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Contents

9th ICAZ Conference, Durham 2002
The Future from the Past (eds Roel C. G. M. Lauwerier and Ina Plug) pp. 153–158

16. Tocuila and its Research/Public Outreach Program

Joaquín Arroyo-Cabrales, Luis Morett A. and Oscar J. Polaco

For the past six years, much attention has been focused on a paleontological site located in Tocuila, 40 km east of México City. An amazing bone bed containing at least five mammoths and several other extinct and extant species, and the sediments within which the bones lay, show an intriguing pattern of the environment 11,000 years ago, right at the time when people were appearing in the Basin of México. The possibility that a catastrophic event was the cause of the fossil deposit has attracted the attention of geophysical scientists, including volcanologists. With such an extraordinary site, developing an original approach that combines simultaneously both the researcher's academic activities with a public exhibit seems appropriate. The educational effort is aimed at showing how the researchers excavated the deposit, and how the scientific work has reconstructed the actual paleoenvironmental landscape based on the faunal and sedimentological studies.

Introduction

Paleontological heritage is an important cultural and scientific resource within a country. In México, it has been only the past 16 years that the federal government realized the importance of such a resource and looked after its protection through a presidential decree. Eventually, that decree should be followed by a Paleontological Law approved by the Congress (J. García-Bárcena, personal communication 2002). The Instituto Nacional de Antropología e Historia (National Institute of Anthropology and History – INAH by its Spanish initials) is the federal institution that was chosen for the preliminary legal protection. However, for the time being and before the law is approved, several localities have been found and their protection has been undertaken through different means, including the procedure followed to protect and conserve the locality reported here.

It has been more than 100 years since the presence of mammoth remains in the Basin of México was first documented. For the past 30 years, the written reports have increased into the tens. However, most of those have documented salvage excavations, without further research on their importance (Lorenzo and Mirambell 1986). A major exception is Tocuila, a mammoth-bearing locality that has received much attention over the past six years, both from the general public and from academics within a range of institutions and disciplines (Cortés 1998; Gándara 2003; Gill and West 2001; González G. and De Stéfano F. 2002; Weintraub 1997).

Tocuila and its Research/Public Outreach Program

The paleontological locality of Tocuila is located about 40 km east of downtown México City, at the small village of San Miguel Tocuila, Municipality of Texcoco, State of México (Fig. 1). Construction of a water cistern for a cafeteria in July 1996 brought to light one of the most important Quaternary sites in México. At the time, laborers found some large bone fragments when they struck a complete mammoth skull. Fortunately, the co-owners of the property, Mr. Celso Ramírez and Mr. Francisco Venegas, decided to request advice from the nearby university museum, National Museum of Agriculture. This action later led to a decision to undertake a scientific excavation instead of a salvage one, cosponsored by INAH and the museum's university, the Universidad Autónoma de Chapingo.

The initial decisions were to undertake a complete standard excavation and to retain most of the materials at the locality. This latter decision was due to both the heavy loads in bringing the fragile bones into the

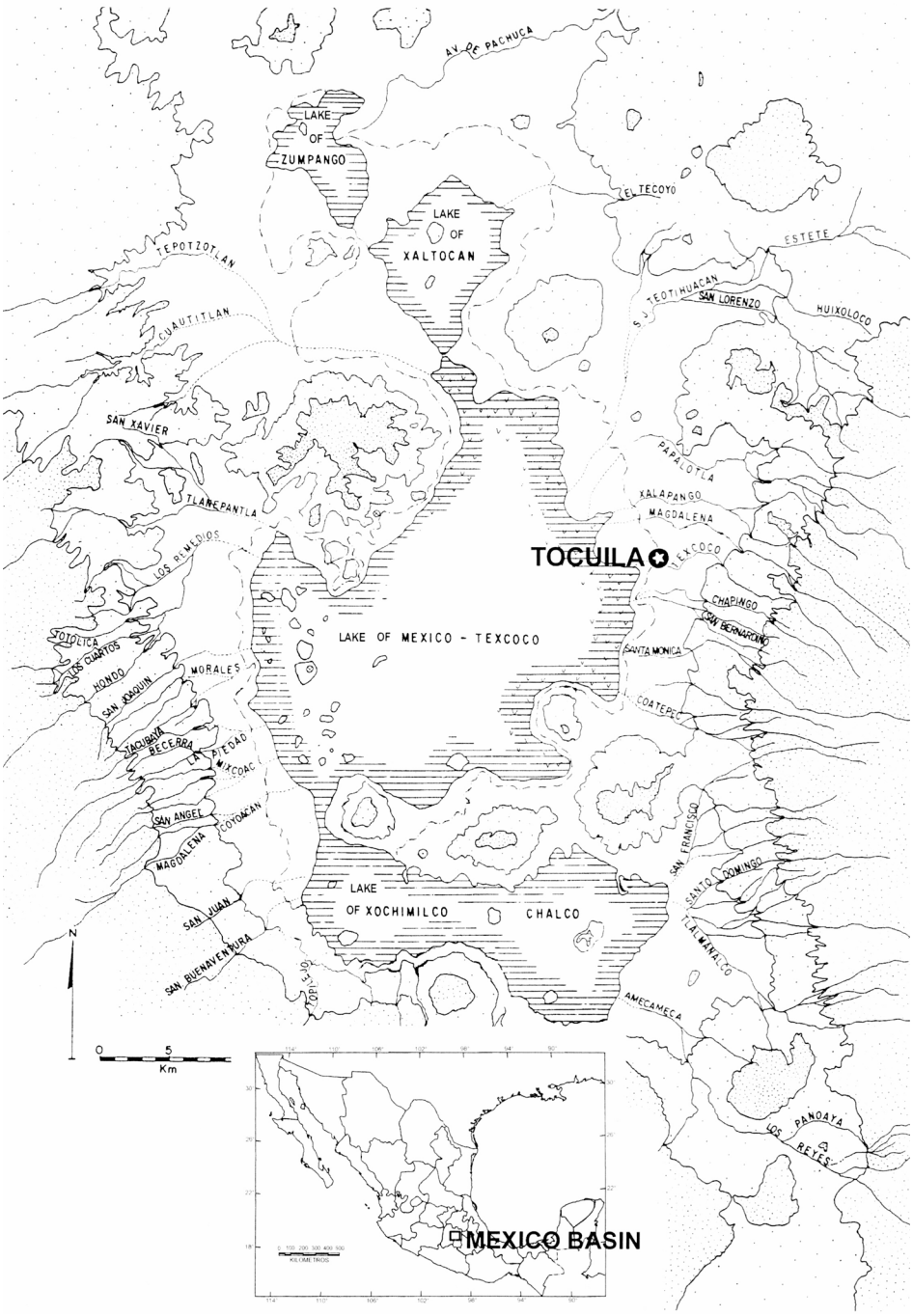

Fig. 1. Map of the Basin of México, showing where the Tocuila site is located.

laboratory as well as a requirement from the landowners and the community to continue the studies there. From the start of excavations the people were very interested in the on-going studies. Visitors were received every day. Concerns about them because they might fall in the pit and hurt themselves, and damage the bones were unfounded. People really behaved wonderfully, and the locality suffered not one act of vandalism.

During the excavation, the continuous interaction with people in the community led to learn that several other localities had been found nearby the current locality. Most of them were hidden by the landowners, fearing that either expropriation, slowing of their building efforts, or otherwise taking away the uncovered materials would happen, as was the case in the past for other localities within the basin. Because they realized that none of those events occurred with the recently discovered locality, they felt more confident in talking about other possible localities (Fig. 2).

One of the people's fears was that the academics would

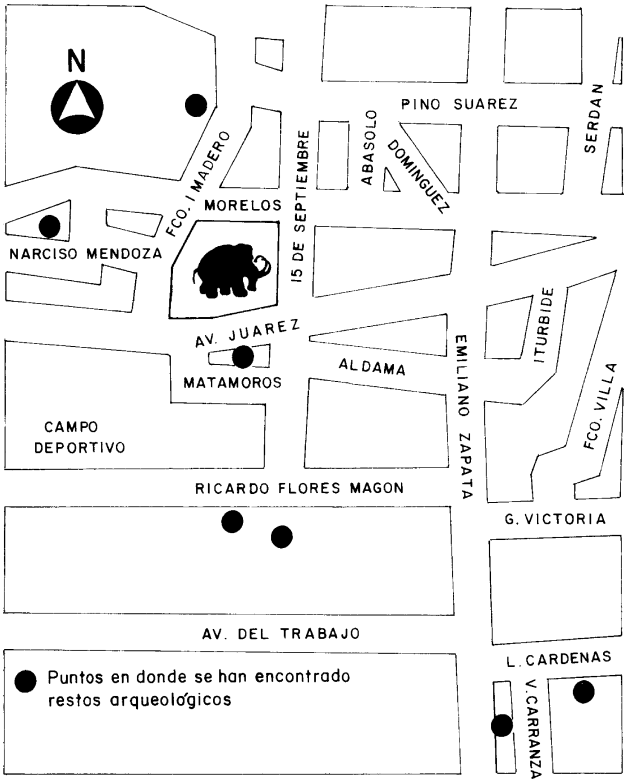

Fig. 2. Map of the town of San Miguel Tocuila, showing the current excavation site, and other possible localities (•) according to the community people.

remove all of the materials from the site, while they wanted to keep them *in situ* to constitute the basis of a local museum. Because of those concerns, research activities would be a museum project, meaning that any research would be carried on along with those activities designed to enhance the educational significance of the site. As such, all of the excavation and conservation efforts have been done in front of visitors to avoid any further fears of material removal.

The working area spread over 30 m^2, in a 5x6-m pit, to a depth of 3.15 m, and was excavated during three months. Excavation and stratigraphic levels were followed, and geometric position data for each bone specimen were recorded (Fig. 3). The research was developed on an interdisciplinary and interinstitutional basis (sedimentology, palinology, geophysics, volcanology, geomorphology, radiometry, paleontology, and molecular biology) in order to discover the processes that led to the formation of the deposit and the preservation of the mammoth remains (Morett 1997). The activities in the past seven years have allowed for temporarily preserving the site, trying carefully to follow all conservation standards, as well as document any preservation problems.

Different samples from the fossiliferous sediments were assayed by radiocarbon dating, including standard and AMS ^{14}C on sediment samples, as well as AMS ^{14}C on mammoth bone. An average of 11,188 ± 76 years BP for the standard ^{14}C dates is in agreement with the AMS ^{14}C date on bone (11,100 ± 80 years BP), and those from

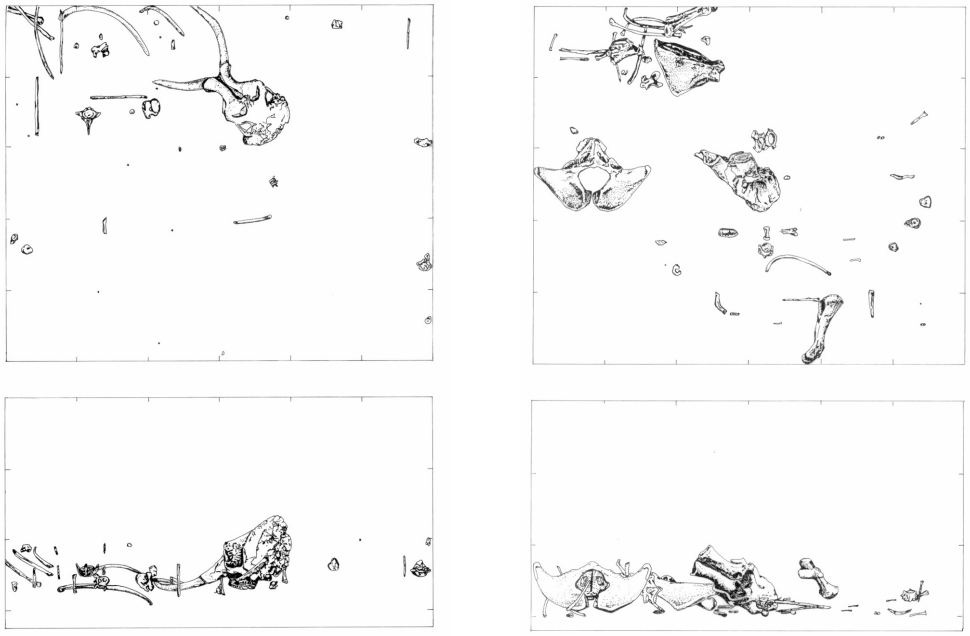

Fig. 3. Excavation maps and profiles at the Paleontological Site Tocuila (State of México): (left) Level 7, depth at base: 271 cm; (right) Level 8, depth at base: 285 cm.

the AMS ^{14}C for sediments are within the extremes (10,220 – 12,615 years BP) (Morett *et al*. 2003).

The approximately 1,000 bones exposed to date, mainly pertained to the plains mammoth *Mammuthus columbi* (Falconer). Those remains included three skulls that are almost complete, 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. A few remains were of horse (*Equus* Linnaeus), bison (*Bison* H. Smith), camel [*Camelops hesternus* (Leidy)], rabbit [*Sylvilagus cunicularius* (Waterhouse)], and an extinct large felid [either *Smilodon* Lund or *Panthera atrox* (Leidy)] within the lower sediments package. In the upper layers, fishes, turtles (*Kinosternon* Spix), and aquatic birds, including the flamingo *Phoenicopterus* cf. *P. rubber* Linnaeus, and ducks (*Anas* Linnaeus) were found (Corona-M. and Arroyo-Cabrales 1997; Morett *et al*. 1998a; 1998b). The faunal assemblage from the lower layers was similar to other such findings in the Basin of México as well as the Mexican Plateau. That assemblage was proposed as characteristic for the grassland late Pleistocene fauna in central México (Polaco and Arroyo-Cabrales 2001).

The large concentration of bones was actually a continuous bone bed that brought some logistical problems for both preservation and research. Many of the small to medium-size fragments had to be removed from the bone bed to allow for walking inside the pit. This procedure also allowed for preservation of those bones outside the locality, while leaving the large specimens in place. Also, as the locality is located at the edge of what used to be Texcoco Lake, the water table is close to the bottom of the current excavation area, and the humidity has being difficult to keep away from bones. Instead of using PVAC as originally assayed, treatment was changed to an epoxy-based consolidant that is mixed with water; it is easily going into the bones, even with high moisture content.

Also, due of the high humidity levels in the area, a base consisting of a resin-based sponge-like material, has been built for all of the completely exposed *in situ* bones. Slowly digging below of the bones, and exchanging the sediments by the resin material accomplished that. This base has kept the bones dry, and without any mold growing.

Future studies will search for the spatial limits of the fossiliferous deposit that will help to build a framework for undertaking further excavations to solve some specific questions. Those questions include the processes that formed the deposit (*e.g*. see Siebe *et al*. 1998 *vs*. Gonzalez *et al*. in press), the agreement about the presence of cultural evidence associated with the bones (*e.g*. see Johnson *et al*. 2001 *vs*. Haynes 2002), and those related to osteological issues that could contribute to understanding the causes for the late Pleistocene extinction of megafauna in North America (Gonzalez *et al*. 2001; Morett 2002).

Because visitors have assisted at the locality from the beginning of the excavations, initially temporary facilities were built, and undergraduate students from a Design career program designed a temporary exhibit in order to explain the importance of the materials and how to conserve them. Based on such an effort, the community became confident in the scientists, which was important for learning about previous fossil findings in the town. This information indicates that the town is located in a potentially highly fossiliferous region. Also, in this first stage of the project, two brochures (Morett *et al*. 1996; 1997) and a poster were prepared to increase the awareness of people in the Basin of México.

In the second stage, a small community museum was built around the excavated area, with small grants from the Municipality of Texcoco (Fig. 4). The museum holds the recovered bones on-site, many of which were preserved *in situ*. A community museum is a legal agreement with INAH in which the community in an region plays a major role in the designing, building, and maintaining of a museum in their community. Only their own request for such a museum is what could start its planning, and they would be responsible for the heritage protection. This arrangement has received the greatest support in the country lately as it allows people in a community to acquire responsibility, provide care and protection, and gain pride of the cultural heritage in their region, instead of just being looked after and dependent upon the decisions of others.

Wide aisles were set to provide observation areas for the fossils from the top, and those aisles were also used for displaying small exhibit cases with bone examples from some of the animals found in the locality. Museographic labels were prepared to explain to the visitors about the findings and what they were viewing, and also a small popular booklet with the history of the site, and the fauna that was found and artistic depictions of the animals, was printed (Morett A. and Arroyo C. 2001; 2002). Plans to complete the museum include finishing a mural with a paleoenvironmental depiction by a local artist of how the landscape around the locality looked like 11,000 years ago, as well as displaying the bones and artistic reconstruction of the different animals recovered in the site. Finally, a small research centre is planned to host national and international visiting scientist using the locality, and for storing the collection and other remains from the local area. Most of these plans are dependent on the final decision in regard to the property. The current owners are only leasing the property to the community.

In regard to public outreach, the locality has been depicted in several communication media. From the beginning of the excavations, and while researchers were still planning the field season, the locality received media coverage. This coverage included news at regional ('La Prensa del Estado de México'), national ('El Universal', 'La Jornada', 'Reforma'), and international (DPA

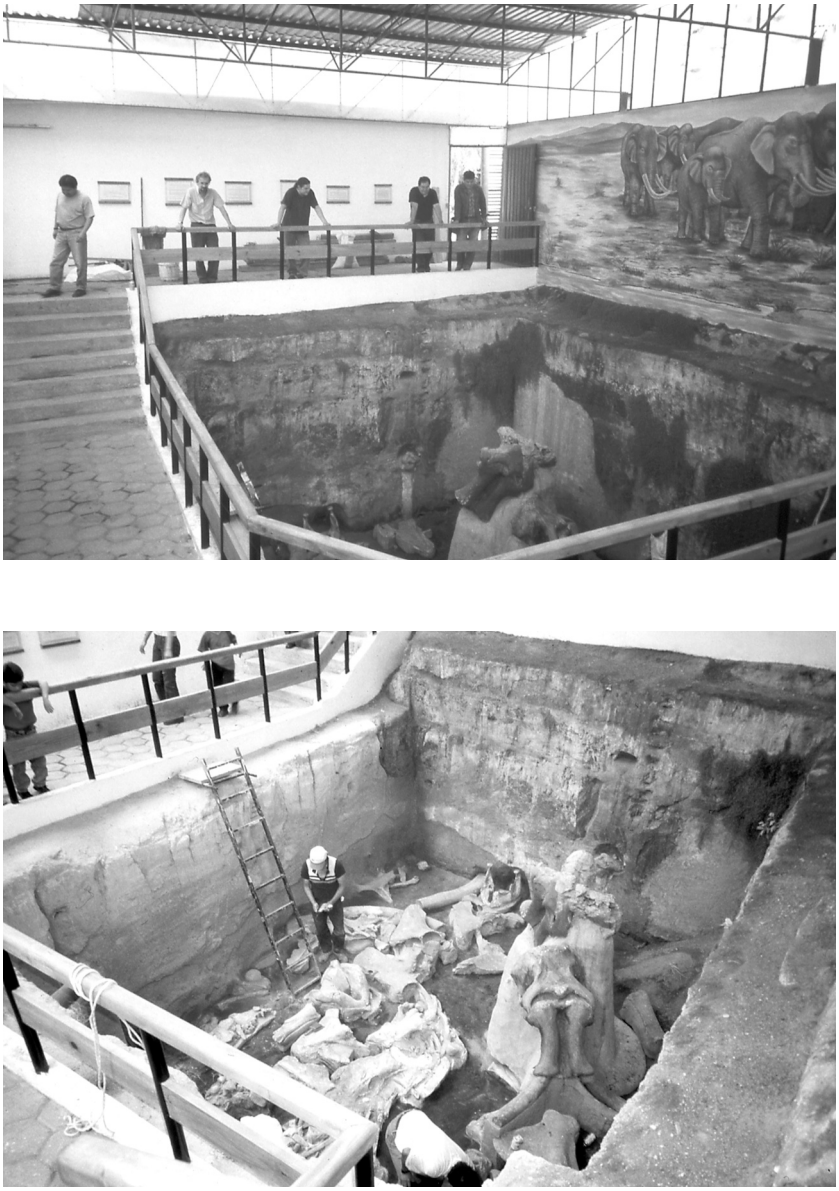

Fig. 4. Current view of the museum built at the paleontological locality of Tocuila: (above) View at the main entrance to the building; (below) View at the actual deposit. Photographs by Oscar J. Polaco.

Deutsche Presse-Agentur GmbH) newspapers, as well as periodical magazines ('Contenido', 'El Huevo', National Geographic); TV news programs, like 'Hechos' (Azteca), and 'Buenos Días' (Televisa); and more extended TV programs, such as 'In vitro' ('Tesoros Paleontológicos en el ex-Lago de Texcoco' – Paleontological Treasures in the former Texcoco Lake), Channel 11 IPN; México; 'Animal Death Traps', Discovery Channel, New Zealand; and 'Extinct' (Mammoths), Wall to Wall Television, England. Finally, radio coverage was developed for the 1996 field season, and then in early 1998.

The museum is also considered part of a cultural tourist circuit that includes other museums, like the early man Tepexpan site museum, and the Museum of Geology in downtown México City where a complete mammoth skeleton is on exhibit. The focus of the circuit is to show to the people the importance of the fossil findings in the Basin of México for the paleoenvironmental reconstruction and understanding of the peopling of the region, and why it is recommended that anytime they find any buried bone they advise the authorities or the academics about such item. Since the circuit is planned to attract young people, mostly school kids, it is hoped that the museum will enhance their learning experience, and contribute for their knowledge and understanding of the importance for protecting the paleontological heritage.

The overall experience of interacting with the public as part of the ongoing research has been a new one for

most of the research team. Certainly, the team has gained much in dealing with the people and their questioning. Some of the analyses have been focused to answer those questions and provide information for future outreach activities and exhibits.

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