Ball court in la quemada, northern Mesoamerica: Absolute chronological contributions through the archeomagnetic study of associated fire pits

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ABSTRACT
Since the Late Preclassic, the ball court has been one of the most widely distributed features throughout Mesoamerican territory. Despite its maximum splendor in sites in the Mayan and Olmec area, this ritual and political phenomenon has important architectural expression within the archaeological complex of La Quemada in Zacatecas. To place this enclosure in an absolute chronological framework, an archeomagnetic study was carried out on two fire pits within rooms associated with the court and a burnt cavity on one of its walls. The dating exercise for the first fire pit yielded an interval between 931 and 1006 CE as the best estimate of temporality for its last use. Two equally likely intervals were obtained from the second one (693–947 CE and 1463–1623 CE), so it is not possible to rule out any of them. The burnt cavity revealed a single interval between 757 and 980 CE. These periods would correspond to the La Quemada Phase and its transition to the Citadel Phase, which was the last period of activity in the area before the ball court was abandoned. However, the dating of fire pit 2, which shows a possible late occupation (1463–1623 CE), could be interpreted as a reoccupation during the Postclassic by Zacatecos groups.

1. Introduction

The ball court is considered the most important feature of Mesoamerican culture. Numerous ball courts have recently been discovered from the Early Formative period (1500–1000 BCE; Blomster and Salazar Chávez, 2020), though their origins and evolution remain poorly studied. The ball game was one of the most widely distributed activities in Mesoamerica, both spatially and temporally. It was found in early sites such as the Late Preclassic Olmecas up to the Postclassic Mexicas and spatially in the Maya, Oaxaqueña, Gulf of Mexico, Central Altiplano, and Western and Northern Mexico areas. It is an architectural component that orders space inside pre-Hispanic settlements and has different shapes and sizes. It was usually located among main buildings and their number varies in each location. It had an important ritual or political character among the population because it had astronomical connotations where the cosmic duality of day and night was present, as well as associations with war and fertility.

The pre-Hispanic settlement of La Quemada was in the center of the Malpaso Valley (State of Zacatecas, Mexico) and was distributed at the top, sloping on an elongated hill from northwest to southeast. Old builders adapted and leveled the hill by creating large platforms for ceremonial, housing, and administrative purposes. Currently, five levels are recognized. The lowest level was located in the southern part of the hill and corresponds to a place to which all its inhabitants had access. Two pyramidal bases made up the main entrance to the city. A large cobbled path led to the large square where the ceremonies were held and to the \textit{Salon de las Columnas}. Subsequently, the main ball court and great Piramide Votiva was where the main deity of the site resided. Two huge staircases gave access to a second level, where housing, ceremonial, and administrative spaces such as \textit{El Cuartel} and the \textit{Plaza de la Piramide} were located. On the third level was a large square surrounded by rooms known as \textit{Conjunto de los Maestros}. In this place stood a pyramidal base, a central altar, and large halls. The fourth level consisted of a square with a central altar and pyramid, surrounded by a peripheral sidewalk and rooms, known as the \textit{Plaza de los Sacrificios}. Moreover, there were possible column room (Hers, 1995). Finally, on

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the fifth level, the Ciudadela area was located in the highest and farthest area from the main center, consisting of a square with a central altar, a pyramidal base, and a hall of columns.

La Quemada had an important interaction with Chalchihuites Culture, such as Alta Vista north of Zacatecas, the canyon region west of Zacatecas, and the Bajo and the Tunal Grande region. The pottery known as Tepozan was distributed in these regions, which stood out for its complex iconography. The distribution denoted a symbolic exchange that made La Quemada the most important religious center in the region. This was manifested in the architecture of the settlement; it had the largest pyramidal base in the area, three ball courts, and several squares with pyramids. The hall of columns was a structure repeated in both Alta Vista and El Cóporo in Guanajuato. In La Quemada, there were three halls of columns where social and religious power was concentrated. They had architectural features that Tula transcended with the Palacio Quemado in the Early Postclassic.

The pre-Hispanic occupation in La Quemada occurred from 300 to 400 CE to 600–650 CE and is known as Malpaso (Jiménez and Darling, 2000). During this phase, the first examples of occupation appeared in the Malpaso Valley. Ceramics shared traits with the region of Chalchihuites, i.e., the tripod pots of the black incised scraffito type with simple decorative motifs, mainly geometric, were locally manufactured (Jiménez Betts, 2005; Jiménez and Darling, 2000). During this period, Teotihuacan was in its splendor as the city reached its maximum population growth and urban complexity (Manzanilla, 2017). The Juchipila Canyon region and the Altos de Jalisco both had an important presence and were the possible origin of the inhabitants of La Quemada.

The La Quemada Phase occurred from 600 to 650 CE to 850 CE. Its beginning was marked by the fall of Teotihuacan, a fact that urged the emergence of a regional power center. During this stage, the greatest architectural growth took place in La Quemada, which was consolidated as a power center in the valley and religious center in the region. Iconography in ceramics radically changed from geometric motifs to figurative representations, as in Chalchihuites (Hers, 2005).

Both the negative ceramics and the type 1 figurine extended widely through the region of the Zacatecas canyons, the Altos de Jalisco, and the Bajo, demonstrating the wide network of social and economic interaction (Jiménez and Darling, 2000).

The last phase was the Citadel from 850 CE to 1000 CE, which ended when a large fire occurred in La Quemada and the settlement was abandoned (Jiménez and Darling, 2000; Legemann, 1999; Medina, 2000). This is evidenced by the presence of charred beams covered with large roof fragments with the imprints of burnt reeds and floors (Jiménez and Darling, 2000).

Some ideas have elaborated on this abandonment and final fire. Early visitors to the site observed evidence of a fire, which was suggested to be the cause of the ancient city's destruction. When formal excavations began at La Quemada, fragments of charred wood and burnt floors (Weigand, 1978) were unearthed. The name La Quemada derives from its final fire and is related to a Wixaric myth that spoke of a walled city destroyed by fire (Weigand, 1978).

There was a consensus among researchers that fire ended La Quemada, yet uncertainty remains over when it happened (Weigand, 1978; Jiménez, 1994). In this final stage, the main access to the top of the hill would have been closed to prevent entrance to small elite groups sheltered there who would have lost control of the population (Jiménez, 2010). Recent studies have pointed out a gradual abandonment of the settlement, from those who vacated the hill to those who occupied the lower part, and even those who completely left a few years later in 900–1150 CE (López-Delgado et al., 2019).

The ball court was one of the most important buildings of the settlement and its shape corresponded to the Mesoamerican tradition. On one flank was the Salón de Columnas with its main square and on the other the Piramide Votiva, which constituted a large public space that anyone could access to witness the ball game ceremony. Its precise date of construction is not known, although it has been noted that it corresponded to the La Quemada Phase, between the years 600 to 900 CE, which was a period of the greatest construction activity in the settlement. The same period was credited with the ball court of the Gualterio site from the Chalchihuites culture (Kelley, 1976).

Thus far, it has been identified that the ball court was modified on different occasions during its use. An enlargement is currently visible in the north end. On the other hand, towards the southern end, a platform was added. Recent excavations carried out in the southwest sector of this southern annexed platform revealed a set of rooms planted on a platform, which probably corresponded to a stage before the last occupation. Inside these rooms, fire pits were found. The discovery of these fire pits motivated archaeomagnetic intervention, since they are in situ structures exposed to fire and therefore susceptible to being dated by three elements (i.e., magnetic inclination, declination, and absolute geomagnetic intensity), which could provide dating with greater precision.

2. The ball court in la quemada

The structure usually consisted of the court, heads, sidewalls, markers, and stands for observers. Sometimes, it lacked heads and was usually reduced to side walls only, as seen in northern Mexico. In La Quemada, three ball courts are known: the main one, located in the public part of the settlement, and two small courts, one on Terraza 18 and one in La Ciudadela.

The first archaeological interventions in the main ball court were made by Pedro Armillas in the 1950s, who consolidated the slope and the staircase to the southern platform. At the top of this platform, a survey was made that allowed for the identification of another platform inside the filling and a ladder of an earlier occupation stage (Jiménez, 2010).

The area between the Salon de Columnas and the Piramide Votiva was long believed to correspond to a “ceremonial corridor”. However, John Charles Kelley proposed it as a court in the form of a Latin letter “I” (Kelley, 1971). Later, Román López and Laura Castañeda made new explorations in the ball court as part of maintenance operations between 1979 and 1980. An inlet along with the court and three crosswise ones were excavated, finding slits that made up the floor of the court, featuring a hardened mud coating and a terraced staircase in the west parament.

The last intervention in the ball court was made by Peter Jiménez, who followed the same lines that López and Castañeda made years prior. The floor sequences were analyzed and several human burials were discovered under the floor of the ball court, as well as the existence of a floor below the lattice (Jiménez, 2010).

3. Study area and details of the analyzed samples

As previously mentioned, the main ball court of La Quemada was located on the first level of the pre-Hispanic settlement, at the bottom of the hill’s southern slope (Fig. 1). This consisted of a structure of approximately 80 m long by 15 m wide with north-to-south arrangement. Its side walls were 1.50 m high and the structure was shaped like a Latin letter “I”, with heads at its northern and southern ends, and maintaining traditional Mesoamerican pattern. At its southern end, there was an attached platform, which was accessed by a staircase located to the south (Fig. 2).

In 2019, during the conservation and maintenance of the La Quemada Archaeological Monument Zone, the excavation of the southern annexed platform of the ball court was determined, in particular its southern west sector, due to the affection caused by visitors, who eroded the terrain, affected the archaeological contexts, and exposed slits that stood out from it and involved great risk.

Archaeological excavations revealed the presence of three rooms divided by masonry walls and three occupation phases based on the overlay of architectural elements. The presence of fire pits inside the
The first two areas selected for sampling corresponded with the two fire pits found within the filling of the last stage, so they theoretically would correspond to a previous stage (Fig. 3). The first fire pit (Pit 1) was composed of slits that delimited a hole above the floor that was 25 × 15 cm per side and 10 cm deep (Fig. 4). The second fire pit (Pit 2) had a circular level that had a 50 cm diameter and was covered with slabs with a semi-spherical clay coating (Fig. 5).

The third selected area was located in the game’s outer region, where there was a tucked wall and secondary bone remains deposit (Fig. 6). In the northwest corner, carved over the mother rock, a hole of approximately 30 cm in diameter by 9 cm deep was discovered. This cavity had the appearance of a rock mortar that could be associated with the grinding of grain. It was covered by a layer of ash (Figs. 7 and 8). Along with the presence of burnt bones, it was clear that it had been exposed to fire. This structure was called a burnt cavity because it had different characteristics than fire pits.
Fig. 4. Pit 1 was composed of rhyolite stones covered by a hardened clay floor inside a platform room attached to the south of the ball court.

Fig. 5. Fire pit composed of a layer of hardened mud and delimited by stones inside a platform room attached to the south of the ball court.

Fig. 6. Tucked wall at the west end of the facade of the south platform attached to the ball court.

Fig. 7. Deposit of bone remains and a dark spot of ash in the northwest corner of the place.

Fig. 8. Carved hole (cavity exposed to fire) on the mother rock with evidence of fire exposure.

Fig. 7. Deposit of bone remains and a dark spot of ash in the northwest corner of the place.
4. Experimental procedures

A series of magnetic experiments were conducted to obtain the characteristic (primary) directions of the thermoremanent magnetization in the samples and to obtain details about their stability. The samples were cut into standard-sized cubic specimens of 8 cm³ and placed within a 5-layer magnetic shield for 15 days to decrease secondary magnetizations of viscous origin. Natural remnant magnetization (NRM) was measured with an AGICO JR6 spinner magnetometer. A total of 44 samples were demagnetized by alternating fields of 10–12 steps with a maximum intensity of 90 mT, using an AGICO LDA-5 demagnetizer. After each demagnetization step, the remaining magnetization was measured with a magnetometer. The characteristic directions (ChRM) of each sample were determined by component analysis (PCA; Kirschvink, 1980), while the averaged directions of each site were calculated using Fisher's statistics (1953).

To identify the magnetic minerals carrying the thermoremanence through their Curie temperature, continuous measurements of magnetic susceptibility based on temperature (also known as k-T curves) were made with an AGICO MFK1 susceptibilometer. To do this, the sample was heated from room temperature to 615 °C at a rate of 15 °C/min in the presence of argon gas to reduce oxidation effects during heating. Afterward, it was cooled at the same rate. Curie temperatures were obtained using the Prevot et al. method (1983).

5. Main results, discussion, and concluding remarks

In the thermomagnetic curves of the samples from the studied fire pits (Fig. 9), the presence of a single ferrimagnetic phase was observed, with a Curie temperature between 515 °C and 570 °C that corresponded with titanomagnetite in titanium, which is very close to pure magnetite. Its heating and cooling records were virtually irreversible and the greatest transformation occurred at relatively high temperatures, i.e., above 450 °C.

Concerning the determination of the mean paleodirections, it can be seen that secondary magnetizations were not important and easily removable in the first steps of the magnetic treatment of alternative fields (usually between 5 and 10 mT). Once this component was removed (most likely of viscous origin), all specimens had linear behavior with a tendency to origin (Fig. 10). The mean destructive field (MDF) value was approximately 15 mT and eliminated more than 90% of magnetization when applying 40 mT fields (Fig. 10). In most cases, it was possible to isolate the primary components of the ChRM characteristic remnant, with at least five points and maximum angular deviation values between 0.6° and 2.8°. However, at the time of the mean direction calculation, some specimens had directions that came out of the grouping pattern and were not included in the calculation of the average direction using Fisher's statistics (1953). Although these specimens were taken in different exposed parts of the same block, they may have suffered some displacement or rotation.

The calculated mean archaeodirection for Pit 1 was $D = 351.3°$, $I = 34.7°$, $\alpha_{95} = 2.6°$, and $n/N = 13/16$, where $D$ is the mean declination, $I$ is the mean inclination, $\alpha_{95}$ is the angle around the average direction within which 95% reliability was the actual mean direction, $n$ is the number of samples used in the calculation, and $N$ is its total number of treated samples. As for Pit 2, the corresponding direction was $D = 358.9°$, $I = 33.4°$, $\alpha_{95} = 2.7°$ y $n/N = 8/12$. Finally, for the burnt cavity, the mean direction was $D = 354.7°$, $I = 33.1°$, $\alpha_{95} = 3.2°$ y $n/N = 6/11$ (Fig. 11). Although the average directions of the three studied structures were similar, we opted to perform the archaeomagnetic dating exercise for each of them independently.

The archaeomagnetic dating was done through MATLAB and the SHA.DIF14K model (Pavón-Carrasco et al., 2011, 2014). Therefore, for Pit 1, we obtained a time interval between 931 and 1006 CE as the best estimate of last-use temporality. For Pit 2, two intervals were obtained with equal probability: one between 693 and 947 CE and another

Fig. 9. Continuous thermomagnetic curves: Magnetic susceptibility depending on temperature for samples: a) Pit 1, b) Pit 2, and c) burnt cavity. See text for further details.
between 1463 and 1623 CE. Finally, for the burnt cavity, a single interval between 757 and 980 CE was obtained (see Figs. 12a–c).

To perform a correct exercise in archaeomagnetic dating, the contexts from which the samples came from were analyzed. In this case, two of the samples corresponded to fire pits inside the rooms arranged on a platform attached to the ball court. The other was a sample that was a cavity (hole) located at the back of the platform. Therefore, two samples corresponded to enclosed and interior spaces and another to the exterior. Pit 1 (sample 1) contained a small overlap with the outer cavity dating interval (sample 3) between 931 and 980 CE. By contrast, for the temporality of Pit 2, the overlap interval was lower than Pit 1, between 931 and 947 CE and 757 and 947 CE for the burnt cavity. It also presented another dating between 1463 and 1623 CE. The dating of the fire pits could determine the last time there was burning activity inside. However, dating between 931 and 1006 CE and 693–947 CE corresponded to the La Quemada Phase and its transition to the Ciudadela Phase. A similar situation was presented for the cavity outside the platform with its range between 757 and 989 CE. Therefore, it would correspond to the last period of activity in the ball court.

Chronologically, the ancient pre-Hispanic settlement of La Quemada first appeared based on the historic narrations of the Aztec pilgrimage, since the site was considered to be the mythical Chicomoztoc (Torquemada, 1986; Tello, 1997; Clavijero, 1991) and thus linked to the Aztec pilgrimage. For this reason, it should correspond to the early postclassical period (Berghes, 1996; Tarayre, 1867). At the beginning of the 20th century, based on a comparison of its buildings and constructed forms, the site was thought to belong to the late postclassical period through correspondence with Tarasco sites (Batres, 1903). The
presence of a hall with columns led other researchers to consider it a Toltec site, established as a means to control the turquoise route (Weigand, 1978).

The first radiometric dating in La Quemada was conducted in the 1970s, where samples from El Cuartel indicated a date between the years 800 and 1200 CE (Crane and Griffin, 1958). However, only dates between 900 and 1000 CE were considered, placing it in the early postclassical period (900–1200 CE) (Crane and Griffin, 1962, Kelley, 1971, Lelgemann, 1992).

Based on the data available in the 1970s, Weigand proposed three phases of occupation: early La Quemada (600–850 CE), mid La Quemada (850–1100 CE), and late La Quemada (1100–1350 CE) (Weigand, 1978).

Subsequently, Trombold (1985) presented an analysis of the chronology of La Quemada based on the ceramics recovered from the surface. It identified the *sgraffitoed-incised* ceramic of the Valle de Malpaso, which was similar to the *sgraffitoed* type known as Canutillo Red-Filled Engraved of the Chalchihuites culture, suggesting an early occupation that corresponded to the Canutillo phase, as well as *Michilia Red-Filled* and *Mercado Red on Cream* ceramics of the Alta Vista and Ayala phases, for which reason we proposed the initial phase (600–800 CE), the La Quemada phase (800–1000 CE), and the abandonment phase (1000–1100 CE) (Trombold, 1985). Subsequent carbon 14 samples established the initial phase to be between 290 and 530 CE, maximum development at 600–800 CE, and abandonment after 800 CE (Trombold, 1988). Trombold conducted a new review, considering the 14C radiometric studies, ceramic typology, architecture (since architectonic superimpositions are identified), and the narrowing and subsequent closure of access to the stairways (Trombold, 1990). Thus, La Quemada and Alta Vista are considered to be contemporary settlements, with La Quemada presenting its cultural development between 600 and 900 CE (Trombold, 1990).

A chronological proposal was presented by Lelgemann (1992) based on the analysis of ceramics and establishing three cultural complexes. The first of these was Malpaso (550–600 CE), which was characterized by early red inlay type ceramics equivalent to Canutillo in Alta Vista, as well as the bichrome negative (black over red or brown) ceramics that continued into the following complex. The second was the Palomas complex (550–600 to 700–750 CE) in which the red inlay and black negative prevailed over brown ceramics. The Quemada complex (700–750 to 850–900 CE) corresponded with the maximum development during the late classical period, in which the red over cream, late red inlay, *pseudocloisoné*, and polychrome negative ceramic types prevailed. Finally, there was the Ciudadela complex (850–900 to 950–1000 CE), which marked the age of decadence and abandonment but had no diagnostic materials (Lelgemann, 1992).

Further improvements were made to Nelson’s (1997) chronology, which suggested that La Quemada began around 500 CE, with its main
period of occupation between 600 and 750 CE, reducing it to its monumental core by the end of the 9th century and undergoing abandonment by 900 CE, with no postclassical occupation. Thus, the Hall of Columns became a classical building in this region (Nelson, 1997).

Another sequence of occupation was proposed by Jiménez and Darling (2000) based on the ceramic materials and figurines present in La Quemada. They first established the Malpaso complex (350–400 to 600–650 CE) based on the black or brown incised tripod ceramics with geometric motifs related to the Chalchihuites culture. In the La Quemada complex (600–650 to 850 CE), it corresponded with the greatest development phase, wherein the material culture was distinguished by ceramics decorated in the negative with a clear influence of the Zacatecas. In contrast, the sgraffitoed types resembled those in Chalchihuites during the same era. Also present were ceramics of the Pseudo-cloisonne and Valle de San Luis polychrome from San Luis Potosí, as well as Bolaños and Valle de Juchipila types. The type I figurine was common in the Jalisco highlands, which demonstrated regional interactions (Jiménez and Darling, 2000). The end of the occupation of La Quemada was marked in the Ciudadela complex (850–1000 CE), a period typified by the closure of upper spaces, a defensive character, and a huge fire that consumed the city (Jiménez and Darling, 2000). In this case, the Palomas complex of the previous sequence was integrated into the Ciudadela complex.

Dendrochronological studies together with radiometric analyses of $^{14}$C have furthered our understanding of La Quemada’s occupational sequence (Turkon et al., 2018). In this manner, beam samples were obtained from El Cuartel in La Quemada and the Hall of Columns at Los Pilarillos. For El Cuartel, the archaeological excavations conducted by Marco Santos indicated two constructive phases (Turkon et al., 2018). In contrast, the studies conducted by Nelson (1997) in the Hall of Columns at Los Pilarillos indicated occupation from 550 to 800 CE (Turkon et al., 2018). Based on dendrochronological analysis of the beams, El Cuartel was established between 600 and 700 CE (Turkon et al., 2018). In contrast, the Hall of Columns at Los Pilarillos was built 50 to 100 years after La Quemada (Turkon et al., 2018).

Archaeomagnetic studies were integrated into the analysis of La Quemada’s occupation sequence. Based on archaeological explorations, samples were taken of the floor in the portico of the Hall of Columns and in the Plaza of Sacrifices on the third level (López-Delgado et al., 2019). The data produced by this study shows that between the years 854 and 968 CE, the floors of the Plaza of Sacrifices were burnt, while the floors of the Hall of Columns were exposed to fire between 1018 and 1163 CE (López-Delgado et al., 2019). Thus, we believe that there was a gradual abandonment of the settlement. At the end of the La Quemada complex, the high part was vacated, which closed accesses to prevent collapses while continuing to occupy the lower part. By the Ciudadela phase, there was a total abandonment of the settlement.

A recent study specifies the maximum occupation of La Quemada in
the Epiclassical period (600 to 900 CE) (Torvinen and Nelson, 2019). In this study, Torvinen and Nelson conduct a detailed analysis to establish an arrangement of the ceramics and matrices of Harris for the archaeological stratigraphy, determining that El Cuartel and La Terraza 18 were built at the same time, i.e., 600 CE (Torvinen and Nelson, 2019).

Unlike previous archaeomagnetic analyses (López-Delgado et al., 2019), on this occasion only spot traces of combustion were detected, which corresponded with areas exposed to fire, such as the two fire pits. They did not extend to an entire place, as they did for the arcade floors of the Salon de Columnas or in the Plaza de los Sacrificios (López-Delgado et al., 2019). Regarding the hole outside the platform, it was also of a point type since there was only ash inside the hole. When removing the dark layer, the combustion on the outside exterior of the hole was noticeable, perhaps due to a built-in post that would have served as a torch. However, the existence of a dating related to a possible late occupation, between 1463 and 1623 CE, could suggest a reoccupation during the Postclassical period by Zacatecos. This phenomenon was observed for El Cuarte and Zacatecos groups, whose temporality was determined by a charcoal sample obtained from a fire pit located above a collapsed room. While Pit 1 was lax-based at floor level, Pit 2 featured stains that delimited the space and had a layer of semi-spherical mud at a slightly higher level than the previous one. These characteristics of Pit 2 could suggest a reuse of the space, possibly by a Zacatecos group, who were known to inhabit the ruins of La Quemada.

We explicitly declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all co-authors. We further confirm that the order of authors listed in the manuscript has been approved by all authors. This work is an example of frontier research. Dr. Goguitchaichvili (Geophysics) and Dr. Carlos Torreblanca (archeology) led the investigation while numerous and very laborious magnetic experiments were performed by Drs. Morales, Kravchinsky, Cejudo and Garcia. Dr. Lopez and Bautista carried out most of sample collection campaign.

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migración al Valle de México, a través del actual Estado de Libre de Zacatecas. Copiada tras investigaciones y levantamientos en este lugar y esclarecida por el manuscrito en jeroglíficos aztecas del Museo de México: Carl de Berghes, Münsterpumpe, cerca de Stolberg 1835. Traducción y estudio introductorio y notas de Achim Legemann. Gobierno del Estado de Zacatecas, Universidad Autónoma de Zacatecas y Centro Bancario del Estado de Zacatecas.


