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Original paper

Evidence of pre-Columbian settlements in the forest of the Tuxtla Volcanic Field, Veracruz, Mexico

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Resumen

El campo volcánico de los Tuxtlas se localiza en el margen occidental del Golfo de México, en el estado de Veracruz, México. El campo está compuesto por cuatro grandes estructuras volcánicas y cientos de conos volcánicos, domos de lava y maares. En el pasado, el área estuvo cubierta por una densa selva en cuyos márgenes florecieron varias de las antiguas ciudades del Veracruz central y meridional. En el interior del bosque no se han encontrado ruinas arqueológicas, aunque los actuales habitantes del área encuentran frecuentemente fragmentos de cerámica que atestiguan la presencia de lo que pudieron ser pequeños asentamientos con un régimen seminómada. Desafortunadamente los objetos hallados son removidos de su sitio y son difíciles de fechar. Sin embargo, en el curso del estudio de los depósitos volcánicos del área se reconocieron cuatro unidades litoestratigráficas distintas relacionadas con eventos de flujos de lodo en cuyo interior se encontraron objetos y fragmentos de cerámica y en algunos de ellos carbón. Secciones de los depósitos fueron observados en detalle y muestreados para su análisis granulométrico y datación. Las muestras de carbón fueron datadas por medio de métodos estándar de radiocarbono (C-14) y las muestras de cerámica por la técnica de termoluminiscencia (TL). Las muestras arrojaron edades de 1176±100 (TL) años antes de ahora (BP, por sus siglas en inglés), 1385±70 años BP, 1157±105 (TL) años BP, y 2050+245-235 (C-14) años BP. Dado que dentro de la selva no existen materiales adecuados para la producción de cerámica, su procedencia es incierta; las ciudades prehispánicas mas grandes y cercanas se localizan hacia el occidente del campo volcánico (Tres Zapotes y Matacapan).

Palabras clave: Campo volcánico de los Tuxtlas, fechamiento de cerámica por Termoluminiscencia, Mesoamérica Precolombina.

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Abstract

The basaltic Los Tuxtlas Volcanic Field (LTVF) is located at the western margin of the Gulf of Mexico in the State of Veracruz, Mexico. The field is a massif composed of four large volcanic structures and hundreds of scoria cones, lava domes and maars. This area was in the past covered by a dense forest in whose margins flourished several of the ancient cities of importance in central and southern Veracruz. Within the forest no enduring archeological ruins have been found; but the present inhabitants of the area frequently find fragments of ceramics and stone that attest to the presence of what could have been small settlements with a seminomadic regime. Unfortunately the objects found have been removed from their emplacement and are difficult to date. However in the course of our study of the volcanic deposits in the area we found four mudflow deposits containing pre- Columbian pottery objects and shards, as well as charcoal in some of them. Sections of the deposits were observed in detail and sampled for granulometric analysis. The charcoal samples were dated using standard radiocarbon methods (C-14); where charcoal was absent the pottery shards were dated with thermoluminescence (TL) techniques. The samples from these sites yielded ages of 1176±100 years BP (TL), 1385±70 BP years (C-14), 1157±105 years BP (TL), and 2050+245-235 years BP (C-14). Since in the area there is no clayey and silty material suitable for production of pottery; the closest and largest prehispanic cities, *Tres Zapotes* or *Matacapa*, are located to the west of the LTVF..

Key words: Tuxtla volcanic field, Thermoluminescence dating in ancient ceramics, Precolumbian mesoamerica.

Introduction

The basaltic Los Tuxtlas Volcanic Field (LTVF) also known as Tuxtla Volcanic Field, and Los Tuxtlas Massif, is located in the Mexican State of Veracruz (Figure 1), where it emerges from the lowlands of the western margin of the Gulf of Mexico. Composed of four large volcanoes and more than 250 cones and maars, it spans approximately 200,000 km2 an area known as *La region de los Tuxtlas* (Los Tuxtlas Region). Nelson and Gonzalez-Caver (1992) dated the rocks of the LTVF, and found that they can be grouped in two age groups separated by a hiatus of about 1.8 Ma, they dubbed these groups as the 'Older Volcanic Series' (OVS; 7 to 2.6 Ma BP) and the 'Younger Volcanic Series (YVS; 8Ka BP–Present). Nelson *et al*. (1995) found that in the LTVF alkaline rocks are prevalent, although not unique, and considered that some rocks of the LTVF had signatures of subduction related to the Cocos plate. Nevertheless researchers such as Verma (2006) consider that the origin of the LTVF is not related to the subduction of the Cocos plate thereby the problem of its origin is still unsolved. In this paper we will focus in an area surrounding San Martin Tuxtla volcano, which constitutes most of the YVS (Figure 1). Due to the fertility of the soils formed from the basaltic rocks and heavy rainfalls, the area covered by rocks of the younger series, is nowadays the center of a 1551.2 km^2 forest reserve (Figure 1). In the past, however, the rainforest covered the entire volcanic field and beyond. At the margins of the LTVF important pre-Columbian settlements of different cultures flourished. To the west, the city of *Tres Zapotes* was occupied by the Olmec and later cultures for almost two millennia (900 BC to 900 AD). Some 30 km to the east, the city of *Matacapan* had also a long occupational history. Apparently, the site was first occupied during the Pre-classic period but it thrived in the classic and late classic periods (~100 AD -900AD), when it had a "key role in the trading network dominated by Teotihuacan", the dominant culture in central Mexico in those times (Santley *et al.*, 1984; Diehl, 2000). Smaller archeological constructions have been found to the southeast of the volcanic field and on the western side of Catemaco lake, but none in the area surrounding San Martin Tuxtla (Figure 2). However, in that area the villagers have found numerous artifacts in stone and ceramics, which being removed from its original place are difficult to date or conjecture about their emplacement. Looking for evidence about possible pre-Columbian settlements in those areas we were able to find pottery shards and charcoal fragments in four mudflow deposits. The pottery fragments correspond to the domestic type of pottery, which does not allow its cultural identification, but their age can be determined through thermo-luminescence methods. In this paper we present the general characteristics of the deposits were the objects were found, of the fragments and their ages whenever possible. We believe this findings are relevant to the historical and environmental studies on the area.

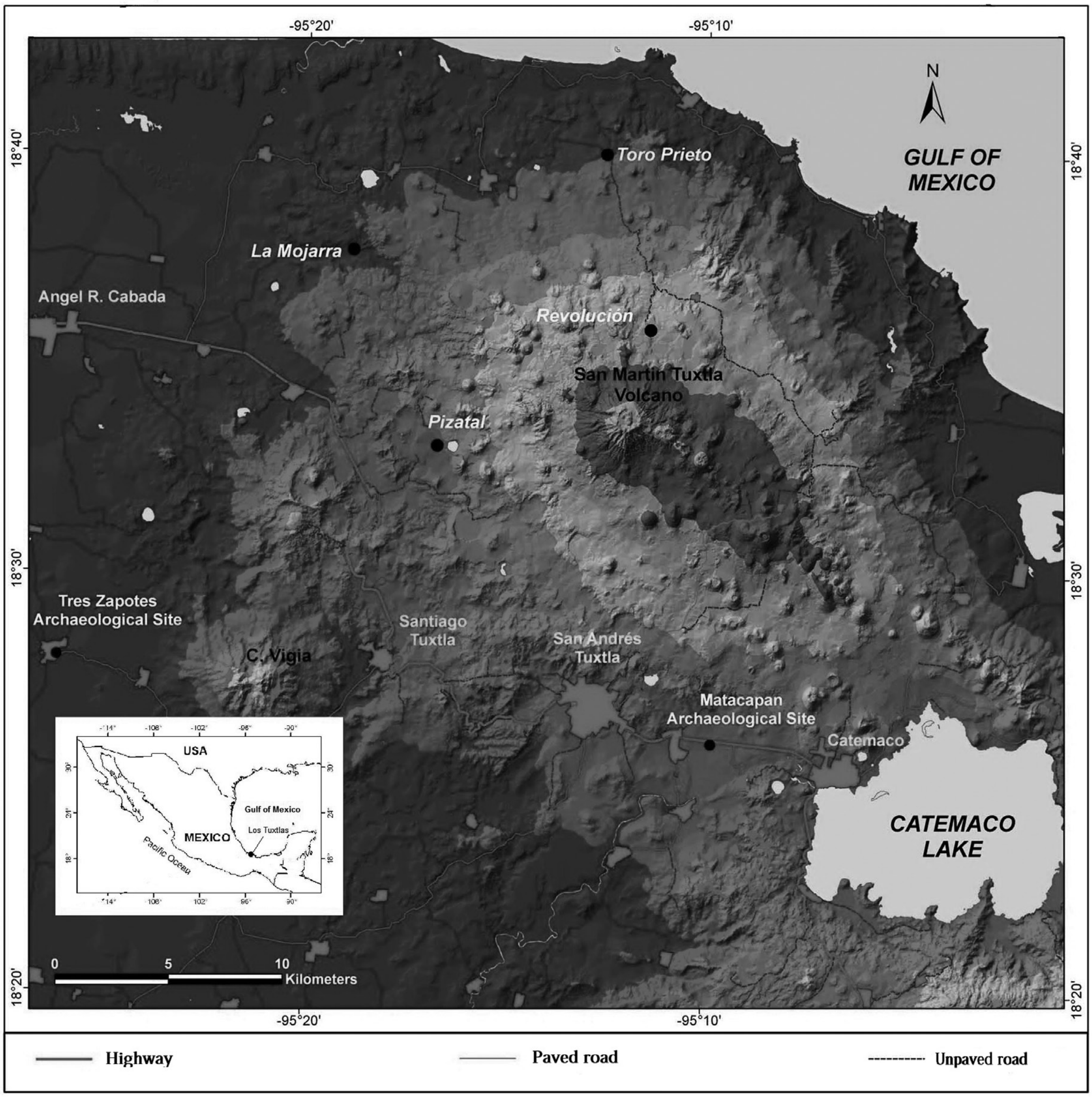


Figure 1. Location of Los Tuxtlas Volcanic Field and study sites: Revolución de Arriba, Pizatal, La Mojarra and Arroyo Toro Prieto.

Geographical characteristics of the LTVF

The LTVF has a tropical climate influenced by the trade winds of the northern hemisphere, which bring a significant precipitation during the summer season. In addition, rainfalls occur also at other times firstly because tropical storms and hurricanes extend the rainy season into the fall, and secondly because during the winter season the displacement of cold air masses from the north also cause precipitations (Gutiérrez García and Ricker, 2001). The average mean temperature is 25° and the average annual precipitation goes from 805 mm at the town of R. Cabadas to 1962 mm at Catemaco, with peak intensities greater than 400 mm (Gutiérrez García and Ricker, 2011). Most of the original forest was converted into farmland either to grow sugar cane or pasture for livestock. In fact, the first sugar cane plantation in Mexico was established in the nearby lowlands to the west by Don Hernán Cortés, the Spanish conqueror. As mentioned before nowadays an area of 15.1 km2 centered at San Martin Tuxtla Volcano has been declared Biosphere Reserve under UNESCO's Man and Biosphere Program (SEMARNAP, 1998). The area constitutes a

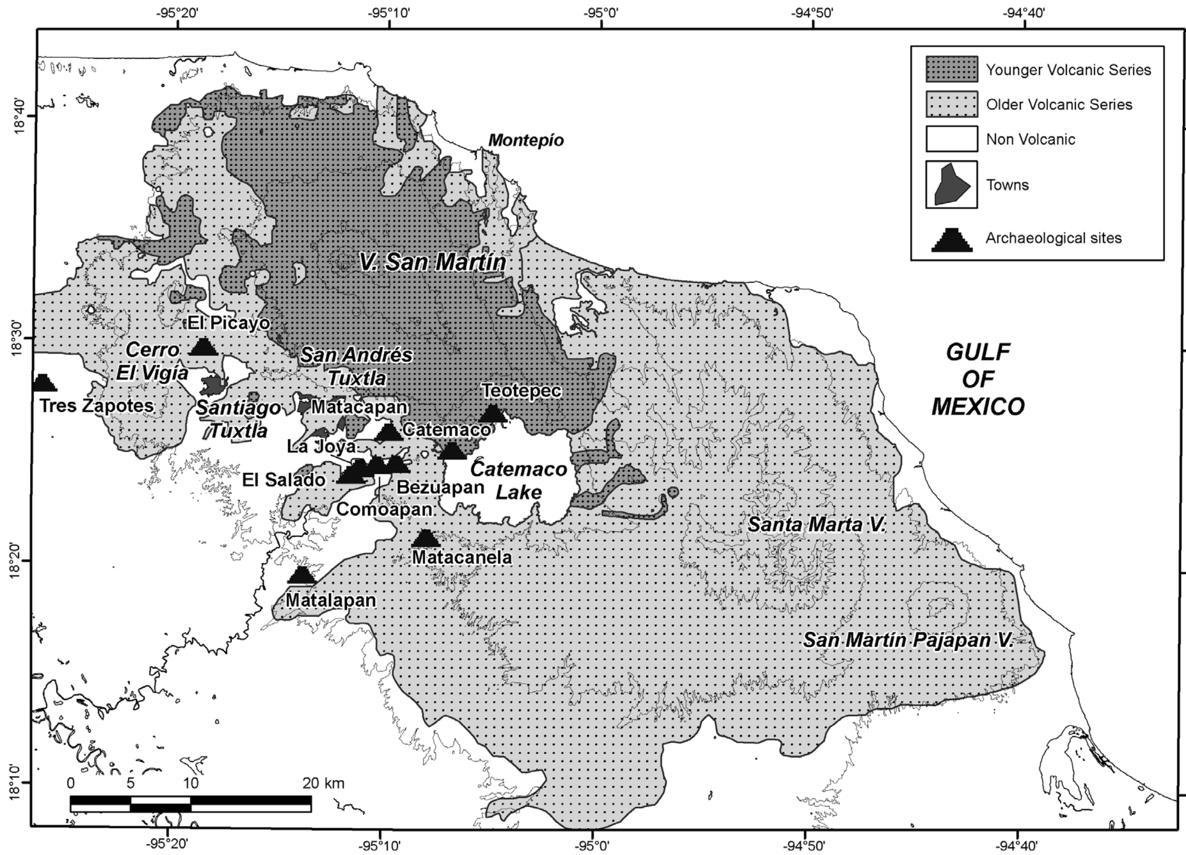


Figure 2. Generalized geology and archaeological sites at Tuxtla Volcanic Field (Geology modified after Nelson and González-Caver, 1992; Archaeological sites after Santley *et al*., 1984).

conjunction of the northernmost tropical forest, the temperate forest of central Mexico and the endemic environment. Therefore, it became the habitat of a large diversity of species both animal and vegetal, which unfortunately have diminished with time (González-Soriano *et al*., 1997). The drainage for the area is provided by numerous streams in a radial pattern with center in San Martin Tuxtla volcano most of them intermittent but also a few perennials fed by the numerous springs in the area. The soils of the Region, mostly andisols and alfisols, were derived from the basaltic products of the many eruptions in the Field; its formation is very rapid due to the large precipitations and tropical climate (Flores-Delgadillo, 1999). The landforms of the Region are predominantly lava and scoria domes and cones, maars and four large composite volcanos. The slopes of Volcanoes San Martin Tuxtla, Cerro el Vigia, The Santa Marta complex, and San Martin Pajapan are slanted at different angles acquired during their formation and subsequent erosion. In the region of study, San Martin Volcano, the tallest of all, has been classified as shield volcano (Simkin and Siebert, 1994) and is composed of lava flows, and ash and lahar deposits. This volcano presented the latest stage of volcanism with an eruptive event in 1793, which lasted more than 6 months in its explosive stage and about 2 years in an effusive phase (Espindola *et al*., 2009). The cones of the study area (YVS) show height to base diameter ratios between 0.125 and 0.18. These values correspond to heights between 20 and 240 m with an average value of 80 m. These data suggests that the cones of this area are less than 50,000 years old (Reinhardt, 1991).

Characteristics of the Mudflow deposits and objects collected

Figure 1 shows the locations were mudflows with pottery shards were found, these were named: "Revolución de Arriba", "La Mojarra", "Pizatal", and "Arroyo Toro Prieto". Deposits at those locations exhibit the following characteristics:

Revolución de Arriba Mudflow Deposit (Site 1: 18° 35.871′, 95° 11.401)

It is located some 300 m to the SE of the village of *Revolución de Arriba* it is a brown, whitish brown when dry, massive deposit with dispersed centimeter sized fragments of dark red scoria, small pieces of charcoal and pottery shards (Figures 3a, b). A few hundred meters to the east of this site (Site 2: 18° 35.825′, 95°11.356′) another similar outcrop is found under a layer of reworked gray ash. This deposit contains more abundant potshards and charcoal (Figure 3c). The pottery shards are centimeter-sized fragments of very coarse pottery. The proximity to the previous site and the similarity in age suggests that both sites belonged to the same settlement. Both sites are located close to the margin of an intermittent stream. The grain size distribution of this deposit is shown in (Figure 3d). The amount of clay size particles varies between 6% and 12% of the total and we therefore the deposit can be considered as non-cohesive (Scott, 1988).

La Mojarra Mudflow Deposit (Site 2: 18° 37.711′; 95° 18.860′)

It is located in the outskirts of the village of La Mojarra (note that this is not the same town where the famous Stella 1 of early Mesoamerican origin was found, which in Figure 1 appears farther west). The deposit covers the margins of a perennial stream crossed by a road in whose lateral cuts it is exposed (Figures 4a, b). It is reddish brown, massive with dispersed fragments of whitish, angular cobbles, and abundant pottery shards, some of which could be reassembled into a complete bowl-like piece of pottery (Figure 4c). A few obsidian blades were also present. The deposit is also non-cohesive since its grain size distribution, shown in Figure 4d; presents only a 3% amount of fines. However the presence of a horizon of several tens of centimeter blocks gives the impression in some parts of being a debris flow.

Pizatal Mudflow Deposit.(Site 3: 18°37.711′, 95° 18.860′)

This deposit is located near Pizatal (also spelled Pisatal) crater lake, a maar of about 500 m in diameter, and covers an extension on which sugar cane is nowadays planted (Figures 5a, b). The deposit is exposed on the sides of the road, which is leveled every year to facilitate the transportation of the sugar cane by trucks; it is brown, light brown when dry, massive, with some rounded pebbles. The deposit contains many pottery shards, some of them from more elaborate artifacts than in the above deposits,

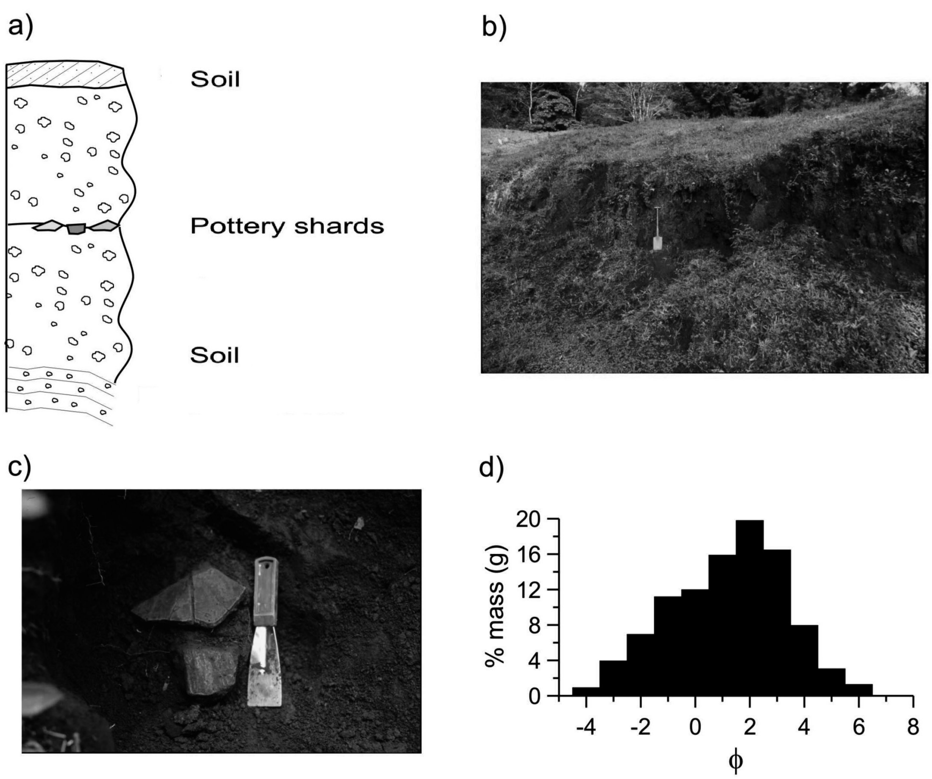


Figure 3. Revolución de Arriba. (a) Schematic section of the deposit. b) Aspect of the deposit. The insert shows some of the fragments collected at this site. (c) Granulometry of the deposit

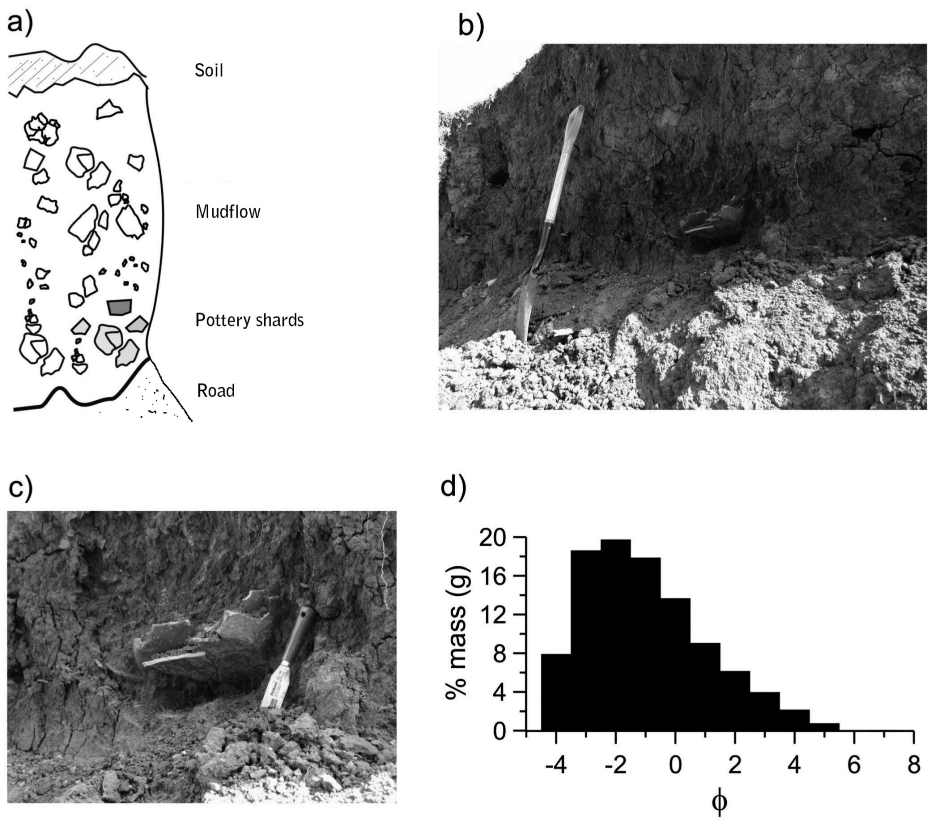


Figure 4. La Mojarra. (a) Schematic section of the deposit. (b) Aspect of the deposit. The insert shows some of the fragments collected at this site. (c) Granulometry of the matrix of the deposit at La Mojarra.

for instance Figure 6c shows what seems to be a bottle stopper in the shape of an animal's head. Findings like this are frequent, mostly after heavy rains, according to villagers of the nearby towns. This deposit might originate from overspills from the Pizatal crater lake, an event that occurred even in recent times. The grain size distribution of the deposits appears in Figure 5d, and the amount of fines is 19%. Unfortunately this deposit could not be dated by radiocarbon, since we could not find any charcoal sample, and the thermoluminescence results did not provide a reliable age due to the failure of the additive dose procedure, probably as a result of a non-favorable composition of the ceramic.

Arroyo Toro Prieto Mudflow Deposit (Site 4: 18° 38.229′, 95° 12.037′)

This deposit forms the banks of the intermittent *Arroyo Toro Prieto* stream, and is exposed by a deep trail cutting across the banks and riverbed. The deposit is brown and massive (Figures 6a, b). It contains small fragments of charcoal and some brittle, centimeter-sized, scattered pottery fragments with very rounded edges (Figure 6c). Even from its appearance this deposit seems to be older than the other deposits. Its grain size distribution is shown in Figure 6d, with an amount of fines of 13%.

Dating methods

The charcoal samples were collected in aluminum sheets and sent for dating to the Laboratory of Isotope Geochemistry of the University of Arizona, Tucson, Arizona, USA where they were dated using beta counting techniques (Table 1). The thermoluminescence analyses on pottery shards were carried out by the authors at the Laboratory of Thermoluminescence of the Instituto de Geofísica at UNAM (Spanish acronym for the National Autonomous University of México). The samples were collected from the inside the deposits at about 30 cm from the surface exposed to the light and deposited immediately in thick black plastic bags. The U, Th and K concentrations in the matrix surrounding the samples were measured *in-situ* for annual dose rate determinations in with a portable gamma ray spectrometer. The laboratory treatment of the samples is explained in Ramirez *et al*. (2010). In our particular case the correction for water content was made considering water saturation in the samples because of the high rainfall rates at the TVF region. The amount of water in the samples was determined from the difference in weight between dried and water saturated samples. As an example of the TL analyses leading age calculation Figure 7 shows the natural TL curve of sample SM03-8.

The plateau test for verification of the stability region of the spectrum is displayed in Figure 8, which in this case is between 275°C and 425°C. Figure 9 shows the results of the additive dose method for calculation of the equivalent dose (Q). The results for the supralinearity correction are shown in Figure 10.

Results

The results of the C-14 and thermoluminescence analyses are shown in Tables 1 and 2. The pottery shards from Arroyo Toro Prieto and Pizatal did not yield results amenable to sound estimates of the age, except to rule them out as modern. The ages provided by the samples show that the deposits are as old as 1000 years and 2050 (+245 -235) BP. The last age corresponds to the arroyo Toro Prieto deposit and agrees very well with its characteristics, with less, small, rounded and very soft shards suggesting an older age than the age of the other ceramics. At the two close sites of *Revolución de Arriba* we obtained TL ages 1157±105, 1156±80 and 843±50 BP and C-14 ages 1385±70, 1555±70. The differences in age are significant but can be attributed to several causes, the C-14 ages were taken from samples of charcoal of unknown origin, probably from logs of aged trees. The sample with the younger TL age (843±50 BP), having been collected from the upper part of the deposit could have been deposited and closed to light at a much later date. The same can be said of the samples from la Mojarra, which yielded ages of 1 697±65 the sample collected from the lower part of the deposit and 1 176±100 the sample from the upper part.

Discussion and conclusions

The presence of the objects described attest to the presence of human activity in the forest. Since the objects are varied, have remained to this day and were located close to riverbeds it is reasonable to assume that the human presence occurred in small settlements in the forest, and that they carried out a seminomadic regime or else more enduring constructions could be found. The objects themselves indicate that: (a) these people traded goods with places where ceramics and obsidian could be obtained, (b) seems reasonable to think that other settlements were present at those times but due to their regime of life no material remaining of their presence has been preserved The ages obtained belong roughly to two periods in the historian's scheme of Mesoamerica. The age of the deposit Arroyo Toro Prieto falls at the beginning of the classical or late pre-classic period, when the Olmec culture had been reduced to Tres Zapotes

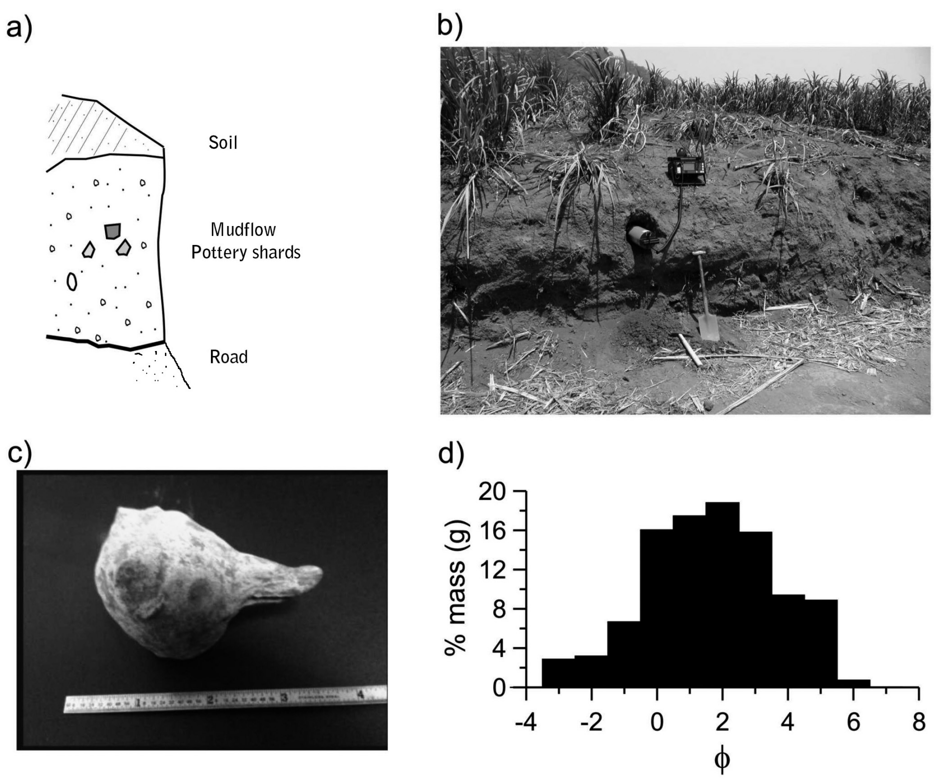


Figure 5. Lago Pizatal. (a) Schematic section of the deposit. (b) Aspect of the deposit. The insert shows some of the fragments collected at this site.(c) Granulometry of the matrix of the deposit.

Tabla 1. Radioisotope concentrations in soil and samples.

	Ceramic			Soil		
	^{238}Uranium [ppm]	^{232}Thorium [ppm]	^{40}Potasium [%]	^{238}Uranium [ppm]	^{232}Thorium [ppm]	^{40}Potasium [%]
SM03-6 INF	5.120	5.780	0.987	0.530	6.430	0.250
SM03-6 SUP	5.150	5.420	0.690	0.530	6.430	0.250
SM03-8	5.840	9.600	1.441	0.370	4.000	0.150
SM03-9-INF	6.060	8.950	1.590	0.390	4.330	0.160
SM03-9-SUP	6.200	6.370	0.950	0.390	4.330	0.160

(Pool, 2007). The samples from the other three sites belong to the post classic period well within the era of increasing ruralization of the population in the Matacapan area (Santley *et al.*, 1984). These data suggest that the occupation of the forest surrounding the San Andres Tuxtla volcano area by small human settlements occurred some 2000 years BP and roughly 1000 years BP as well. Some of these settlers were probably driven out of the forest by the volcanic activity of San Martin volcano or any of the hundreds of monogenetic vents in the field. According to the chronicler of San Andrés Tuxtla, Medel y Alvarado (1963), an eruption from San Martin Tuxtla in 1530 led to the foundation of today's Santiago Tuxtla. Although there is no evidence to this claim, but old narratives picked up by this author, it would not be an uncommon episode: However, there is proof that in the last 2000 years at least 3 cone and maar forming eruptions occurred near Matacapan, leaving deposits in the site and its surroundings (Reinhardt, 1991). Due to the heavy precipitation in the

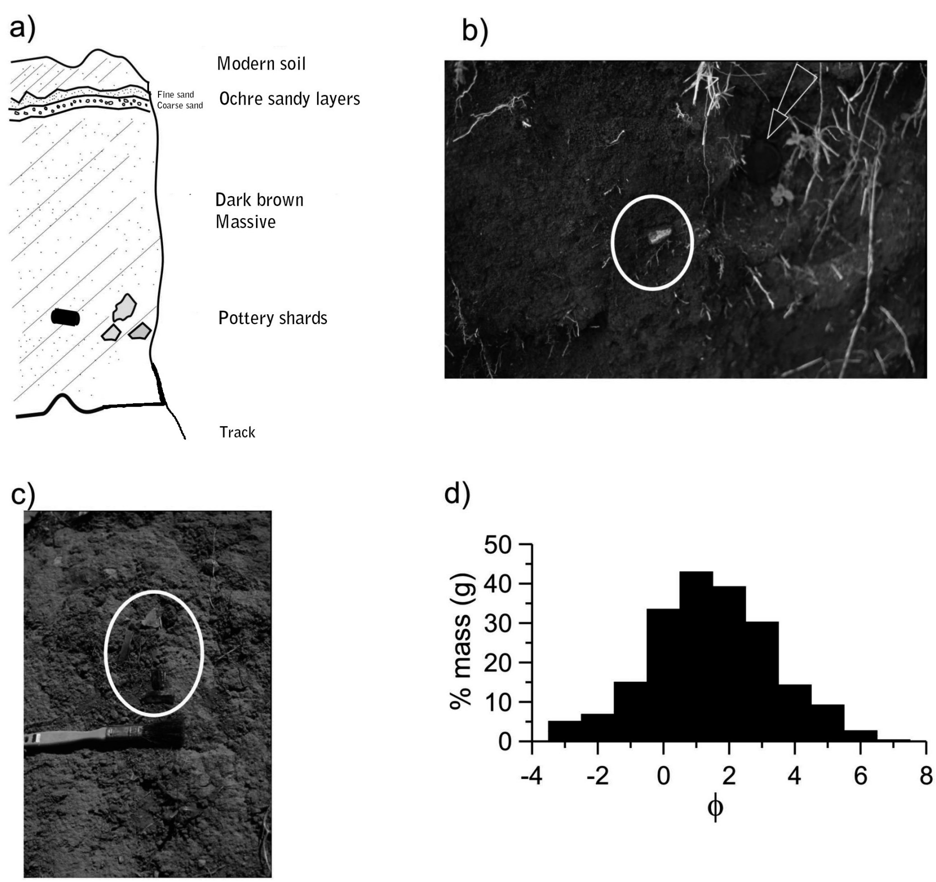


Figure 6. Arroyo Toro Prieto (a) Schematic section of the deposit. (b) Aspect of the deposit. The insert shows some of the fragments collected at this site.(c) Granulometry of the matrix of the deposit.

Figure 7. Natural thermoluminescence of sample SM03-8.

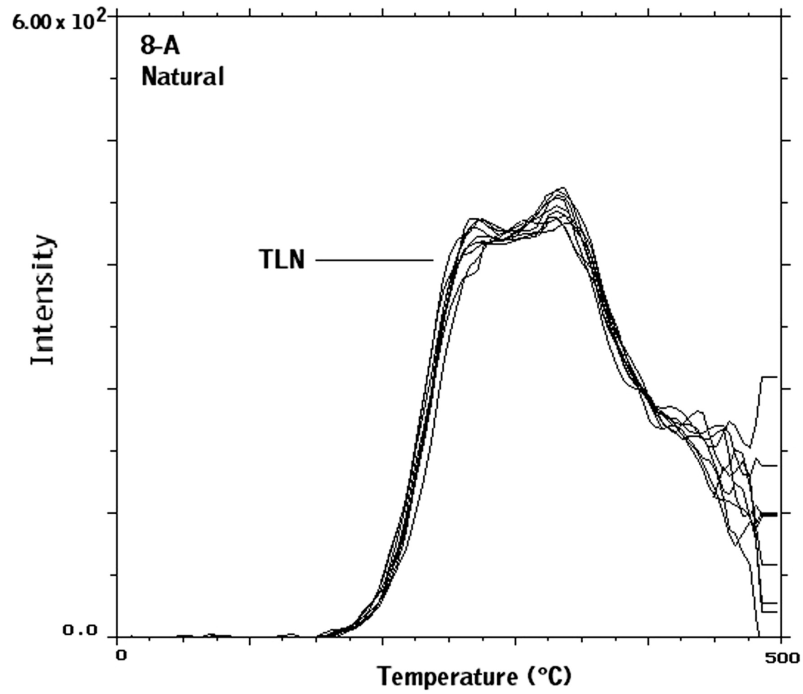


Figure 8. Plateau test for verification of the stability region of the spectrum, which for sample SM03-8 is between 275°C and 425°C.

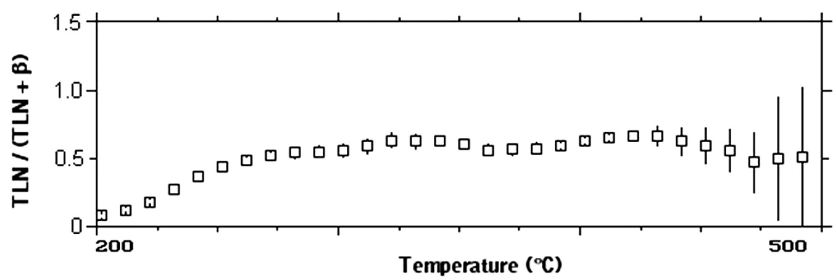
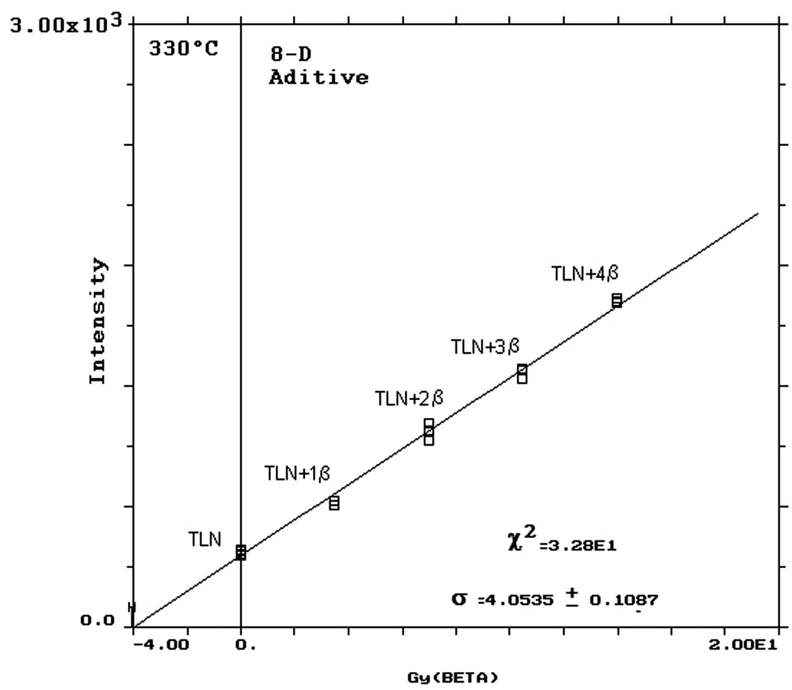


Figure 9. Results of the additive method for calculation of the equivalent dose (Q).



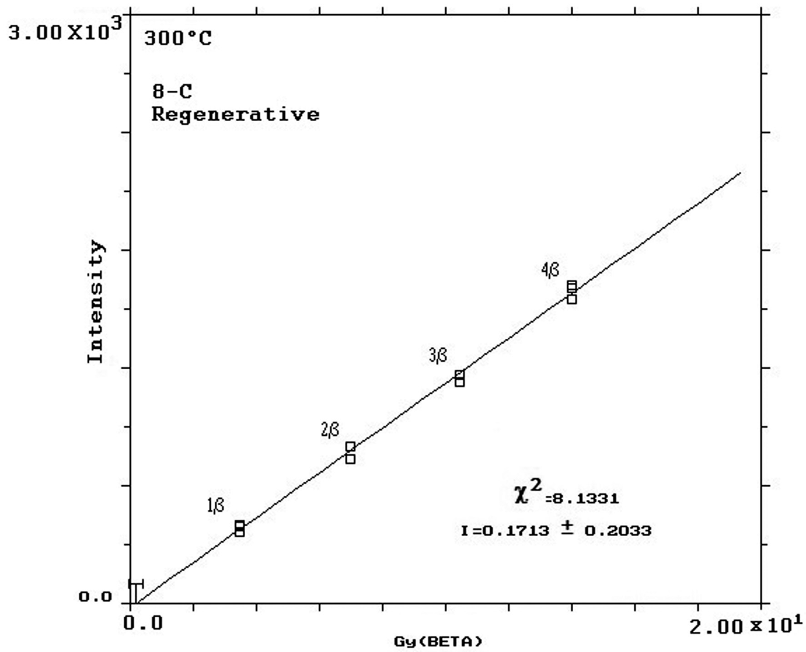


Figure 10. The results for the supralinearity correction.

Table 2. Radiocarbon and Thermoluminescence ages and other relevant data.

Sample	Paleodoses (Gy)	Anual Dose Rate (Gy/año) ($1x10^{-3}$)	Age (years)	Site	Radiocarbon*	UA Sample Number*
SM03-5SUP	X	X	Not modern	Pizatal	X	
SM03-6INF	5.53±21	3.257±.09	1 697±65	La Mojarra	X	
SM03-6SUP	3.64±.31	3.094±.06	1 176±100	La Mojarra	X	
SM99-5INF			X	Revolución de Arriba site 1	1385±70	A-11104
SM03-8	4.16±.38	3.595±.08	1 157±105	Revolución de Arriba site 1	1555±70	A-11105
SM03-9INF	4.40±.30	3.806±.09	1 156±80	Revolución de Arriba site 2	X	
SM03-9SUP	3.92±.24	4.650±.09	843±50	Revolución de Arriba site 2	X	
SNM02-20	X	X	Not modern	Toro Prieto	2050+245-235	A-12647**

*Dating was carried out at the Laboratory of Isotope Geochemistry, Department of Geosciences, The University of Arizona, Tucson, Arizona
** counted 4000 minutes

area those communities were also subjected to flooding and mudflow hazards. The presence of numerous mudflow deposits in the edifice of San Martin Volcano indicate that this phenomenon is recurrent and continues into our days. The non-cohesive nature of the deposits indicates that the mass movements are due to unstable non consolidated materials.

Acknowledgments

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