Journal of Archaeological Science: Reports 30 (2020) 102274

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

The memory of fire in El Coporo (Northern Mesoamerica): Apogee and abandonment

Alejandra García Pimentel[a], Avto Goguitchaichvili[a,*], Carlos Torreblanca[b], Rubén Cejudo Ruiz[a], Vadim Kravchinsky[c], Rafael García[a], Juan Morales[a], Miguel Cervantes[a]

[a] Servicio Arqueomagnético Nacional (SAN), Instituto de Geofísica, UNAM, Unidad Michoacán, Campus Morelia, Antigua Carretera a Pátzcuaro No. 8701 Col. Ex-Hacienda de San José de la Huerta, 58190 Morelia, Michoacán, Mexico

[b] INAH Zacatecas, Mexico

[c] Geophysics, Department of Physics, University of Alberta, Edmonton, Alberta T6G2E1, Canada

ARTICLE INFO

Keywords:
Mesoamerica
Absolute chronology
Archaeomagnetism
Mexico
Guanajuato
El Coporo

ABSTRACT

Most detailed archaeometric studies come from central and southern Mesoamerica while many important sites belonging to the western regions are not yet rigorously studied. Here we report a detailed rock-magnetic and archaeomagnetic study from the El Coporo archaeological site at the northern border of Mesoamerica. Our study of more than 100 oriented samples was performed on the six most important sites distributed along the archaeological zone. Continuous thermomagnetic curves revealed magnetite as responsible for magnetization accompanied by unstable (titano)maghemite. Most of the samples are characterized by a single component magnetization, which is almost completely removed applying 50 mT, suggesting the presence of relatively low coercivity magnetic minerals. Characteristic directions were precisely determined for four out of six studied sites, yielding statistically undistinguishable directions. Corresponding archaeomagnetic age intervals range from 820 to 950 A.D. in good agreement with previous archaeological studies that suggested a period of abandonment at about 900 A.D. as an attempt to reoccupy the place by the Toltecs. Numerous archaeological evidences argue in favor of an intentional fire. However, the possibility of ritual closure should be also considered since there is no evidence of violent or warlike actions.

1. Introduction

Mesoamerica is a cultural region that includes the central and southern territories of Mexico together with Guatemala, Belize, El Salvador, western Honduras and Nicaragua where various pre-Hispanic cultures such as the Olmecs, Toltecs, Teotihuacanos, Zapotecs, Aztecs, Mixtecs and Mayas developed. In Mexico, the northern border of this cultural region includes the states of Michoacán, Guanajuato, Jalisco, Mexico and partly Veracruz. The chronology of Mesoamerica is comprised within three great intervals: the Preclassic period, which begins around 2000 BC and ends approximately 300 AD; the Classic period between 300 and 900 AD and the Postclassic period that comprises from 900 AD to 1521 AD. This chronology is based on stratigraphic sequences based mainly on pottery and architectural styles.

The first archaeomagnetic investigations in Mexico were carried out by Nagata et al. (1965), who determined the absolute geomagnetic paleointensities on pottery samples from Cuicuilco in the south of Mexico City, and on basalts and pyroclastic rocks of the Xitle historic eruptions (Soler-Arechalde, 2006). Daniel Wolfman in 1969 analyzed the first samples for archaeomagnetic dating proposing an updated chronology for Mesoamerica between 0 and 1200 AD. Wolfman (1973) considered chronological order of the geomagnetic virtual poles based mainly on stratigraphy and pottery style and very few available ^{14}C dates, recognizing that they were insufficient for an adequate description of the secular variation of the geomagnetic field. The sites studied by Wolfman are located in central Mexico, the Oaxaca valley, Zapotal, central and western Chiapas, Guatemala and Honduras (Soler-Arechalde, 2006). Archeomagnetic studies increased considerably during the last two decades, allowing to expand the range of archeological artifacts, as presented by the study of Goguitchaichvili et al. (2004), who analyzed four Mesoamerican wall paintings, from which the direction of its remnant (pictorial) magnetization was determined successfully. This is considered a pioneering work in the determination of archeodirections for Mesoamerican murals containing reddish pigmentation. Apparently, a mixture of magnetite and hematite is responsible for magnetization (Goguitchaichvili, 2018). Morales et al.

* Corresponding author.
E-mail address: avto@igeofisica.unam.mx (A. Goguitchaichvili).

https://doi.org/10.1016/j.jasrep.2020.102274
Received 12 September 2019; Received in revised form 17 January 2020; Accepted 28 January 2020

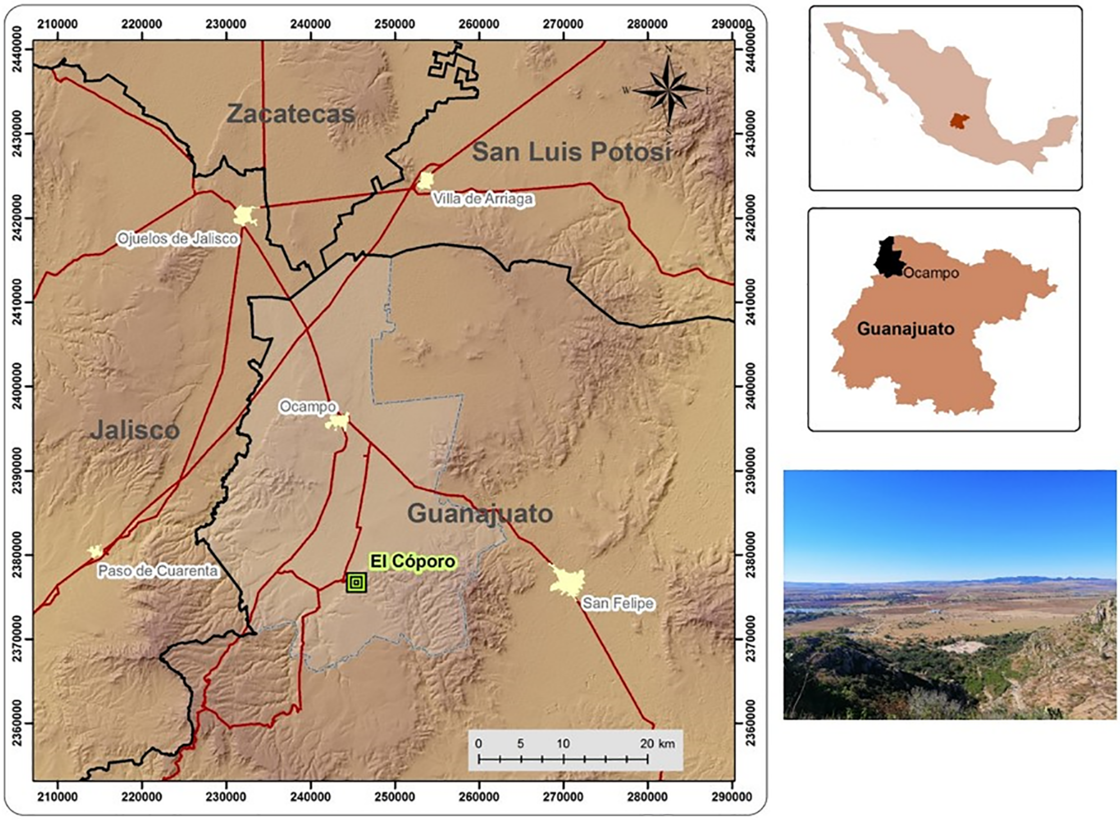

Fig. 1. Schematic locations map and general view of El Coporo archaeological zone in State of Guanajuato, Mexico.

(2015) reported an archeomagnetic study of the burnt floor of the archeological site of Plazuelas (State of Guanajuato) in order to determine the age of abandonment of the site. The absolute dates obtained in this study for the last exposure to fire of the analyzed floor were quite consistent with the archeological evidence available for the Plazuelas site (Goguitchaichvili, 2018).

The principal aim of this investigation is to contribute to the absolute chronology of El Coporo archeological site and to obtain some firm constraints on its still debated abandonment and decline periods. A detailed archeomagnetic study was carried out on six of the most important complexes (more than 100 samples) distributed throughout the archeological zone.

2. Archeological context and sampling

The archeological site El Coporo is located within the municipality of Ocampo (21°32′58″N 101°28′22.71″W), northwest of the state of Guanajuato (Fig. 1), on the foothills of the Sierra de Santa Bárbara and next to the community of San José del Torreón (Torreblanca-Padilla, 2015). The El Coporo site was settled on the hill of the same name whose flat top was used to build the ceremonial area. The El Coporo plateau is surrounded by two canyons. Both on the slopes and on the low or flat part, there are evidences of multiple old buildings. Torreblanca-Padilla (2015) classified several cultural areas as follows: El Llano, Gotas, Montes, Puerto del Aire, Coporo, Caracol and Pilar complexes. Regarding the architecture, it may be appreciated the presence of a sophisticated system of squares connected by roads manufactured in slabs. A particularity at the regional level is a room with wooden columns, as well as the orientation of the pyramidal basement, towards the west, which allows an inference on the importance that the sunset represented for the inhabitants of El Coporo.

The archeological investigations at El Coporo began in 1962, with the first explorations carried out by Beatriz Braniff. In 1962, she performed pioneering archeological surveys and excavations both on the top of the hill and on the slopes. Based on these investigations, the northwest region of Guanajuato, as well as the southeastern part of Zacatecas and western San Luis Potosí, began to be known as the Tunal Grande culture of co-tradition. As a result of this excavation, a first ceramic classification was suggested for El Coporo (Braniff, 1963, 1972), this being a regional reference (Torreblanca-Padilla, 2015). The pottery type called Valle de San Luís, with a red and black decoration on an orange background, is considered as the diagnostic indicator of the Tunal Grande. This ceramic style has been detected in sites such as El Cerrito and Peñón Blanco in Zacatecas, Chinampas and El Cuarenta in Jalisco and on the San Damián River near San Miguel de Allende. Based on the dispersion of this ceramic type, a new pottery style called San Luís Policromo has been proposed, which includes the Coporo in Guanajuato, El Cerrito in Querétaro, the Sierra de Comanja region in León and the La Montesa area in southeastern Zacatecas (Torreblanca-Padilla, 2015). This ceramic classification allowed a comparison between the Coporo and the *Bajío Guanajuatense* and Northern Mexico. In a first correlation of ceramic types, a three-phase occupational sequence for the Coporo was proposed, associated with the Mesoamerican Preclassic, Classic and Postclassic periods, mentioned below:

- Early Coporo (500 BC – 300 AD). This phase was defined by the presence of ceramics called Coporo Gray, associated with the Morales Phase of the Laja River area. All these artifacts are associated with a funerary context (Torreblanca-Padilla, 2015).
- Middle Coporo (300–900 AD). This phase was defined based on the association of ceramics considered as "local" with others such as *Blanco Levantado Cloisonné*, San Luís Valley and Anaranjado Delgado. These pieces were described as a bi-chrome type with a polished surface, fine orange to light brown paste, with sand, quartz and pyrite as a degreaser. The Anaranjado Delgado also may be correlated with Teotihuacán IV.

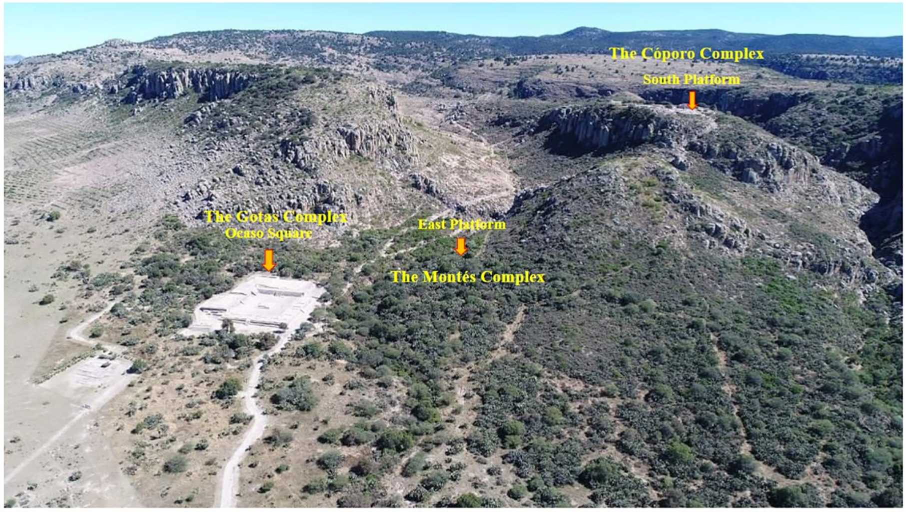

Fig. 2. Sampled site locations showing the Gotas, Montes and Coporo complexes.

- Late Coporo (900–1100 AD). Finally, this phase was represented by the association of "local" ceramic types with the Blanco Levantado style that refers it to the Early Postclassic in Tula.

In order to cover wide intervals of temporal and spatial occupation of El Coporo archeological site, six localities with clear evidence of burned soil floors were sampled in detail belonging to the Gotas, Montes and Coporo complexes (Figs. 2 and 3). Five of these sites correspond to previously excavated areas, while sample V (The Montes complex) was collected from an unexcavated area.

3. Magnetic measurements

Rock-magnetic experiments allow to reveal the magnetic carriers and their thermal stability. Continuous thermomagnetic curves were recorded up to 620 °C with a 15 °C per minute heating rate using a MFK1 AGICO Ltd susceptibility meter equipped with a furnace under normal atmosphere. Measurements of remnant magnetization were carried out using a JR6a spinner magnetometer while alternating field treatments were performed using a LDA-3 AGICO demagnetizer with a maximum available alternating field of 95 mT. Because of the unstable thermal behavior, no absolute intensity experiments were intended. The characteristic remnant magnetization (ChRM) directions for each specimen were computed by linear regression including at least 5 demagnetization steps (Kirschvink, 1980). Fisher (1953) statistics were employed to calculate statistical parameters associated to the mean directions. All magnetic measurements were done at the facilities of the National Archeomagnetic Service at Campus Morelia - UNAM.

4. Results

Susceptibility vs. Temperature curves revealed an unstable thermal behavior (Fig. 4). The heating and cooling curves are irreversible, suggesting that some alteration occurred during heating. The common feature of all samples is a clear evidence of almost magnetite (or Low-Ti titanomagnetite) phase with Curie points ranging from 567 to 586 °C.

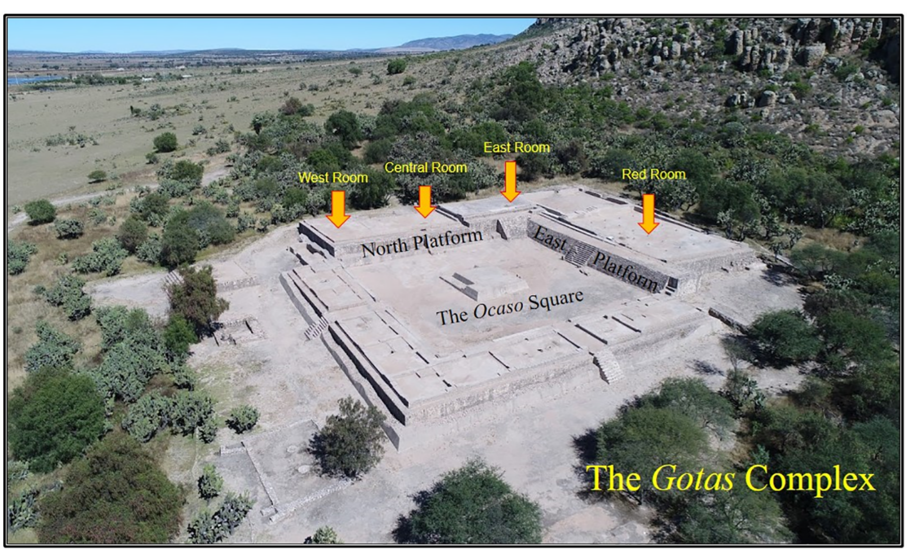

Fig. 3. The details of sampled locations at *Ocaso Square* (The Gotas Complex). See text for more details.

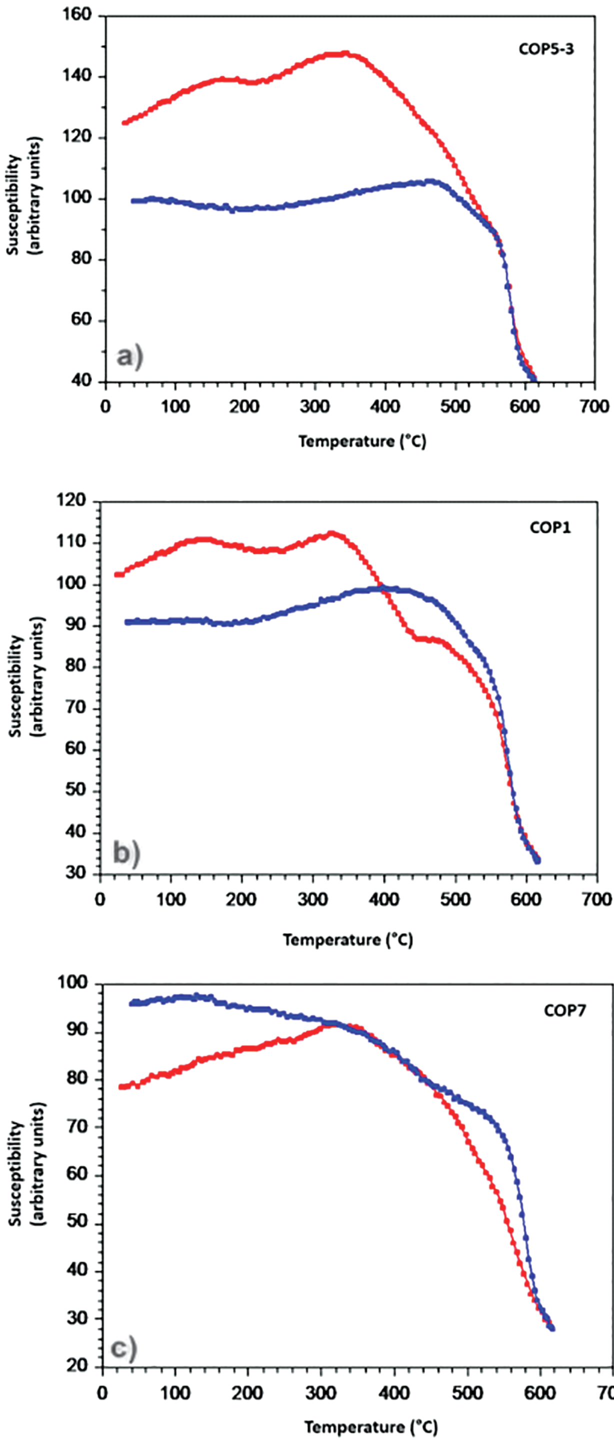

Fig. 4. Susceptibility vs. temperature continuous thermomagnetic curves for representative samples. Heating plot is shown in red while the cooling cycle is represented by blue color.

Beside of this dominant ferrimagnetic phase, a low temperature phase is observed between 220 and 240 °C on the heating curve exclusively, which may indicate the inversion of (titano)maghaemite. It should be noted however, that this transformation occurs commonly at about 350 °C. No firm evidence of the presence of hematite grains is detected.

Some representative examples of natural remnant magnetization demagnetization plots (so-called Zijderveld diagrams) are reported in Fig. 5. Most of the samples are characterized by a stable, uni-vectorial component, which is almost demagnetized at 40 mT (Fig. 5a and b) indicating that a relatively low coercivity ferromagnetic mineral is the carrier of remnant magnetization. Few samples exhibited a clear evidence for viscous overprint which was easily removed applying 10 mT (Fig. 5c). All samples from Site III (see Table 1 and Fig. 5d) were rejected because of inconsistent paleodirections and poorly defined demagnetization patterns. Archeomagnetic directions were precisely defined for four localities (Table 1), yielding α95 values of 4° or less. Site IV (Ocaso Square, North Platform) yielded slightly scattered directions with α95 of 8.7°.

The mean archeodirections obtained here were compared with the SCHA.DIF.14 k model (Pavón Carrasco et al., 2014). Archeomagnetic dating was performed using the MATLAB dating tool of Pavón Carrasco et al. (2011) and the probability density functions at the 95% probability level (Fig. 6). Because very similar paleodirections were obtained from all studied sites, the possible aracheomagnetic intervals are similar (Table 1). While all ages roughly range between 820 and 950 AD, site IV yields a larger interval from 685 to 1069 AD (Table 1). This is due to the fact that mean directions are quite scattered and thus this age interval should be considered with some caution.

5. Discussion and concluding remarks

Most of archaeological artifacts including pottery samples, correspond to the last stage of occupation, corresponding to the Epiclassic period (600–900 AD). After the fall of the great Teotihuacán approximately at 600 AD, a clear decline of commercial networks and a new territorial conformation deriving in new regional governing centers were documented. During this stage, the Tunal Grande consolidates its maximum regional extension, creating a center of power in each valley. In the state of Guanajuato, El Coporo becomes the capital of the Ocampo Valley. The abandonment of El Coporo is a matter of debate. Some archeological considerations may indicate the decline of the site at about 900 AD while some recent studies (Torreblanca-Padilla, 2015) indicate a period of reoccupation between 900 and 950 AD by the Toltecs. By the year 1000 AD the Tunal Grande region or northern border of Mesoamerica is completely uninhabited by Mesoamerican agricultural groups. After the abandonment of El Coporo, as well as the entire valley of the Rio Grande de Ibarra and the surrounding valleys, there is a depopulation stage of the region located in the period between 1000 AD and 1300 AD. At that time the region is re-occupied by former nomadic settlers. By the time of the Spanish Conquest, El Coporo is covered by thorny vegetation, which prevented its colonization.

The main outcome of this investigation is the fact that whatever sampling localities are involved along the Coporo archeological zone, their absolute archeomagnetic datings intervals are very similar, which indicates that the big, generalized firing event occurred at same time suggesting unique episode. The presence of burned beams and soot stains observed on the floors of the Ocaso Square, as well as in several places within the Coporo and Montes complexes, allows us to propose the hypothesis of an intentional fire. This hypothesis is reinforced by the presence of collapsed buildings due to the generalized firing. However, the possibility of ritual closure should be also considered, since there is no evidence of violent or warlike actions. The presence of large burned spaces in pre-Hispanic settlements such as La Quemada

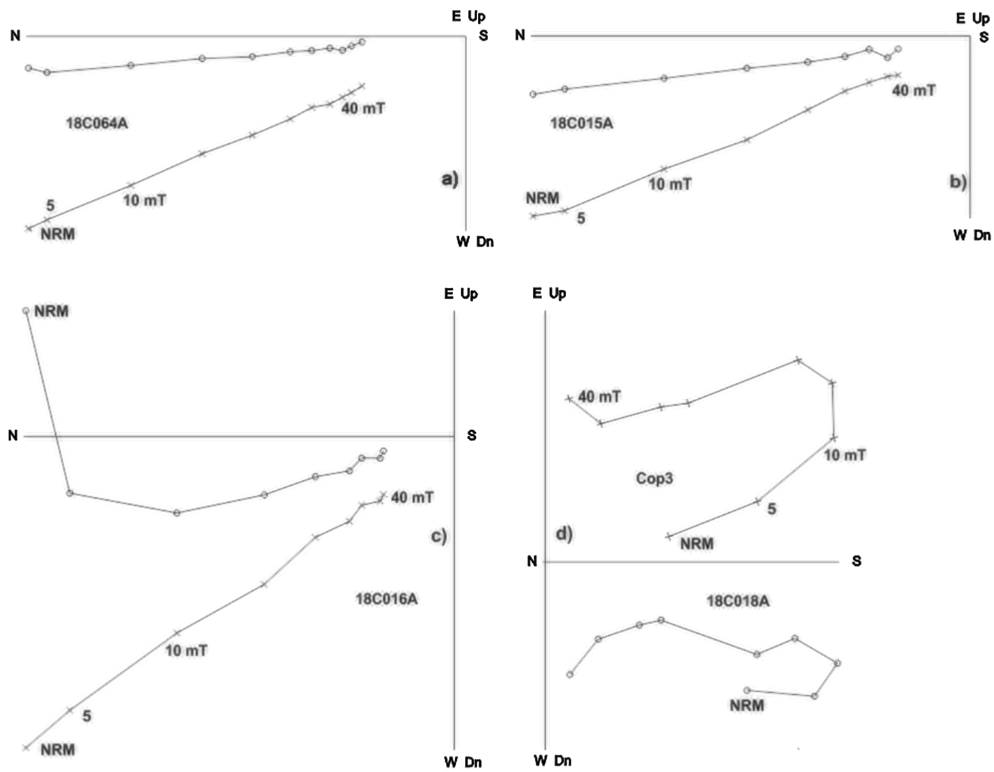

Fig. 5. Representative examples of orthogonal vector plots (also known as Zijderveld diagrams) illustrating the alternative field treatments up to 95 mT for El Coporo samples.

Table 1
A summary of archaeomagnetic results obtained for El Coporo sites: n is the number of samples used in the calculation of the site mean direction, N is the total number of samples measured; α_{95} and k are precision parameters of Fisher statistics. Dec. declination; Inc. inclination.

SITE	Structure	Location* N	E	n/N	Inc (°)	Dec (°)	α_{95} (°)	k	Possible Dating Intervals (d.C.)
I	*Ocaso* Square East platform Red Room	2377062	0245217	8/8	25.7	353.8	4.2	136	**769–946**
II	*Ocaso* Square North platform East Room	2377081	0245211	8/9	27.4	351.4	3.9	143	**840–977**
III	*Ocaso* Square North platform Central Room	2377089	0245196	0/8	–	–	–	–	–
IV	*Ocaso* Square North platform	2377086	0245791	7/8	30.5	353.2	8.7	44	**685–1069**
V	*Montes* Complex, East Platform	2376933	0245192	8/8	24.3	349.3	3.7	189	**863–967**
VI	Coporo Complex, South Platform	2376720	0245498	8/8	26.4	352.4	2.8	295	**827–963**

***Location:** UTM WGS84 Datum 13 N.

(López-Delgado et al., 2019) and Plazuelas (Morales et al., 2015), and now El Cóporo, show a repetitive pattern. In addition, it seems that there is a gradual abandonment, due to the very few archaeological materials found inside the enclosures. Both in Coporo and Plazuelas, there is a strong evidence of looting caused by the occupants themselves. It is also well known that the end of the Epiclassic period is characterized by an abandonment of the original settlements and population mobility in search of new territories. Based on the above, we assume, rather than a fortuitous fire, a regional phenomenon of abandonment of these archaeological sites.

Previous archaeological studies suggested a period of abandonment at about 900 AD, and an attempt to reoccupy of site by the Toltec culture (Braniff, 1972). Ceramic materials recovered in El Coporo, such as *Plumbate* and *Blanco Levantado*, are characteristics of the Toltec culture (Braniff, 1963, 1972). The Late Coporo period (900–1100 AD) is currently considered to be the Caracol phase (900–1000 AD) (Torreblanca and Villalpando, 2015). Based on new archaeomagnetic ages, it is possible that the El Coporo culture was most likely extinguished likely between 850 and 950 AD, a period that coincides with the reoccupation of the area by the Toltecs. The site was completely abandoned by 1100 AD, and no evidence of human occupation was found between 1100 and 1300 AD.

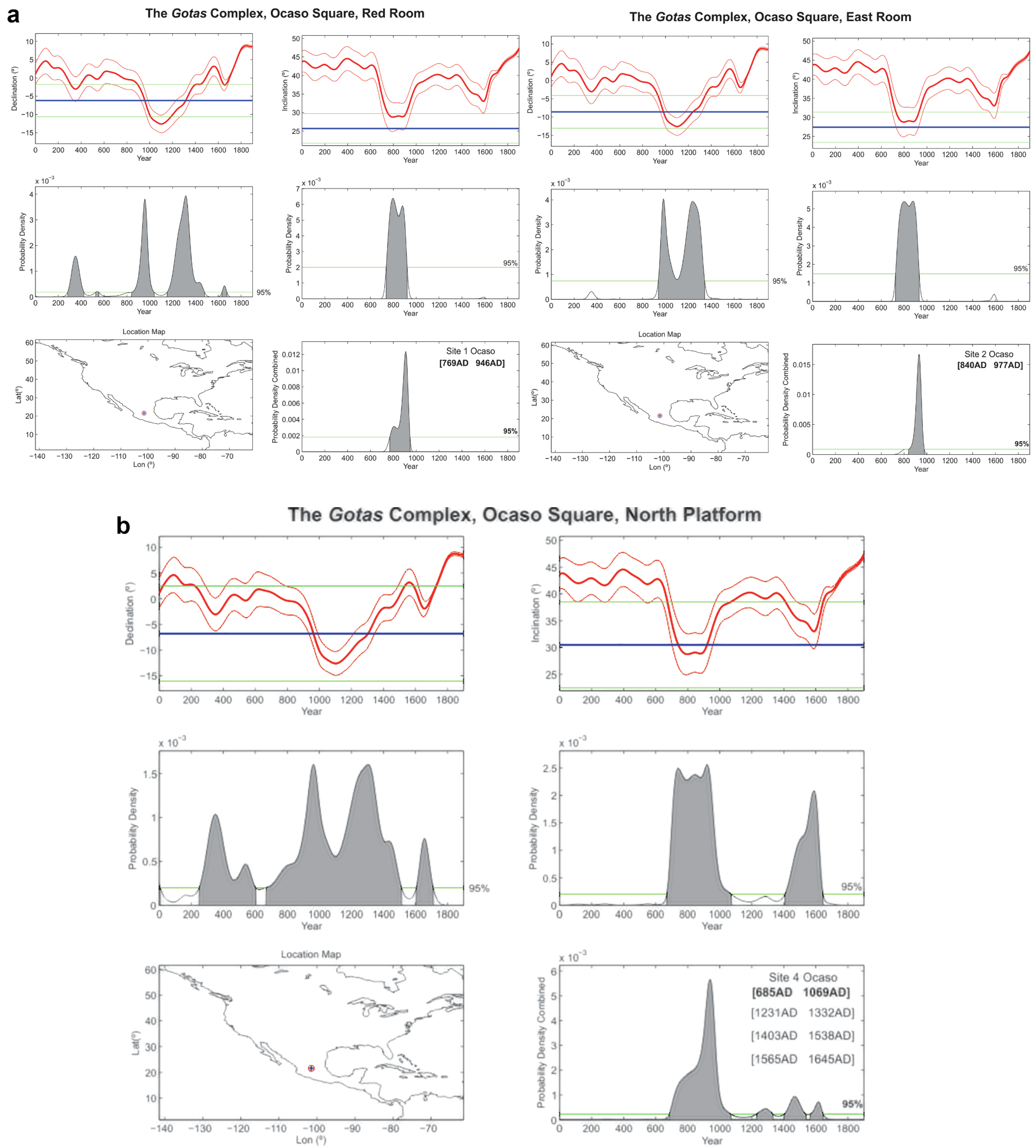

Fig. 6. a–c. Archaeomagnetic dating using a MATLAB tool provided by Pavón-Carrasco et al. (2011, 2014) for El Coporo site (21°32′58″N 101°28′22.71″W). The blue line are the mean declination and inclination with their green error bands expressed as the parameter a95 given in Table 1. The green lines on the probability density functions indicate the different thresholds for the declination and inclination considering the level of probability chosen. The dating process follows the descriptions given by Lanos (2004), which is based on the combination of temporal probability density functions of the geomagnetic field elements, relating the behaviour of geomagnetic field with the paleosecular variation curve obtained using the model SHA.DIF.14 k for Central Mexico.

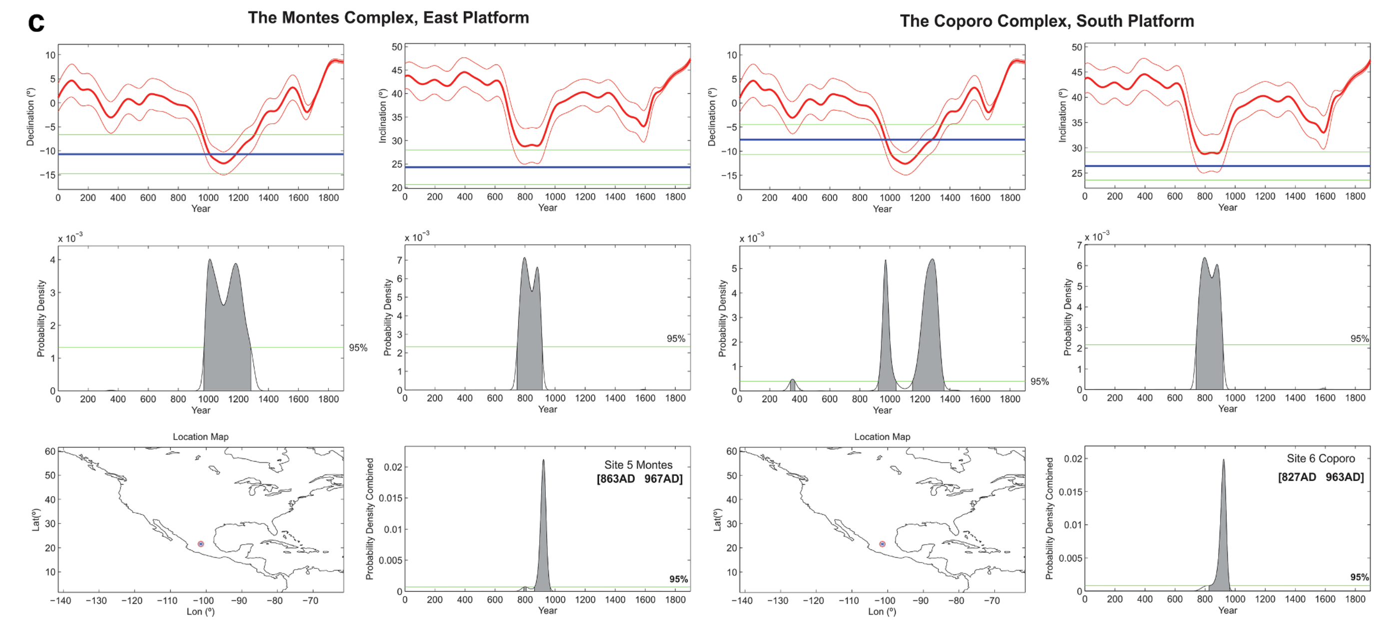

Fig. 6. (*continued*)

Authors contributions

Avto Gogichaishvili and Alejandra Garcia designed the research, analyzed and interpreted data, prepared most of the manuscript. Carlos Torreblanca provided archeological context description. Ruben Cejudo and Vadim Kravchinsky analyzed magnetic mineralogy data. Rafael Garcia helped with archaeomagnetic dating global models while Juan Morales and Miguel Cervantes helped in sample collection campaign.

Acknowledgements

This work was supported by CONACYT grant n° 252149 and DGAPA PAPIIT n° IN101920. V.A.K. acknowledges partial support given by the Natural Sciences and Engineering Research Council of Canada (NSERC grant RGPIN-2019-04780).

References

Braniff, B., 1963. Breve informe sobre las excavaciones en El Cóporo, Guanajuato. Archivo técnico de la sección de arqueología del INAH Guanajuato.

Braniff, B., 1972. Secuencias arqueológicas en Guanajuato y la cuenca de México: un intento de correlación", en Teotihuacan: xi mesa redonda de la sociedad mexicana de antropología. Sociedad Mexicana de Antropología, México, pp. 273–323.

Fisher, R.A., 1953. Dispersión on a sphere. In: Proceedings of the royal society, a.217, pp. 295–305.

Goguitchaichvili, A., Soler, A., Zanella, E., Chiari, G., Lanza, R., 2004. Pre-columbian mural paintings from mesoamerica as geomagnetic field recorders. Geophys. Res. Lett. 31 (12), l12607.

Goguitchaichvili, A., 2018. Avances en arqueomagnetismo y geofísica aplicada I. Pacual Izquierdo - Egea, Graus, España.

Kirschvink, J.L., 1980. The least-squares line and plane and the analysis of palaeomagnetic data. Geophys. J. Int. 62 (3), 699–718.

Lanos, Ph., 2004. Bayesian inference of calibration curves: application to archaeomagnetism. In Buck, Millard, A. (Eds.) Tools for Constructing Chronologies: Crossing Disciplinary Boundaries. Springer-Verlag, London pp. 43–82. Vol. 177.

López-Delgado, V., Goguitchaichvili, A., Torreblanca, C., Cejudo, R., Jimenez, P., Morales, J., Soler, A.M., 2019. La Quemada: Decline and abandonment in two stages on the classic period northern frontier of Mesoamerica. J. Archaeol. Sci.: Rep. 24 (2019), 574–581.

Morales, J., Castañeda, C., Cárdenas, E., Goguitchaichvili, A., 2015. Evidencias sobre la edad de abandono del sitio arqueológico Plazuelas (Guanajuato, México) mediante la datación arqueomagnética de un piso quemado. Arqueología Iberoamericana 28, 40–45.

Nagata, T., Kobayashi, K., Schwarz, E.J., 1965. Archeomagnetic intensity studies of South and Central America. J. Geomagn. Geoelectr. 17, 399–405.

Pavón Carrasco, F.J., Rodríguez-González, J., Osete, M.L., Torta, J.M., 2011. A Matlab tool for archeomagnetic dating. J. Archaeol. Sci. 38, 408–419.

Pavón Carrasco, F.J., Osete, M.L., Torta, J.M., De Santis, A., 2014. A Geomagnetic Field Model for the Holocene based on archeomagnetic and lava flow data. Earth Planet. Sci. Lett., 388, 98–109.

Soler-Arechalde, A.M., 2006. Investigaciones arqueomagnéticas en México. Fundamentos. Historia y futuro. Instituto de Geofísica, UNAM, Ciudad de México.

Torreblanca-Padilla, C.A., 2015. El Coporo. Una antigua ciudad bajo la nopalera. Guanajuato, México.

Torreblanca Padilla, C.A. y Ana Ruth Villalpando Alba, 2015. Fases de ocupación prehispánica en torno a El Coporo, Guanajuato. En Relaciones interregionales en el Centro Norte de Mesoamérica, pp.157–173. Ed. La Rana, IEC, Guanajuato, México.

Wolfman, D., 1973. A re-evaluation of mesoamerican chronology: ad 1–1200. PhD Thesis. Colorado University, pp. 293.