure 1 Map of the Basin of Mexico showing the location of the Tocuila Mammoth Site. Also showing the volcanoes from which the two main Late Pleistocene tephra marker units around the basin were formed; UTP: Upper Toluca pumice and TFP: Tutti Frutti Pumice. **a** Detailed map of the surroundings of Tocuila.

ed scientific excavation open for public viewing instead of just a salvage excavation. The site is situated at 19°31'11" N, 98°54'31" W, at an altitude of c. 2240 m (Fig. 1). The working area spread over 30 m², in a 5 x 6 m pit, to a depth of 3.15 m; it was excavated during three months. The excavation and the stratigraphical levels were recorded, as were geometric position data for each bone specimen. Also, different specialists collected samples for other studies since it was decided to apply an interdisciplinary approach to this excavation. Conversations with town visitors showed that at least 15 other findings of mammoth remains have occurred in the vicinity of the site during the past 50 years.

SITE DESCRIPTION

Most of the approximately 1,000 bones belong to the plains mammoth *Mammuthus columbi* (Proboscidea, Elephantidae). The remains include three skulls that are almost complete, other two incomplete skulls, and four mandibles, all of these from at least five individuals ranging in age between young and adults, and with both sexes represented (Fig. 2). Most mammoth bones were not articulated, except for a right hind leg that was complete, including the phalanges, and close to a large pelvis near the base of the deposit. The molars of some of the individuals are not symmetrical, this may be explained either by the differential embryological development of the molars as they grew (A. Lister, personal communication 1999), or by shrinkage of the species gene pool due to inbreeding in the regional populations. In addition to the mammoth bones there are few remains of horse (*Equus* sp.), bison (*Bison* sp.), camel (*Camelops hesternus*), rabbits (*Sylvilagus cunicularius*) within the lower sediment package, and in the top layers, fishes, turtles (*Kinosternon* sp.), and aquatic birds, including the flamingo *Phoenicopterus* cf. *ruber* (Corona-M. & Arroyo-Cabrales 1997; Morett *et al.* 1998a,b), and ducks (Corona-M., personal communication 1998). The faunal assemblage from the bottom layers is similar to other such findings in the Basin of Mexico as well as the Mexican Plateau, and that assemblage has been proposed as being characteristic of the Late Pleistocene grassland fauna in central Mexico (Ferrusquía-Villafranca 1978).

Initial study of the mammoth bones have shown that different taphonomic factors, such as trampling and slight weathering, affected the bones, but that not much transport occurred. Also, there are some bone fragments that show a pattern of modified bone similar to that produced by human flaking, suggesting a possible association of man with this faunal assemblage. Different samples from the fossiliferous sediments were assayed for radiocar-

Table 1 ^{14}C dates available for the paleontological site in Tocuila, State of México. Abreviations for laboratories are: INAH - Dating Laboratory, Instituto Nacional de Antropología e Historia, México; A(AA) - Laboratory of Isotope Geochemistry, The University of Arizona, U.S.A.; OxA - Radiocarbon Accelerator Unit, Oxford University, United Kingdom.

LAB NUMBER	SAMPLE NUMBER	DEPTH	MATERIAL	AGE (yBP)	DEVIATION (±)
INAH-1658	TOC-1-213	170-173	CHARCOAL	11,277	139
INAH-1659	TOC-1-222	170-205	CHARCOAL	11,274	116
INAH-1660	TOC-1-261/ TOC-1-333	205-230	SEEDS/ CHARCOAL	11,541	196
INAH-1661	TOC-1-277	230-270	SEEDS	11,296	230-270
INAH-1662	TOC-1-424/ TOC-1-436	270-300	SEEDS	10,553	188
A-9313 (AA23161)	TOC-1-241	204	SEDIMENT	10,220	75
A-9314 (AA23162)	TOC-1-555	305-306	SEDIMENT	12,615	95
OxA-7746	TOC-1-		BONE, *Mammuthus columbi* skull	11,100	80

bon dating, including standard and AMS ^{14}C on sediment samples, as well as AMS ^{14}C on mammoth bone. Dates are shown in Table 1. An average of 11,188 ± 76 yBP for the standard ^{14}C dates is in agreement with the AMS ^{14}C date on bone (11,100 ± 80 yBP), and those from the AMS ^{14}C for sediments are at the extremes.

LATE PLEISTOCENE PALEOENVIRONMENT AT TOCUILA

In order to understand the processes that formed the deposit and that preserved the mammoth remains, it was necessary to develop a multidisciplinary approach involving sedimentology, paleontology, volcanology, geophysical methods, ^{14}C dating and molecular biology. The Basin of Mexico contained a number of shallow lakes during the Late Pleistocene. Tocuila lies on the eastern margin of Lake Texcoco, which during recent times has tended to be saline in nature. Bradbury (1971, 1989) has suggested that brackish conditions also existed in the lake during the late Pleistocene.

The Basin of Mexico is unusual in that it lies within an active volcanic area. Two large stratovolcanoes, the Nevado de Toluca and the Popocatepetl, were active during the Late Pleistocene, as were other smaller volcanoes. Therefore it is not surprising that many of the sediments on the lake margin are volcanic in origin. These include not only primary ashfall deposits but also the products of mudflows, or lahars, which formed when heavy rain washed loose volcanic ash and other debris down from the higher ground around the lake. Analysis of the sediments surrounding the bones indicates that they contain large quantities of pumice and other volcanic materials. The pumices are rounded, indicating that they have been reworked. The deposit is therefore interpreted as a volcanic mudflow or lahar. Geochemical analysis of the pumice (Siebe *et al.* 1997b) indicates that the pumice comes from the Tutti-Frutti eruption of the Popocatepetl volcano, which occurred at about 14,000 BP (Siebe *et al.* 1997a). The gap of nearly three thousand years between the eruption of the pumice and ash and its incorporation into the lahar is puzzling. Siebe *et al.* (1997b) speculate that the ash and pumice may have become mobilised during a climatic warming that led to the melting of high-level snow and ice at the end of the last glacial period.

Figure 2 Photograph of the *Mammuthus columbi* remains at Tocuila.

However, recent studies (Gonzalez *et al.* 2001) indicate that the lahar deposit is associated with the upper Toluca Pumice (UTP) about 10,500 yBP.

The fact that the bones are largely disarticulated could suggest that the volcanic mudflow was not the cause of death of the mammoths, but that their skeletons became incorporated in the mudflow and were redeposit in their present position, further investigation is warranted. The good condition of the bones would seem to indicate that the time which elapsed between death and burial can not have been more than a few months. It also would suggest that the skeletons were not transported a great distance by the mudflow. Although there is a spread of radiocarbon dates (Table 1) through the sequence, we believe that the 1.7 meters of sediments containing the mammoth remains were deposited either in a single event or in several pulses over a very short period of time. Directly below the mammoth lahar, there is a dark sandy ash deposit that is approximately 30 cm thick (Fig. 3). Our initial interpretation of the stratigraphical sequence had this ash being deposited shortly before the emplacement of the lahar unit. However, careful examination of the sediments exposed in the NE corner of the excavation and in trenches dug in neighboring fields to the S and SW of the site indicated that the stratigraphy was more complicated. There is a complex sequence of volcanic ashes, lake silts and laharic deposits, which lie on top of this black ash horizon but are older than the deposits containing the mammoth remains (Fig. 3). This indicates that the mammoth lahar was deposited in a channel, which was cut through the sediments as far as the black ash layer. Initial indications are that this channel must have run approximately ESE-WNW, with the flow originating from the high ground to the East of Tocuila.

Whilst it might appear at first glance that with this high concentration of volcanic sediments the Basin of Mexico must have been a very hostile environment at the end of the

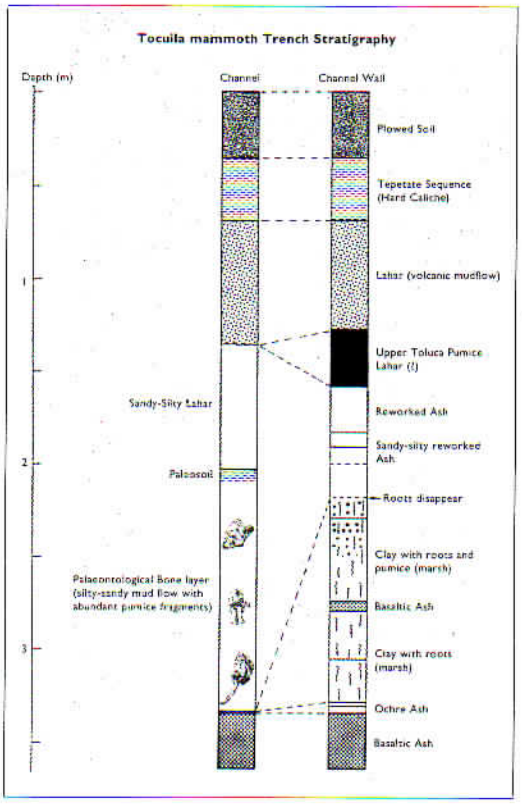


Figure 3 Diagram showing tentative stratigraphic correlations between the mammoth-bearing channel deposits and the unfossiliferous non-channel deposits.

Pleistocene, it is important to realize that these events were short-lived and that for the vast majority of the time the fauna could live undisturbed by volcanic activity. However, these relatively few catastrophic events have assured a high preservation potential for the Late Pleistocene fauna in the Basin of Mexico. The excavated area has been incorporated into a small museum, which holds on site the recovered bone remains, many of which are preserved *in situ*. Although the displays are not yet finished, the site can be visited. Future studies will search for the spatial limits of the fossiliferous deposit, which will help to build a framework for undertaking further excavations to solve some specific questions. These include the processes that formed the deposit, the possible presence of human activity associated with the bones, and those related to osteological issues that could contribute to our understanding of the causes of the late Pleistocene extinction of megafauna in North America.

ACKNOWLEDGEMENTS

The continuous support of the Instituto Nacional de Antropología e Historia, and the Universidad Autónoma Chapingo is greatly appreciated. Also, it is a great honour to acknowledge the two co-owners of the property, who have allowed the use of their land for such a long time, without any objection, Mr. Celso Ramírez and Mr. Francisco Venegas. We thank to our colleagues that have participated at the different stages of the project, including Drs. Jaime Urrutia Fucugauchi and Claus Siebe, Instituto de Geofísica, UNAM; Dr. José Ortega, Laboratorio de Geología, INAH; Ing. Quím. Magdalena de los Ríos Paredes, Laboratorio de Fechamiento, INAH; Dr. Austin Long, Laboratory of Isotope Geochemistry, University of Arizona; Dr. Paul Pettit, Radiocarbon Accelerator Unit, Oxford University and NERC in the UK for funding for AMS dating on bone; as well as several assistants and students who have participated during the project. Some funds were secured through the kindness of Fundación Cultural Trabajadores del Arte y de Pascual A.C., as well as some construction materials from the Municipality of Texcoco.

REFERENCES

Bradbury, J.P., 1971 - Paleolimnology of Lake Texcoco, Mexico. Evidence from diatoms - Limnology and Oceanography 16: 180-200

Bradbury, J.P., 1989 - Late Quaternary lacustrine paleoenvironments in the Cuenca de Mexico - Quaternary Science Reviews 8: 75-100

Corona-M., E. & Arroyo-Cabrales, J., 1997 - New record for the flamingo (*Phoenicopterus* cf. *P. ruber* Linnaeus) from Pleistocene-Holocene transition sediments in Mexico - Current Research in the Pleistocene 14: 137-139

Ferrusquía-Villafranca, I., 1978 - Distribution of Cenozoic vertebrate faunas in Middle America and problems of migration between North and South

America - in: Ferrusquia-Villafranca, I. (ed.) - Conexiones Terrestres entre Norte y Sudamerica, Simposio Interdisciplinario sobre Paleogeografia Mesoamericana - Boletin del Instituto de Geologia, Universidad Nacional Autonoma de Mexico 101: 193-321

Gonzalez, S, Huddart, D., Morett, L., Arroya-Cabrales, J. & Polaco, O.J., 2001 - Mammoths, volcanism and early humans in the Basin of Mexico during the Late Pleistocene/ Early Holocene - in: Proceedings of the 1st International Congress 'The World of Elephants", Rome. 704-706.

Lorenzo, J.L. & Mirambell, L., 1986 - Mammutes excavados en la Cuenca de México (1952-1980) - Cuadernos de Trabajo del Departamento de Prehistoria, Instituto Nacional de Antropología e Historia 32: 7-151

Morett, L., Arroyo-Cabrales, J. & Polaco, O.J., 1998a - El Sitio Paleontológico de Tocuila - Arqueologia Mexicana 5: 57

Morett, L., Arroyo-Cabrales, J. & Polaco, O.J., 1998b - Tocuila, a remarkable mammoth site in the Basin of Mexico - Current Research in the Pleistocene 15: 118-120

Siebe C., Macias, J.L. Abrams, M., Rodriguez, S. & Castro, R., 1997a - Catastrophic prehistoric eruptions at Popocatepetl and Quaternary explosive volcanism in the Serdan-Oriental Basin, east-central Mexico: Pre-meeting excursion fieldtrip guidebook No. 4, January 12-18, IAVCEI General Assembly, Puerto Vallarta, Mexico: 1- 88

Siebe, C., Schaaf, P., Urrutia-Fucugauchi, J.J. & Obenholzner, J., 1997b - Mammoth bones embedded in a late Pleistocene Lahar deposit from Popocatepetl volcano, near Tocuila, Valley of Mexico - Geological Society of America, 1997 Annual Meeting Abstracts with Programs, Salt Lake City: A-164

received 6 July 1999

DEINSEA - ANNUAL OF THE NATURAL HISTORY MUSEUM ROTTERDAM
P.O.Box 23452, NL-3001 KL Rotterdam The Netherlands