Mediterranean Archaeology and Archaeometry, Vol. 2010, No. 4, pp. 121-127

ANALYSIS OF ZAPOTEC CERAMICS OF THE CAXONOS RIVER BASIN, OAXACA, MEXICO BY THERMOLUMINESCENCE (TL)

A. Ramirez[1], P. Schaaf[1] and E. Ortiz[2]

[1]Laboratorio de Termoluminiscencia, Instituto de Geofísica, Universidad Nacional Autónoma de México, Ciudad Universitaria, Coyoacán, 04510, Distrito Federal, Méxic

[2]Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México

Corresponding author: rangel@geofisica.unam.mx

ABSTRACT

One of the most common materials that appear in archaeological excavations is the ceramics. Ceramic is an evidence for different activities and cultural periods. Thermoluminescence (TL) has been shown to be a very effective method for dating of archaeological ceramics. In this paper, we present the results of 18 Zapotec ceramics from different archaeological sites of the Caxonos River Basin, Northern Sierra of Oaxaca, Mexico, analyzed by TL. Based on these results, we established the first chronological data set of this important Mesoamerica site. Our new data give evidence for the existence of a trade route through the Caxonos River Basin used since 500 AD between the central valley of Oaxaca and the Gulf of Mexico. Methodologically we used the fine grain technique (4-11μm) and for the determination of the paleodose the additive method was applied.

KEYWORDS: thermoluminescence, dating, ceramics, zapotec

INTRODUCTION

Social sciences have recognized for a fairly long time the important role of external trade contacts in regard to the developmental trajectories of societies. For all models, the understanding of the degree of communication between human groups is a critical step for examining ways how diffusion or trade influenced cultural contacts. These questions are quite important, especially in studies of the exchange phenomena in Mesoamerican societies. In this contribution, our main interest is focused on the connection between the valley of Oaxaca and the Gulf coast of Mexico. In the Early Period (1500-500 BC), the main route passed through the Cuicatlán Canyon. Later, around 500 AD, there was a Zapotec expansion from the central valley of Oaxaca to the the Caxonos river basin. This basin, like the Cuicatlán Canyon, is a passageway that crosscut the Sierra Madre Oriental and connected the eastern portion of the central valley of Oaxaca with the coastal plain of the Gulf of Mexico. Although this region was quite important for the Zapotecs of the Classic Period (300-800 AD), until now there was no comprehensive analysis of the ceramics from this region available together with a lack of information concerning the chronological sequence of the site occupation. In 1996 the Caxonos River Project started with an exhaustive survey that covered 4000 km^2 (Figure 1). We decided to excavate at least one archaeological site of the mountain range and one on the plain coast, because these areas have not been systematically investigated in the past. In 2000 we made an analysis to model ancient routes connecting archaeological sites from different points of the Valley of Oaxaca with the coastal plain (Gutiérrez et al., 2000). The main corridor connects the lowlands with the Oaxacan sites of the eastern arm of the Tlacolula Valley. Separate paths from the Oaxacan sites merge at a nodal point near Mitla before climbing the surrounding mountain range. From here the course of this corridor runs precisely along the Caxonos river basin, crossing the Zapotec Caxonos villages. The major branch continues to the east passing by other Zapotec highland sites and the Ayotzintepec Valley following the margin of the Caxonos river to finally arrive at the actual town of Playa Vicente in the coastal plain. Río Playa is located in the vicinity of Playa Vicente. In the mountain range we excavated the archaeological site named "La Mesa". This site is on the summit of the mountain known as San Francisco, and is located on a small ridge that projects into the gorge formed by the Caxonos River. Figure 1 shows that La Mesa and Río Playa are situated in a strategic position of the study area. La Mesa is located at the starting point of the corridor and Río Playa at its end. The pre-Hispanic settlement La Mesa consists of some elongated platforms. At the top of these levels there is a small architectural complex formed by two mounds. On the western and the southern side of the high plateau a complex system of terraces can be observed. Upon these terraces three untouched tombs were found. The funerary architecture is very simple and consists of large box-like structures without antechambers.

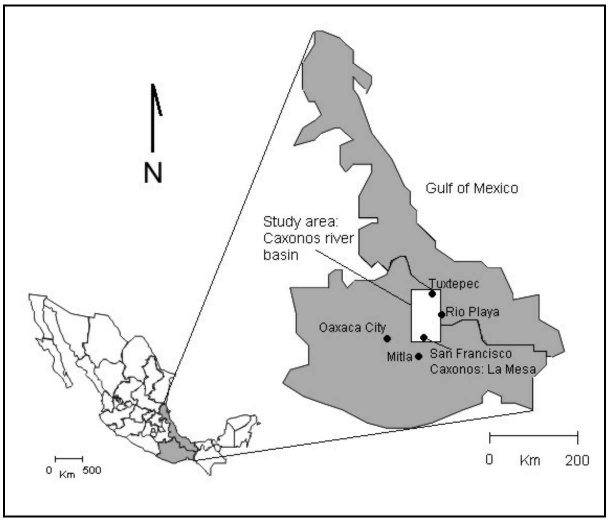

Figure 1. Location of the study area: The Caxonos river basin

On the coastal plain we excavated the Río Playa site. This is a small complex of earth mounds that had been looted in the past, so the archaeological context has been altered. During the survey stage, we found one terrace close to the river that had not been affected by the looters or human activity. Both La Mesa and Rio Playa sites were selected for our investigations because they are representative for each area and can provide significant information.

For TL analysis we also included some samples recovered from the surface of other archaeological sites. The objective was to determine if there was significant difference between the samples recovered from the excavation sites in comparison to those collected from the surface. On the other hand, the central valley of Oaxaca has been explored and excavated intensively by archaeologist since the early 20th century and therefore we collected controlled samples from previous archaeological excavations that were dated between Late Pre-Classic and the Post-Classic period (100-1521 AD).

Between 1998 and 2000 we started to excavate the principal sites of this region. Most of the our explored archaeological sites are in the mountain range of the Northern Sierra with a cloud forest environment which did not facilitate the recovering of charcoal samples for radiocarbon dating. For that reason, the TL method was selected to solve the chronological sequence. Ceramic analysis performed during the Caxonos project included a total of 6561 sherds which were subdivided into 17 types, separated in three large groups. Due to the lack of complete vessels or decorated sherds we had to classify our pottery by wares. Wares that have been considered to belong to the Sierra define the first group (Sierra Group, figure 2), wares related to the central valley of Oaxaca form the second group (Valley Group, figure 3) and wares similar to those found in the Gulf coast comprise the third group (Gulf Group, figure 4). We observed a high predominance of orange wares in the Sierra Group sherds and most of the pottery was used for domestic purposes.

In the central valley of Oaxaca we also found ceramics associated to funeral contexts such as gray and orange bowls. The Valley Group is characterized by the presence of fine and coarse gray vessels (Type G3 and G12 of Monte Albán). However, some of the principal pottery shapes of the Valley Group were also found in some of the main sites of the mountain area. In the Coastal Group we distinguished fine gray and orange wares. Although we could not find complete vessels it was possible to identify some of the most typical potteries of this zone. For TL analysis we selected the most common sherds from each group. In the case of the samples recovered from the archaeological sites of La Mesa and Río Playa, the main objective was to establish the chronological sequence of these sites. Especially in La Mesa there is evidence from archaeological findings such as a gold pendant that this town had also a colonial. In the case of the other samples collected from different archaeological sites of the region, the TL results will help us to adjust their ceramic sequence.

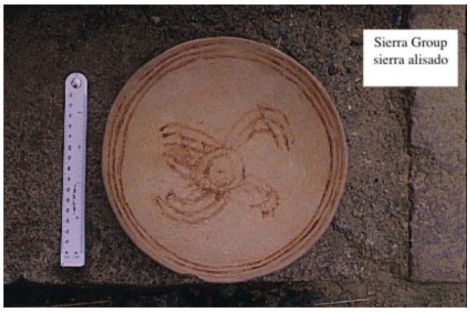

Figure 2. Sierra group ceramics (sierra alisado typology)

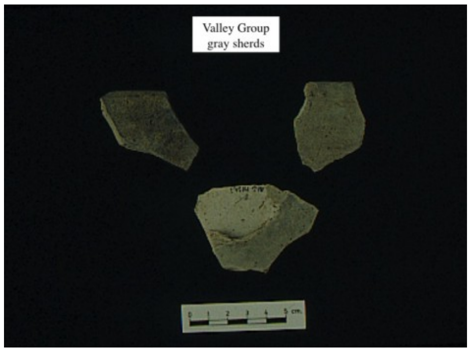

Figure 3. Valley group ceramics (gris typology)

Figure 4. Costa group ceramics (naranja fino typology)

Figure 5. Excavation at La Mesa, San Francisco Caxonos

SAMPLE PROCESSING

In the locations where the ceramics samples were extracted, we placed a portable gamma spectrometer and the parameters to measure the concentrations of uranium, thorium and potassium in the surrounding soil for annual dose rate determinations. Figure 5 shows the excavations at La Mesa, San Francisco Caxonos. The samples were first catalogued and then we selected small ceramic fragments for TL analysis applying the fine grain technique (Zimmerman, 1971). A 2mm layer was first removed from the surface. The remaining sample was crushed and powdered in an agate mortar. Subsequently the sample was treated with H_2O_2 to remove the organic material and HCl to neutralize carbonates. The grain sizes from 4 to 11 μm (Fine grains) were separated and deposited on aluminium discs. The samples were measured with a Daybreak 1100 automatic reader with a heating rate of 10 °C/s using a filter combination of Corning 7-59 and Schott BG39. Irradiations were performed with a ^{90}Sr beta source with an activity of 100 mCi.

GEOCHEMICAL ANALYSIS

Table 1 shows the results of the geochemical analysis of soil and pottery samples. The determination of uranium, thorium and potassium in soil was measured with a portable gamma spectrometer during sampling. For U and Th analyses of ceramics an alpha particle counter was used and potassium was determined with flame photometry.

Table 1. Chemical analysis of soils and ceramics

	Soil			Ceramic		
Sample	Uranium (ppm)	Thorium (ppm)	Potassium (wt %)	Uranium (ppm)	Thorium (ppm)	Potassium (wt %)
OA1	0.754	4.014	1.200	3.870	6.950	1.973
OA2	0.754	4.014	1.200	6.750	11.730	3.617
OA3	0.754	4.014	1.200	5.040	7.040	2.604
OA4	1.242	6.219	0.915	4.870	9.970	1.468
OA5	0.754	4.014	1.200	5.700	4.410	1.829
OA6	0.878	5.790	1.480	5.670	14.160	3.155
OA7	0.754	4.014	1.200	4.580	6.770	2.173
OA8	1.242	6.219	0.915	6.050	5.790	1.367
OA9	1.242	6.219	0.915	3.810	7.890	0.944
OA10	0.878	5.790	1.480	5.360	3.020	1.199
OA11	0.754	4.014	1.200	6.160	2.830	1.320
OA12	0.878	5.790	1.480	5.330	4.840	1.367
OA13	1.242	6.219	0.915	7.580	8.660	2.440
OA14	1.242	6.219	0.915	5.030	9.360	3.513
OA15	1.242	6.219	0.915	4.870	7.160	1.170
OA16	0.754	4.014	1.200	4.860	5.240	1.854
OA17	1.242	6.219	0.915	3.230	5.700	1.022
OA18	0.754	4.014	1.200	3.920	2.310	1.025

THERMOLUMINESCENCE SPECTRAL ANALYSIS

The following part describes the procedure for paleodose determination from spectral analysis. As an example we present the results of sample OA3 (The same procedure was applied to all eighteen samples). First the natural TL signal (TLN) was measured. In figure 6 we can observe the natural TL signal with a well defined peak between 270 and 290°C. Subsequently the additive dose method was applied to calculate the equivalent dose rate Q. For that purpose the natural samples were irradiated with different doses. Figure 7 shows the TL spectra of the additive dose method, where we can observe the natural TL signal (TLN) and the natural TL signal together with different artificial doses (TLN+β). In both cases the TL peaks appear in the same temperature range. Using the values of the additive dose method, the equivalent dose "Q" was calculated with a linear equation at 280°C (Figure 8). For a correct assessment of the paleodose it is necessary to identify the stable region of the spectrum without signal loss. For this attempt we used the plateau test (Aitken, 1985) where (natural TL signal/ natural TL+β) versus temperature is plotted (Figure 9). In the case of sample OA3 a well defined plateau in the range between 270 and 290 °C can be observed. The paleodose value (P) is composed of the equivalent dose "Q" and the supralinearity correction "I" (P = Q + I). Once the value of "Q" is obtained, a second irradiation is necessary to calculate this supralinearity correction. Figures 10 and 11 show the evaluation of the supralinearity correction "I", obtained from irradiations of samples disks which were resetted to zero during the first irradiation process (Additive dose rate). When annual dose rate, equivalent dose and supralinearity factor are finally determined, these values are introduced into the age equation:

$$TL_{age} = \frac{\text{Equivalent dose}(Q) + \text{Supralinearity correction}(I)}{\text{Alpha dose}\cdot(k) + \text{Beta dose}\cdot(0.90) + \text{Gamma dose} + \text{Cosmic dose}}$$

$$OA3, TL_{age} = \frac{2.088\,Gy}{4.474 \times 10^{-3}\,Gy/y} = 466 \pm 20\ years$$

$$OA3, TL_{age} = 1543 \pm 20\ years\ A.D.$$

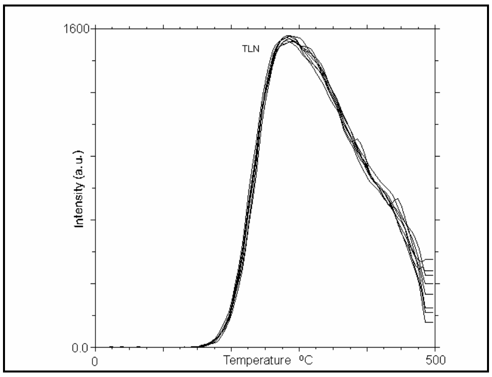

Figure 6. Natural TL signal. A well defined TL peak in the temperature range between 270 and 290°C is shown.

Considerations to the TL age equation: Moisture effect and absorption coefficient for water were determined from Zimmerman (1971). Attenuation factor for beta contribution = 0.90 (Aitken, 1985). Cosmic dose rate = 150 μGy/y (Prescott et al., 1982). Annual dose rate calculations were performed with the Adamiec and Aitken (1998) conversion factors.

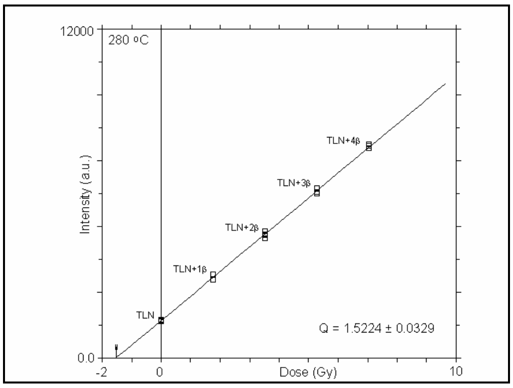

Figure 7. Additive dose method

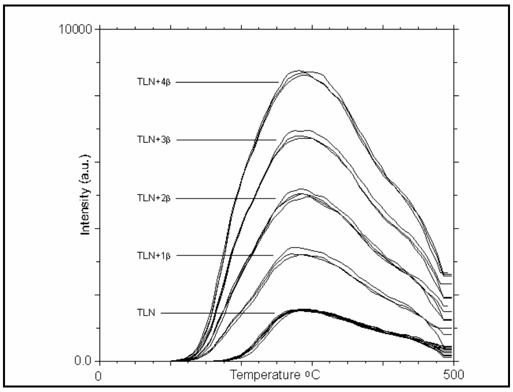

Figure 8. Calculation of the equivalent dose "Q" using the linear regression equation

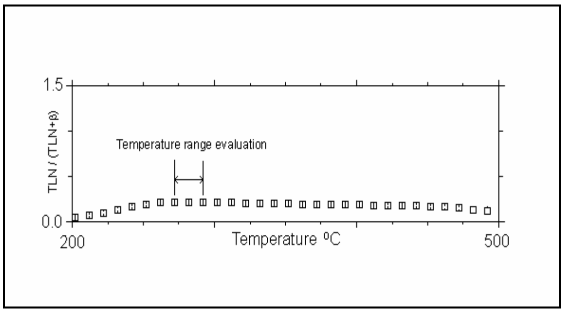

Figure 9. Plateau test. A plateau in the temperature range between 270-290°C is marked

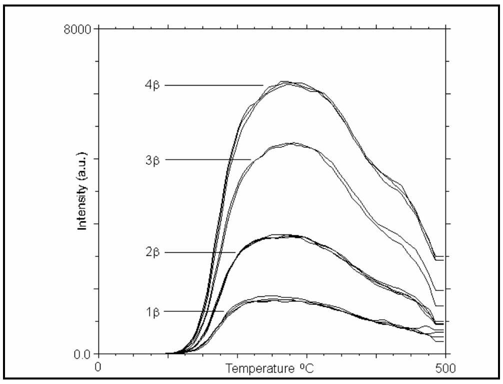

Figure 10. Second glow growth for evaluation of the supralinearity correction "I"

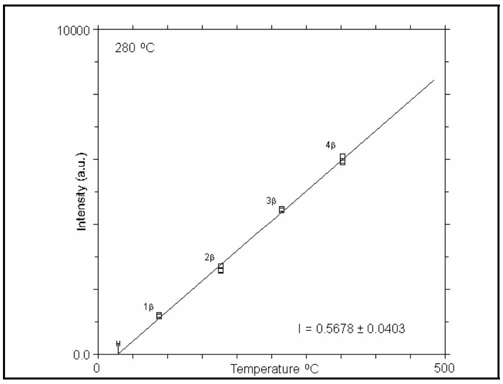

Fig. 11. Determination of the supralinearity correction "I" using the linear regression equation at 280ºC

RESULTS

A compilation of paleodose, annual dose rates and TL ages of the eighteen samples is given in Table 2. Samples OA14 and OA16 showed no reproducible glow curves and sample OA18 did not show a plateau in the plateau test. Table 3 shows the comparison between the obtained TL ages and the proposed ages by the archaeologist (PhD. Edith Ortiz).

CONCLUSIONS

Based on the ceramic typology the earliest materials of the Sierra were related with Monte Alban IIIA-IIIB Phase, which means not before 500AD.

Table 2. Paleodose, annual dose rate and TL ages

Sample	Paleodose (Gy)	Annual dose rate ($x10^{-3}$) (Gy/y)	TL age (years) (2009)
OA1	1.940 ± 0.10	3.374 ± 0.16	574 ± 30
OA2	3.717 ± 0.24	5.889 ± 0.29	631 ± 40
OA3	2.088 ± 0.09	4.474 ± 0.22	466 ± 20
OA4	3.976 ± 0.46	4.607 ± 0.23	863 ± 100
OA5	2.850 ± 0.32	5.426 ± 0.27	525 ± 59
OA6	2.719 ± 0.26	5.335 ± 0.26	509 ± 48
OA7	2.059 ± 0.37	5.702 ± 0.28	361 ± 64
OA8	3.322 ± 0.36	3.930 ± 0.19	845 ± 50
OA9	1.772 ± 0.10	3.850 ± 0.19	1870 ± 140
OA10	1.772 ± 0.10	3.850 ± 0.19	460 ± 25
OA11	2.046 ± 0.12	3.512 ± 0.17	582 ± 35
OA12	1.840 ± 0.18	3.535 ± 0.17	520 ± 50
OA13	3.304 ± 0.11	4.715 ± 0.23	700 ± 23
OA14	No reproducible	4.793 ± 0.22	X
OA15	6.970 ± 0.29	4.133 ± 0.20	1686 ± 70
OA16	No reproducible	3.512 ± 0.17	X
OA17	1.844 ± 0.10	2.720 ± 0.13	678 ± 36
OA18	No plateau	2.559 ± 0.12	X

Based on the TL analyses it seems that the mountain area was occupied since Monte Albán II period, around 200 AD. The earliest TL age from La Mesa (Sample OA9) is a sherd from the Gulf Coast that was recovered from a reoccupied tomb in the archaeological site of San Francisco Caxonos. This is a very interesting result which encourages us to make further TL analysis of this particular ceramic type discovered in other mountain sites.

On the other hand, it is clear and confirmed by the archaeological information and TL chronology, that the ancient highland Zapotecs of La Mesa established an intense exchange relation with the inhabitants of the Oaxaca Valley and the Gulf Coast for the Late Classic period until the Spanish conquest (650-1521 AD).

Another important aspect to remark is that the highland Zapotecs continued with their burial procedures or *caciques* in the traditional pre-Hispanic way after the Spanish conquest of the Zapotec Highlands which took place around 1527 AD. This is confirmed by sample OA10 with an age of 1549 AD. This specific result confirms historical documents in which the Zapotecs maintained some of their ancient mortuary practices almost until the end of the 16th century.The environmental conditions in the Sierra belong to the cloud forest climate. This avoided the preservation of charcoal in the soils because of its elevated humidity.

Therefore thermoluminescence analyses were applied to solve the chronological sequence of this unexplored Mexican region. Samples OA14 and OA16 showed no reproducible TL spectra when they were artificially irradiated and sample OA18 did not show a plateau in the plateau test. For that reasons these samples could not be dated by TL.

Possibly the mineralogical compositions are not favorable for TL dating and show similar features to those ceramics produced in the Gulf of Mexico region, which frequently are also undatable.

Further analyses such as XRD and petrographical studies are necessary to confirm this hypothesis. Finally the samples showed no fading.

Table 3. Thermoluminescence ages and proposed ages (*) by archaeologist Edith Ortiz

Typology	Archaeological Code	TL Code	*Approximate age range (A.D.)	TL age (years) (2009)	Relative TL age (years A.D.)
Sierra alisado	III-2-Mesa-27	OA1	1000 – 1600	574 ± 30	1435 ± 30
Sierra cepillado burdo	III-2-mesa-27	OA2	1000 – 1600	631 ± 40	1378 ± 40
Valle gris burdo	3-2-Mesa-14	OA3	500 – 1000	466 ± 20	1543 ± 20
Planicie burdo poroso	III-2- UNT-30	OA4	0 – 1000	863 ± 100	1146 ± 100
Sierra ahumado fino	III-2-mesa -73	OA5	1000 – 1600	525 ± 59	1484 ± 59
Sierra ahumado burdo	III-2-Mesa-49	OA6	1000 – 1600	509 ± 48	1500 ± 48
Valle fino gris	IV-SCAL 97	OA7	500 – 750	361 ± 64	1648 ± 64
Costa blanco fino	Mesa –B42 –III-2	OA8	500 – 1000	845 ± 50	1164 ± 50
Planicie ahumado burdo	III- Rios – Psta- 825 - 6480	OA9	Unknown	1870 ± 140	139 ± 140
Sierra ahumado fino	III-2- mesa -9	OA10	1000 – 1600	460 ± 25	1549 ± 25
Valle gris	III-2- Mesa-B-42	OA11	500 – 1000	582 ± 35	1427 ± 35
Sierra cocción diferencial	III-2-Mesa-98	OA12	1000 – 1600	520 ± 50	1489 ± 50
Costa gris fino	III-2- Mesa –B14	OA13	500 – 1000	700 ± 23	1309 ± 23
Costa naranja fino	VI-L-JNT-30	OA14	0 – 1000	Not reproduci-ble	X
Planicie cocción diferencial	III-Río-IIA-82 6450	OA15	0 – 1000	1686 ± 70	323 ± 70
Sierra pulido engobe	III-Xoca –II A- LBDO-V-886	OA16	500 – 1000	Not reproduci-ble	X
Costa gris granular	IV-SJA-BJO	OA17	500 – 1000	678 ± 36	1331 ± 36
Valle bayo fino	III-SJUA-88	OA18	500 – 1000	No plateau	X

ACKNOWLEDGEMENTS

Thanks to Kumiko Shimada Miyasaka of the Instituto de Geología, Universidad Nacional Autónoma de México for support with the potassium analyses. Thanks to CONACYT for the support grant to the project G30704-H.

REFERENCES

Adamiec, G. and Aitken, M.J. (1998). *Dose-rate conversion factors: update*, Ancient TL, Volume 16, No. 2, 37-50.

Aitken, M.J. (1985). *Thermoluminescence dating,* Academic Press, London.

Ortiz, E., (2005). *Río Caxonos: Vía de Comunicación y Comercio entre los Valles Centrales de Oaxaca y la Costa del Golfo*. 4o Coloquio Pedro Bosch-Gimpera: La Arqueología Mexicana, Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México, p. 695, México.

Gutiérrez, G., Van Rossum, P. and Ortiz, E. (2000). *Least cost path analysis: an estimation of the most efficient communication route between the Oaxaca valley and the Gulf of Mexico coastal plain, Caxonos River Project*, in Memorias del I Congreso Nacional de Arqueometría, Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México.

Prescott, J.R. and Stephan, L.G. (1982). *Contribution of cosmic radiation to environmental dose*, PACT 6,17-25.

Ramírez, A., Schaaf, P. y Gonzalez, P. (1997), *Fechamientos arqueológicos y geológicos por el método de termoluminiscencia*, Instituto de Geofísica, Universidad Nacional Autónoma de México, Reportes Internos 97-14.

Zimmerman, W.D. (1971). *Thermoluminescent dating using fine grains from pottery*. Archaeometry 13, 29-52.