

Mammoths, volcanism and early humans in the basin of Mexico during the Late Pleistocene/Early Holocene

S. Gonzalez¹, D. Huddart¹, L. Morett-Alatorre², J. Arroyo-Cabrales³, O.J. Polaco³

¹*School of Biological and Earth Sciences, Liverpool John Moores University, Byrom Street, Liverpool, UK - bessgonz@livjm.ac.uk*

²*Museo de Nacional de Agricultura, Universidad Autónoma de Chapingo, México.*

³*Subdirección de Servicios Académicos, Laboratorio de Paleozoología, INAH, México, D.F. - arromatu@prodigy.net.mx*

SUMMARY: The most important Late Pleistocene-Early Holocene fossiliferous localities in the Basin of Mexico are all associated with volcanic and lacustrine sediments. New results from the stratigraphy, tephrochronology and ¹⁴C dating from these sites are presented and evaluated. At the Tocuila mammoth site the bones are embedded in lahar derived from a mixture of tephras of different ages which indicates deposition after the Upper Toluca Pumice. ¹⁴C dating supports this chronology. The Plinian eruption which produced the Upper Toluca Pumice had a major environmental impact in the Basin and is likely to have killed some megafauna and early humans but also preserved a unique picture of Late Pleistocene life. The association of the Upper Toluca Pumice with two human skulls at Tlapacoya and one at Metro Balderas is proved and hence their chronological status established. In addition one Tlapacoya skull is the first directly dated human in Mexico with an age of 9730 ± 65 years BP.

We present new results from an ongoing research programme looking into the relationships between the palaeoenvironment, megafauna (especially mammoths) and early human presence in the Late Pleistocene deposits around the Basin of Mexico.

This area is rich in Pleistocene sediments associated with a fluctuating lake system. The main localities with mammoth remains have been reported around the shores of the lake, where at least 25 localities with mammoth remains (*Mammuthus columbi*) and other Late Pleistocene Mammals (camel, horse, glyptodon, sabre-toothed cat, bison) have been found. About half of these sites are in association with human presence (obsidian blades, cut marks on bone and Lerma-El Jobo type points), Lorenzo & Mirambell (1986).

The basis of a chronological framework for the Late Pleistocene-Early Holocene of the Basin of Mexico is presented, using stratigra-

phy, tephrochronology and radiocarbon dating to correlate some of the more important Late Pleistocene fossil localities including Tepexpan, Tocuila, Tequexquinahuac, Tlapacoya and San Vicente Chicoloapan.

Volcanic activity during the Late Pleistocene-Early Holocene has played a very important role in the palaeoenvironment of the Basin of Mexico. Three major volcanic eruptions of Plinian type have been identified producing tephra marker horizons in the area: Great Basaltic-Andesitic Ash (GBA) at ~ 29,000 years BP (Moose 1997), the Pumice with Andesite Tephra (PWA) at ~ 14,450 years BP (Mooser & Gonzalez-Rul 1961; Mooser 1967) and the Upper Toluca Pumice (UTP) at ~ 11,600 years BP (Bloomfield & Valastro, 1974, 1977).

Using the electron microprobe unit at Edinburgh University we were able to analyse tephra shards from several mammoth localities

which indicated association with specific volcanic eruptions. The sedimentology indicates that in several sites the mammoth bones are embedded in lahar deposits (volcanic mud flows) which indicate catastrophic flood events in the area with examples from Tocuila, Tequexquihuac, Tlapacoya and San Vicente Chicoloapan.

The Tocuila site is particularly interesting because the remains of seven mammoths (*Mammuthus columbi*) were found together in an area measuring only 28 m² embedded in a layer of reworked volcanic material (lahar). Siebe *et al.* 1999 interpreted the sequence as a lahar derived from the Pumice with Andesite tephra marker (PWA), because chemical analysis of pumice found in the deposit corresponds with the composition of tephra which originated ca. 14,000 years BP from a Plinian eruption of the Popocatepetl Volcano. However radiocarbon dating of the bone layer showed that the lahar deposit was formed no earlier than 10,650 ± 75 years BP; indicating a large discrepancy in time. One mammoth skull in the bottom of the sequence gave a date of 11,100 ± 80 years BP. Siebe *et al.* 1999 explained the discrepancy of about 3000 years between tephra deposition and the lahar event as due to the lack of water during the Late Pleistocene when permafrost and glacial ice were prevalent.

During the present study we have re-examined the chemical composition of the silty-sandy volcanoclastic sediments in which the mammoths are embedded (Tab. 1) and found that indeed there are andesitic pumices associated with the PWA eruption, with silica values around 61% but that there were present as well tephra shards associated with the Upper Toluca Pumice (UTP). The latter was erupted from the Nevado de Toluca Volcano ca. 11,600 years BP, with a silica content of 70-71%, associated with another violent Plinian type volcanic eruption.

From the point of view of timing of events that produced the palaeontological bone layer this explanation seems more plausible. Under this scenario it is possible to relate the death of the mammoths at Tocuila with the volcanic activity of Nevado de Toluca. The animal bones

were incorporated in the lahar moving down a gully shortly after the eruption.

However, the bones excavated in Tocuila are well preserved showing evidence of minimal abrasion, which means that they have not been moved far, perhaps because the Tocuila site was close to the shores of Texcoco Lake where the mammoth group initially died. The Tocuila lahar is overlain by lake sediments indicating a relatively high stand of Texcoco Lake.

At other prehistoric sites like Tlapacoya there is also evidence of the presence of the PWA and UTP in situ, with associated laharic events after the deposition of each tephra marker indicating two periods of landscape instability after the deposition of the tephra. This site is important from the point of view of early human occupation of the Basin with two human skulls found in close association with the *in situ* Upper Toluca Pumice (UTP) layer. One of the skulls has been radiocarbon dated to 9730 ± 65 years BP, the first directly dated human from Mexico.

Tequexquihuac the highest of all the studied sites, has mammoth remains (*Mammuthus columbi*) together with horse and deer. A radiocarbon date on a mammoth tusk gave a result of 13,450 ± 40 years BP (β-153,819) with a δ¹³C value of -16.3. The animal bones are embedded in volcanic ash, with very high values of silica of around 76-78% (Tab. 1). This indicates that they are associated with a totally different volcanic eruption and not the PWA or the UTP, because the age and the composition of the tephra does not correspond to any of the known tephra markers. It is likely that the material is coming from one of the nearby rhyolitic domes found to the SE around the Quetzaltepec Sierra (Telapón Volcano).

The Metro Man skull was found in 1970 at 3,10 mts depth during construction work for the Balderas Metro station, in the center of Mexico City. Volcanic ash samples taken from the interior of the skull gave values of silica of 70-71% associated with the UTP eruption. This has proved to be the only way of dating this skull as radiocarbon dating has not been successful due to lack of collagen preservation. This is a common problem in volcanic areas where the bones are mineralised quickly after burial.

Tab.1 - Geochemical analysis of volcanic ash (tephra shards) found in different prehistoric localities around the Basin of Mexico, either in situ or in lahar deposits.

Toc = Tocuila, Tequex= Tequexinahuac. UTP= Upper Toluca Pumice or Tripartite Tephra. PWA= Pumice with Andesite Tephra. Mamm.= With mammoth remains.

Chemical Comp.	Tlapacoya Man Skull UTP In situ TC-9	Tlapacoya PWA In situ TA-5	Toc UTP In situ TocD2	Toc PWA In situ Toc C	Toc UTP Lahar Mamm.	Toc PWA Lahar Mamm.	Tequex ? Mamm. Tx-4	Metro Man UTP
SiO ₂	70.38	61.56	70.41	61.35	70.70	61.92	76.98	70.37
TiO ₂	0.24	0.60	0.24	0.72	0.81	0.96	0.26	0.21
Al ₂ O ₃	13.94	17.03	14.05	17.62	11.86	15.61	13.38	14.05
FeO	1.75	4.01	1.84	4.25	2.71	3.59	0.36	1.82
MnO	0.03	0.06	0.09	0.05	0.03	0.06	0.03	0.05
MgO	0.44	1.92	0.39	2.26	0.29	1.32	0.04	0.44
CaO	1.91	4.66	1.73	5.51	0.64	4.40	1.89	1.93
Na ₂ O	4.30	4.43	4.02	4.74	4.18	4.86	4.38	3.83
K ₂ O	2.71	2.02	2.70	1.84	3.69	1.91	2.52	2.99
Total	95.74	96.32	95.52	98.39	94.96	95.07	99.87	95.72

In conclusion there is a growing body of evidence pointing to the fact that volcanic eruptions were a very strong environmental influence in the Basin of Mexico during the Late Pleistocene. In particular the Upper Toluca Pumice layer (UTP) seems to be associated with lahars that devastated the Basin, possibly killing megafauna and humans. However these sudden processes have preserved the bones of animals and humans in volcanic deposits which help us to recreate a picture of life at the end of the Pleistocene/early Holocene in the Basin of Mexico.

The possible impact that volcanic activity had on mammoths and early humans will be discussed at the Conference, together with the questions associated with the extinction of megafauna in general (environmental stress against human presence).

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