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New Absolute Chronological Constraints to La Playa (Sonoran Desert) Archaeology between the American Southwest and Mesoamerica—From Long Period Human Resilience to Apparent Abandonment

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Abstract: Sonoran Desert archaeological settlement is one of the most representative sites in Northwestern Mexico/Southwestern United States of the Early Agriculture period because of various cultural processes involved, such as the introduction of the first cultigens and the construction of Pit Houses. These early desert village settlements used geomorphological features of the local landscape to facilitate their sophisticated form of agriculture. Most of the features and artifacts at the site are associated with the Early Agricultural period of 3150-1900 cal B.P., while most occupation dates are in the Cienega phase (2800-1900 cal B.P.). Later stages are poorly documented because of the apparent reduction in population, less marked archaeological features, and extreme erosion processes. Systematic archaeological excavation revealed evidence of completely burned Pit Houses. We analyzed 56 samples belonging to four Pit Houses and one different combustion feature (Kiln or *Horno*, as they are locally known) in different areas of the settlement. The experimental procedure included continuous susceptibility vs. temperature measurements and step-wise alternating field demagnetizations. Only 36 samples yielded technically acceptable determinations that allowed the determination of archaeomagnetic directions. Statistically indistinguishable results were obtained from all five studied features. This finding reinforces archaeological evidence of ritual-related paraphernalia and/or apparent abandonment or, at least, migration.

Keywords: Early Agricultural Settlements; American Southwest; North America; Pit Houses; Absolute Chronology; Archaeomagnetism; ritual closure; abandonment

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1. Introduction

The Early Agricultural period in the Southwestern United Sites and Northwestern Mexico is characterized by the first residential settlements and fast population growth [1–3]. Abundant precipitation and, apparently, lower temperatures around 5000 B.P. attracted hunter-gatherers to the Sonoran Desert and allowed access to fertile floodplains [1,4–6]. Among scattered regional sites, La Playa is the largest archaeological landscape in northern Sonora, northwest Mexico [7–9].

La Playa, located in the municipality of Trincheras, Sonora (Figure 1), is considered one of the most representative sites in Northwestern Mexico/Southwestern United States of the Early Agriculture period [2,8,10–12]. It is characterized by various cultural processes: the introduction of the first cultigens in the region, the development of techniques for irrigation canals, the technology of the projectile points, and the construction of Pit Houses.

The latter is poorly represented in the archaeological record due to the strong erosion that affects the site, making it a challenge to find the few specimens suitable for investigations.

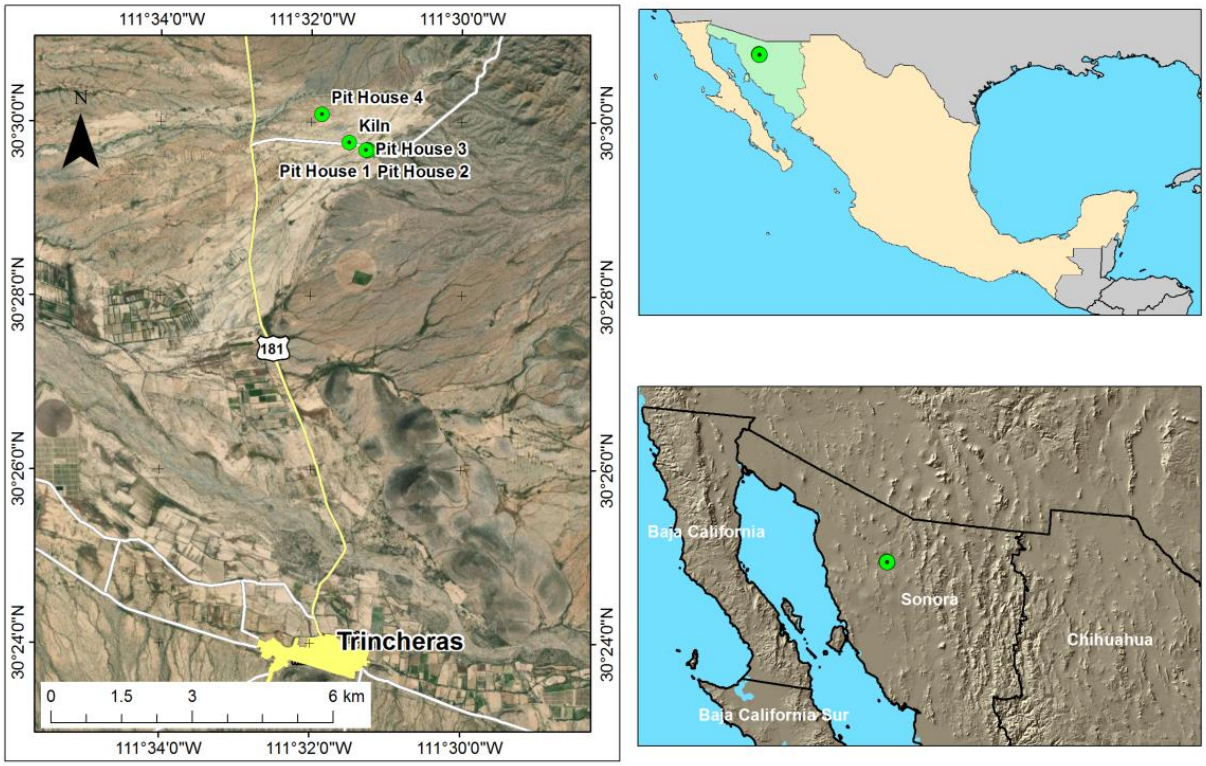

Figure 1. La Playa archaeological site in the municipality of Trincheras, State of Sonora, Mexico showing the locations of Pit Houses and Kiln (*Horno*). The data are obtained from INEGI (INSTITUTO NACIONAL DE ESTADISITICA E GEOGRAFIA), while ArcMap was used to draw schematic maps.

La Playa site shows a complex stratigraphy and geomorphology, which has been constantly altered by hydric and wind agents. While long-term environmental trends promote stable adaptations, more rapid climate changes require human groups to use more rapid resilience strategies. The first farmers in the Sonoran Desert employed the construction of canals to transport water flows from low-intensity streams to irrigate their crop fields ~3000 years ago. These early desert village settlements used geomorphological features of the local landscape to facilitate their sophisticated form of agriculture.

The settlement is a multi-component site that contains evidence of occupation from the Paleoindian and Middle Archaic periods, as well as continuous occupation from the Late Archaic to the mid-20th century. Most of the features and artifacts at the site are associated with the Early Agricultural period of 3150-1900 cal B.P., and most occupation dates are in the Ciénega phase (2800-1900 cal B.P.). There is later evidence of sporadic occupation of Trincheras from 150-1450 A.D. Maize is known to appear in the Southwest around 4100 cal B.P. [13]. During the Early Agricultural period, farmers began to rely more significantly on cultivated plants as an essential part of their diet.

Huckell [14] redefined the Early Agricultural period to distinguish agricultural use from the earlier Late Archaic period. Under this definition, the Archaic period represents the period from after the Paleo-Indian until the use of pottery. Still, the term also refers to the widespread hunter-gatherer-forager subsistence economy. The term Early Agricultural period is used to recognize the presence of domesticated crops in the diet. It is characterized by a subsistence economy based on mixed feeding. The term Late Archaic is retained for sites with contemporary dates that show evidence of a generalized hunting and gathering economy [10,14,15].

The Early Agricultural period, defined by the more intensive use of agriculture, includes new food production strategies and also signifies a change in the material culture, the intensity of settlement occupation patterns, and land [14]. This does not necessarily mean that the forage farming groups were dependent on agriculture for their subsistence, nor were they completely sedentary. The transition from foraging to agriculture was not immediate. Early Agricultural period sites vary in the degree of sedentarization and dependence on agriculture. In general, the period is characterized by dwelling structures of Pit Houses of various sizes, although they are generally a few meters in diameter; elements in walls, stone ovens for firing, hearths, polished metate lithics, pestles, mortars, diagnostic projectile points, stone trays, ornaments in seashells, and ceramic figurines are all included [12,15]. Compared to the San Pedro phase, the Ciénega phase (2800-1800 cal B.P.) sites indicate greater sedentarization and dependence on agriculture, showing more formal structures, a greater diversity of artifacts, a greater number of storage pits, and more storage capacity at the same time. Sometimes, they contain larger communal structures, possibly due to the increase in the population or their greater concentration due to being more sedentary populations [15,16]. Extensive water canal use during the Ciénega phase has been documented, which, in the Tucson Basin, has been dated to 3450-2450 cal B.P. [17,18]. These irrigation canals made agriculture possible in more than one season and possibly throughout the year, as well as the introduction of new crops, which may have contributed to population growth [19]. Using magnetic gradiometry, Cajigas [20] detected approximately 3 km of intact irrigation canals, almost 8700 m^2 of agricultural fields, and 12 circular structures.

After almost two decades of investigating the site and not finding any element with habitation characteristics, in 2010, a strip of sediment with high carbon content and associated artifacts was identified. Similarly, the nearby areas also record the presence of fragments of burnt soil, charred material, and some artifacts. The excavation of these structures revealed the existence of semi-complete and entirely burned Pit Houses, which represent excellent archaeomagnetic targets and, thus, the possibility to date the last firing event. Beyond this main objective, we will try to estimate whether this apparently intentional generalized firing episode at the end of the Ciénega phase (the period of major settlement patterns) relates to ritual aspects or environmental changes.

2. Chronological Framework and Sample Provenance

Besides the series of evidence indicating that the La Playa site spans approximately 10,000 years of human presence, the major occupation can be restricted to a relatively short interval [21]: the Late Archaic/Early Agriculture Period (1500-1200 B.C. to 150 A.D.). There is now a general agreement among the archaeologists that the Early Agricultural period in the Sonoran Desert is divided into the San Pedro and Cienega phases [3,5,21]. Mabry [6,12], however, mentioned an *unnamed phase* (approximately 2100-1200 B.C.) preceding the San Pedro phase (1200-800 B.C.). This author also proposed to divide the Ciénega phase into Early (800-400 B.C.) and Late (400 B.C.-A.D. 40) phases [21]. Carpenter et al. [22] and Martinez–Lira et al. [21], among others, argue that the population at La Playa was essentially sedentary because of the recovery of multiple activity areas, the clear evidence of maize farming, the numerous human burials, as well as the distribution and density of archaeological artifacts [21,22]. Copeland et al. [7], in turn, support the idea that archaeological remains from the Ciénega phase (2800-1800 cal B.P.) identify increases in village size and complexity, as well as more technologically complex artifacts [23]. In addition, the archaeological record from the San Pedro phase (3600-2800 cal B.P.) includes large, un-notched blades, various stone tools, and shell decorations [7,24].

The most common archaeological features at La Playa include Pit Houses (Figure 2a) and burials, including human inhumation and cremation. Some pits and *hornos* (kilns) were also discovered during the last decades. Pit Houses should be considered as particular structures since they were found completely burned and, thus, were susceptible to carrying thermoremanent magnetization acquired during the cooling from high temperatures. The

same is true for the *horno* samples. There were four Pit Houses (Figure 2) and one Horno (Figure 3) sampled under this investigation, while their excavation details may be described as follows:

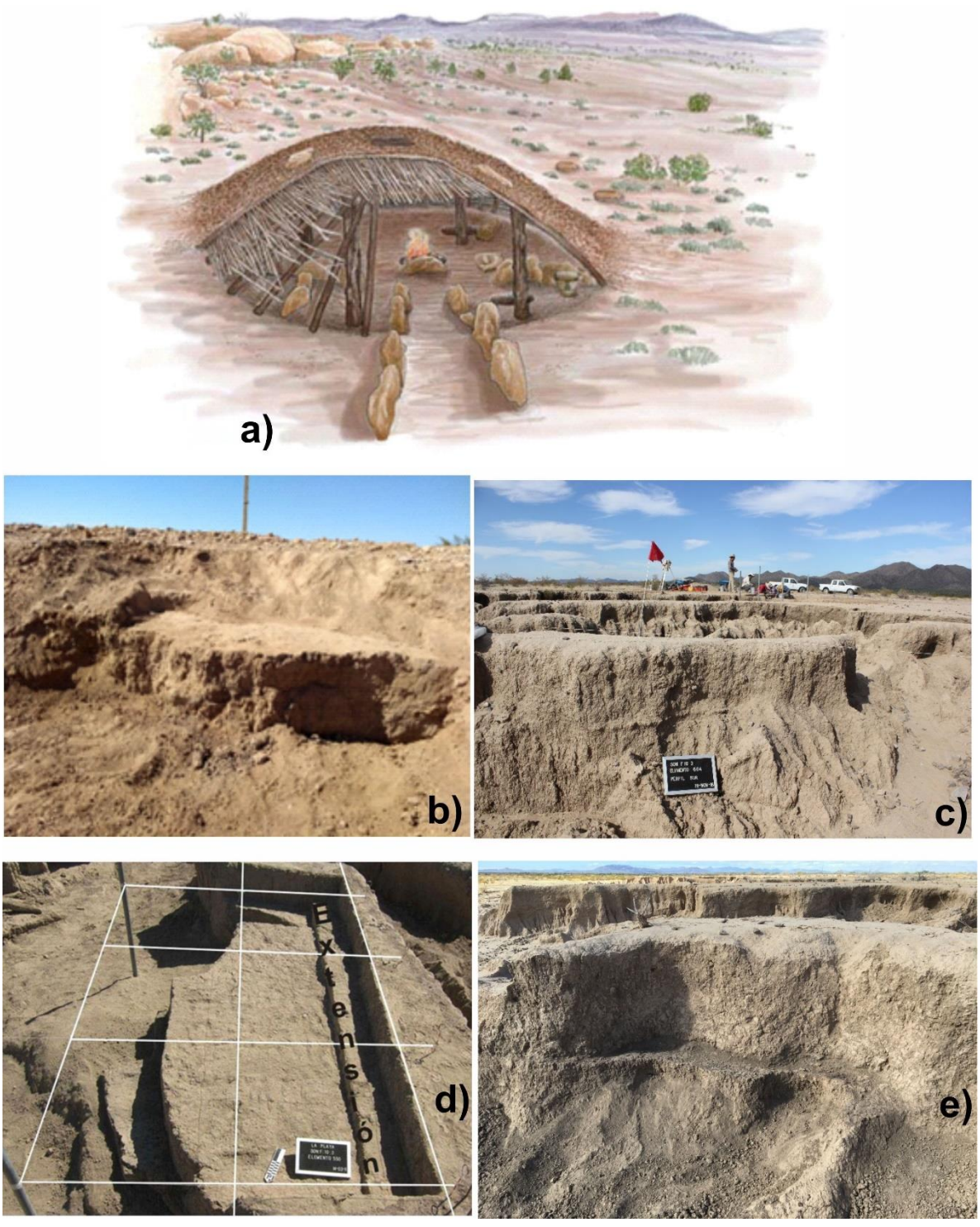

Figure 2. Reconstruction of Pit House, Illustration by Joyce Heuman Kramer; Crow Canyon Archaeological Center (Basketmaker II pithouse (https://www.crowcanyon.org/EducationProducts/peoples_mesa_verde/basketmaker_II_housing.asp, accessed on 7 January 2023) (**a**) and burned features discovered during the excavations (**b**–**e**), see text for more details.

Figure 3. Remains of combustion feature (kiln or *horno*).

Feature 602 (30°29′40.94″ N, 111°31′14.91″ W—Pit House 1, Figure 2b) is located in the vicinity of *Viejo Campamento* area, to the south of the road and to the west of structure 550. Before excavation, only a well-consolidated floor of approximately 4 cm was visible, and only the western limit was observed. The excavation was carried out by metric levels of 10 cm. During the excavation process, the sediment became more compact and darker. No material was recovered from the levels above the floor. Sampled area is the one that contained most of the burned soil observed in the profile, so this square was excavated until reaching contact with the base approximately 30 cm below the surface. In the west profile of the square, at a depth of 20 cm, a charcoal fragment was recovered with no association to any other artifact.

Feature 604 (30°29′40.32″ N, 111°31′14.79″ W—Pit House 2, Figure 2c) is also located in the *Viejo Campamento* area, south of element 602, in an erosion gully approximately 60 cm wide, with an east–west orientation. In the southwest profile, the remains of another floor were identified at a depth of 40 cm. The burned floor level was reached after 4 metric levels of 10 cm, revealing an extremely compact surface with a semicircular limit of 95 cm wide by 43 cm long. No artifacts were recovered in contact with the ground and the walls. Again, what was preserved of the structure was too little to be able to obtain the total dimensions of this pit, since everything was located in the south part and had already eroded. Very few materials were recovered from the excavation of this item: two complete chalcedony flakes and a decorated *Trincheras* type sherd. The area was also scoured trying to locate artifacts that may have eroded from the house; however, no material was recovered.

Feature 614 (30°30′5.35″ N, 111°31′51.43″ W—Pit House 4, Figure 2d) is located in the north of the *Los Entierros* area in an erosion gully approximately 2 m wide. A partially preserved burned floor was detected in the eastern profile under 60 cm of the surface. Above the floor, there was a 7 cm layer of ash that covered it entirely. In the already eroded area, there were many artifacts such as metate hands, bone fragments, and burned soil that possibly belonged to the already eroded parts of this structure. This structure has an irregular, 1.20 m diameter circular shape. The eastern part was totally eroded, and in the rest of the element, it was not possible to differentiate the walls of the sediment in which the element was excavated. Only one 16 cm diameter post hole was recognized, which would be located to the east of the feature, very close to the eroded area. The ash layer was detected at 60 cm deep. More materials were recovered from these levels than the elements described above. Most were bone fragments and small coals. The 5 cm thick ash layer had very low compaction. Mixed with the ash were fragments of burnt earth; however, and unlike previous levels, no coal fragments were recovered. Below the ash was the floor, which was burned and best preserved in the center of the excavated area. Once again, the

walls, to the south and to the north, were not delimited and a small elevation (border) was barely visible, similar to that of Structure 602.

Feature 550 (30°29′40.57″ N, 111°31′16.41″ W—Pit House 3, Figure 2e) is particular because its systematic excavation began in November 2010 when it was located in one of the runoffs of the area called *Viejo Campamento*. It has been proposed that these areas are associated with the settlements of the Early Agricultural Period (800 B.C. to A.D. 200) [25]. This completely charred house revealed a perfectly preserved floor covered by a thin charcoal layer. About 3 to 4 cm post holes in the wall of the house were also detected. This was interpreted as the ocotillo tree frame that makes up the architectural structure of the pit house. The structure seems completely collapsed during the intense firing episode and was what allowed its identification. After the first 30 cm excavated, the delimitation of the house was very clear, marking a circumference that revealed the compacted walls. Almost in contact with the floor of the house, we were able to locate several circular spots, of between 2.5 and 3 cm, with fragments of coal inside. The characteristics of this evidence allowed us to suppose that it was about the secondary posts of the structure that gave shape and supported the walls of this house pi house.

Feature 619 (30°29′45.85″ N, 111°31′29.64″ W) Horno (Figure 3) is located in the *Hornos Alineados* area, a few meters from the dirt road to El Ocuca village. On the surface, it was observed as a concentration of rocks fragmented by fire, with some flakes and pieces of polished lithic ground stone, with an approximate diameter of 1 m and a height of 30 cm. At the base of the concentration of rocks, it was possible to appreciate a crust of burned earth that delimited the wall of the structure formed by blocks. It has a maximum diameter of 65 cm and a frustoconical shape.

Magnetically oriented hand samples leveled with plaster (*Platre de Paris)* were collected from four burned soils belonging to Pit Houses and one Horno. Due to a relatively small sampling area, two or three oriented monoliths were taken from each structure, while at least eight 2 cm cubic specimens were cut from each hand sample.

3. Laboratory Techniques

Prior to magnetic treatments, we carried out susceptibility against temperature measurements in a continuous way and aimed to reveal major magnetic carriers and estimate their thermal stability. AGICO MFK1 susceptibility meter equipped with a furnace was employed for such a purpose using crushed virgin specimens. They were heated (under the air) until about 600 °C and cooled down to the room temperature using the rate of 20 °C per minute rate. As natural remanent magnetization measurements are concerned, samples were placed for 15 days in free magnetic fields of μ−metal shield in order to diminish the effect of potential viscous remanent magnetization.

All remanences were recorded using JR6 AGICO spinner magnetometer at the facilities of National Archaeomagnetic Service of National University of Mexico. Due to the fragility of the great majority of samples, we adopted alternating field treatment to reveal primary, characteristic thermoremanent magnetization. For this purpose, an AGICO LDA3 demagnetizer was used with maximum available peak alternating field of 90 mT. The characteristic remanent magnetization (ChRM) of each specimen was calculated by principal component analysis, based on at least five aligned points of the demagnetization process [26]. The calculation of the mean directions, as well as their associated precision parameters, was carried out following Fisher's statistics [27].

4. Main Results

There are two types of behaviors that may be recognized on the analysis of continuous thermomagnetic curves. The majority of samples exhibit evidence for two magnetic phases during heating (Figure 4, samples SH02 and SH03). The low temperature phase is rather well-defined, showing an important susceptibility drop between 340 and 415 °C, while the second phase correspond to magnetite judging from its Curie temperature. This behavior is commonly interpreted as the inversion of thermally unstable titanomaghemites into

almost pure magnetite [28]. The particular case is reported for one sample from Pit House 4 (Figure 4, SH04). The low temperature phase is presented here as well, while heating at higher temperatures produces an important neoformation of magnetite most probably from the non-magnetic matrix. Due to the marked irreversibility and thermal instability observed on continuous thermomagnetic curves, no paleointensity determination was intended.

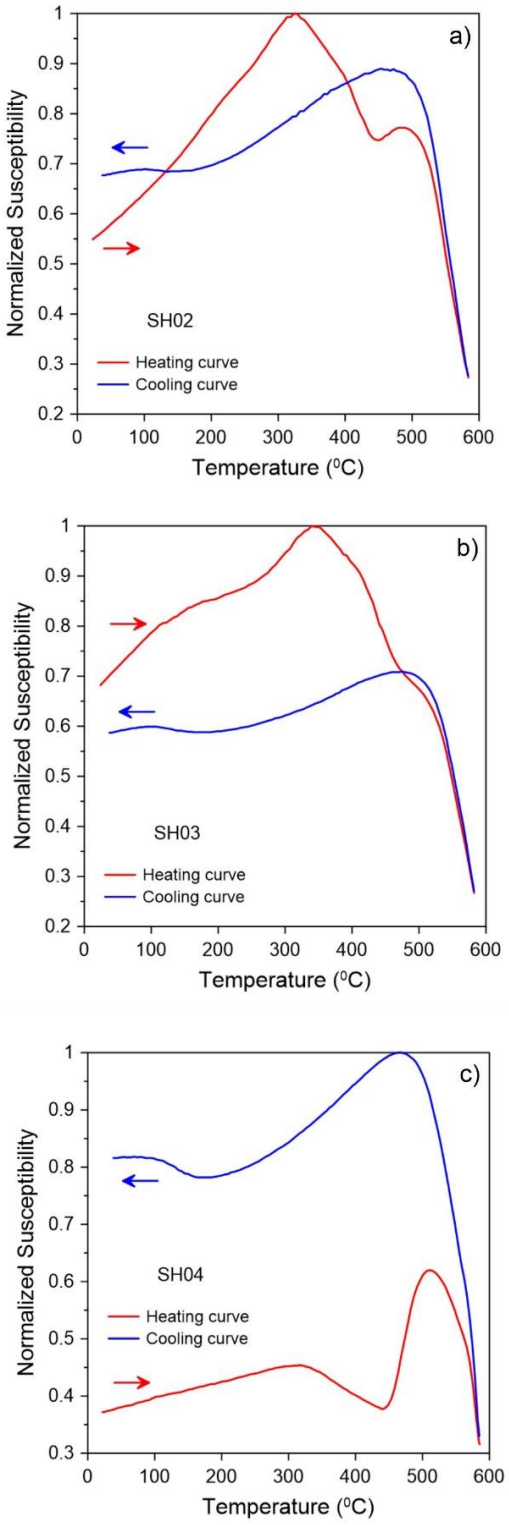

Figure 4. Representative continuous thermomagnetic measurements for La Playa representative samples. The Red (blue) branch corresponds to the heating (cooling) cycle.

Characteristic remanent magnetization is obtained from 36 out of 59 analyzed samples belonging to four Pit Houses and one Horno exhibiting very similar demagnetization patterns (Figure 5). The major part of thermoremanence is removed when applying 80 mT peak alternating field, while median destructive field values range between 25 and 35 mT. These factors attest that the main magnetic carriers are ferrimagnetic grains, and hematite contribution in total remanence is very limited. All individual paleodirection determinations are based on at least five aligned demagnetization steps with the maximum angular deviation (MAD) values within 2.4°. The mean archaeomagnetic directions are reasonably well-defined for all 5 cooling units (4 burned floors belonging to Pit Houses and 1 Horno) for 4 out of 5 of the studied burned features (Figure 6) with a cone of confidence α_{95} between 2.2° and 7.2°. Only Pit House 4 yielded higher α_{95} of 7.2°, which attests rather scattered archaeodirections (Figure 6).

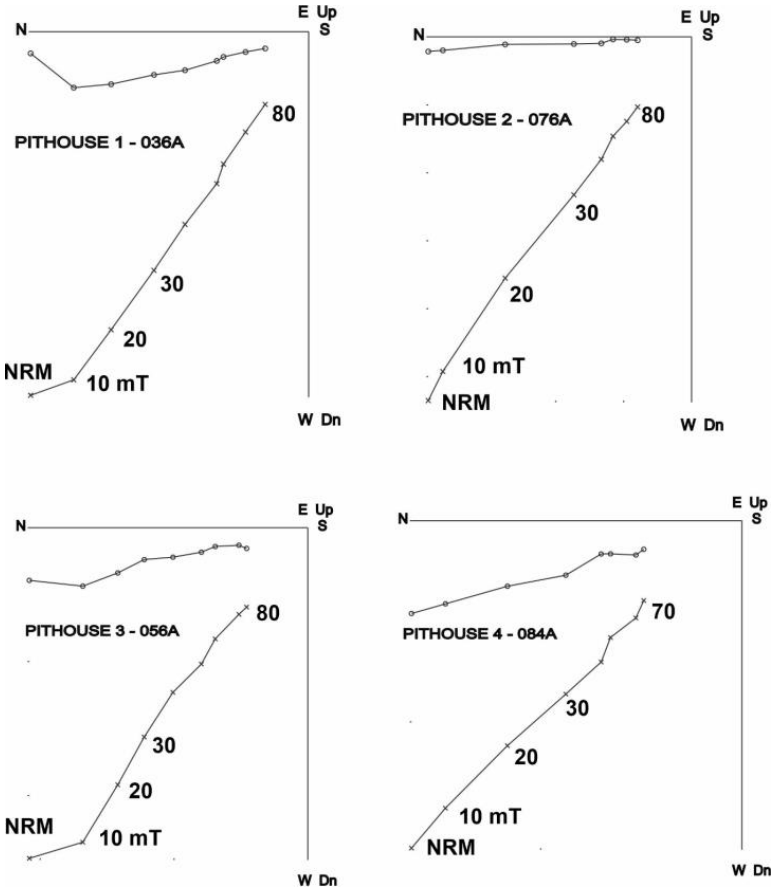

Figure 5. Representative orthogonal diagrams of alternating field treatments for La Playa representative samples.

Statistically undistinguishable paleodirections were obtained from all five studied features (Figure 6) with their α_{95} completely overlapping. Thus, it is evident that all four Pit Houses and one Horno were burned within the same time interval. Mean paleodirections obtained for Pit House 1 are Dec = 349.7°, Inc = 52.2°, α_{95} = 4.6°, k = 145 determined on 8 out of 12 analyzed samples (Figure 6), Pit House 2 provided Dec =347.8°, Inc = 50.8°, α_{95} = 2.2°, k = 544, 9 out of 14 samples; Pit House 3—Dec = 352.0°, Inc = 49.2°, α_{95} = 3.6°, k = 277, 7 out of 12 samples; Pit House 4—Dec = 346.3°, Inc = 49.9°, α_{95} = 7.2°, k = 114, 5 samples out of 9 analyzed. Horno yielded Dec = 348.7°, Inc = 51.1°, α_{95} = 4.2°, k = 210, 7 out of 12 samples.

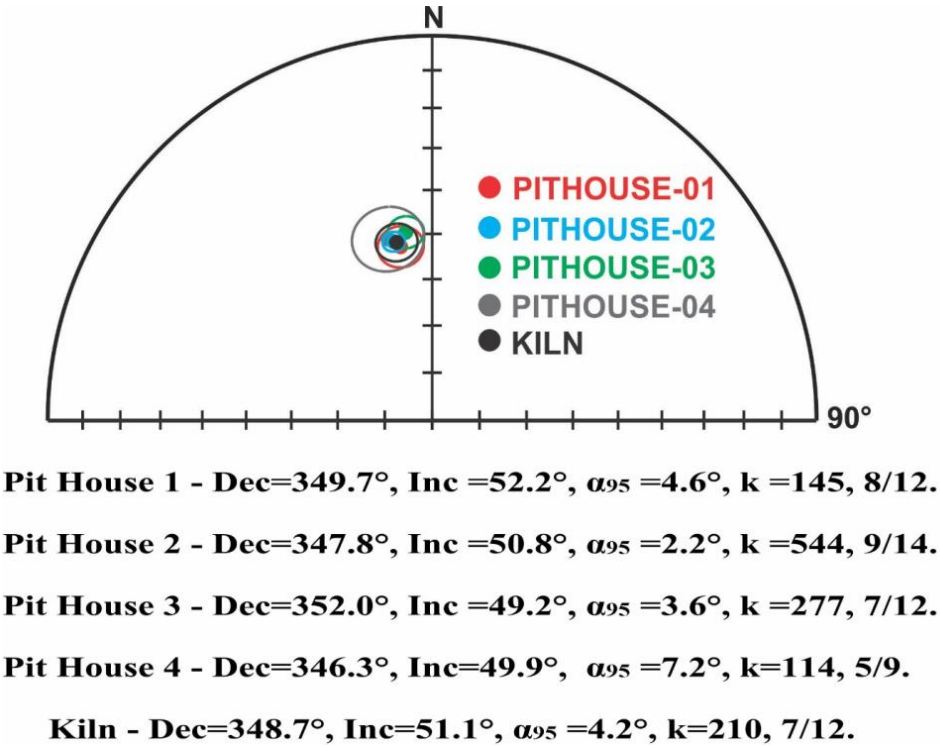

Figure 6. Equal area projection of mean archaeomagnetic directions for four Pit Houses and one kiln (horno).

5. Discussion and Concluding Remarks

The time interval 1000 BC and 500 AD was selected for archaeomagnetic dating purposes based on available archaeological and relative chronological evidences. Unfortunately, this interval is characterized by little available data on local paleosecular reference curves [29,30] and, thus, cannot be correctly used for precise age determination. The same is true for recent global geomagnetic models SHAWQ2K and SHAWQ-Iron Age with additional inconvenient that they represent two different tome intervals [31,32]. Thus, we still prefer to us the model SHADIF14k and MATLAB software from Pavón–Carrasco et al. [33,34]. Dating details and probable intervals obtained at a 95% confidence level are shown in Figures 7 and 8. As expected, the possible dating intervals are very similar (Pit House 1—196 to 48 B.C.; Pit House 2—151 to 88 B.C.; Pit House 3—171 to 87 BC: Pit House 4—206 to 47 B.C.).; Horno—171 to 72 B.C.

Systematic archaeological surveys during the last decades have documented numerous cultural features at La Playa, corresponding to the biggest Early Agricultural period regional settlement [7–9].

Recently available, high standard radiocarbon ages from archaeological contexts at La Playa show that it reached maximum occupancy during the Early Agricultural period, especially during the Cienega phase, which ended roughly between (1 to AD 200) [7]. This pattern is similarly observed at contemporaneous sites in southern Arizona, as Cienega phase villages reach population maximums prior to shifting settlement patterns and the beginning of the Hohokam cultural sequence (in Arizona) [7,35].

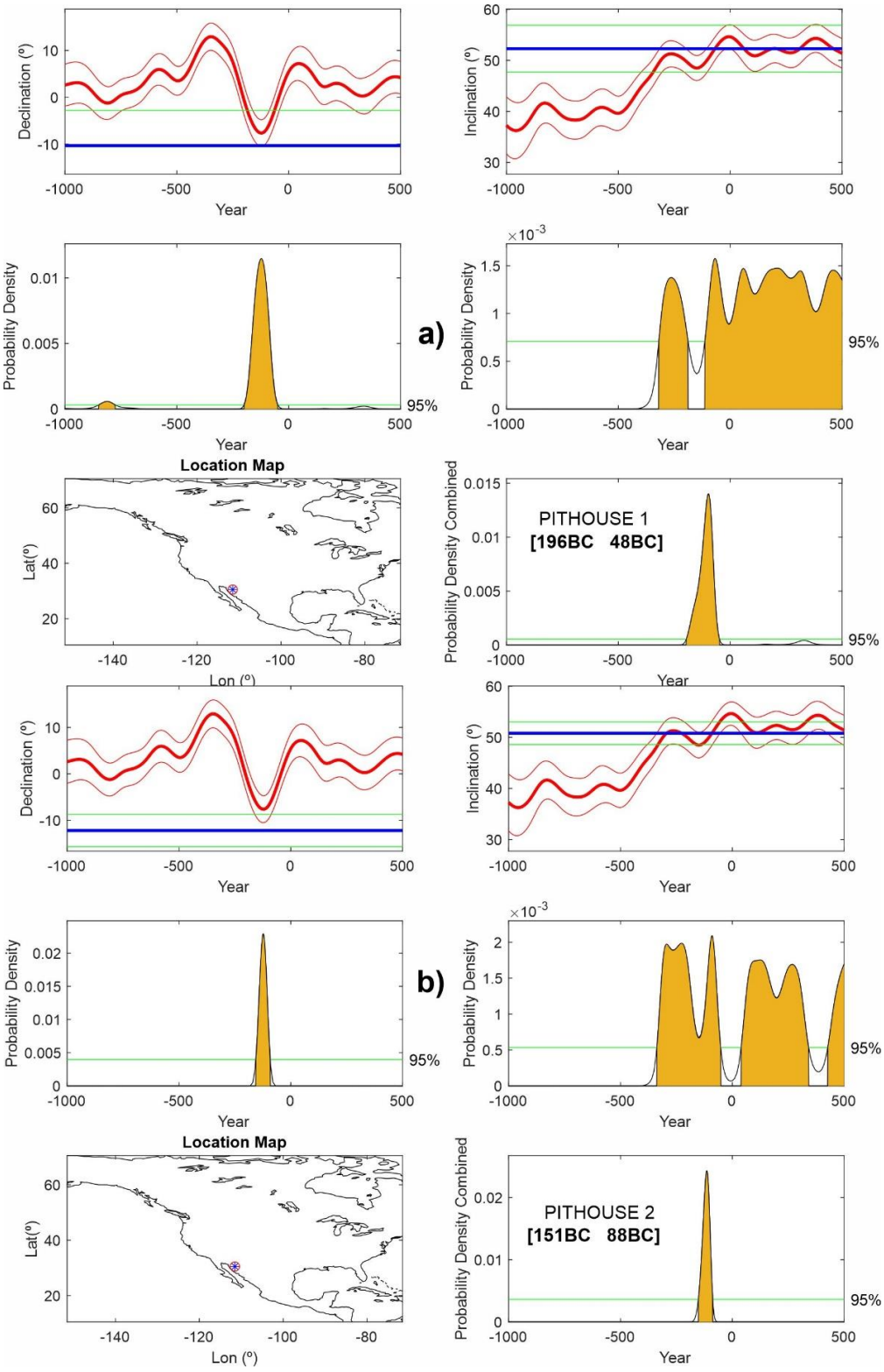

Figure 7. Archaeomagnetic dating using SHA.dif.14k global geomagnetic model [33,34] for Pit House 1 and 2.

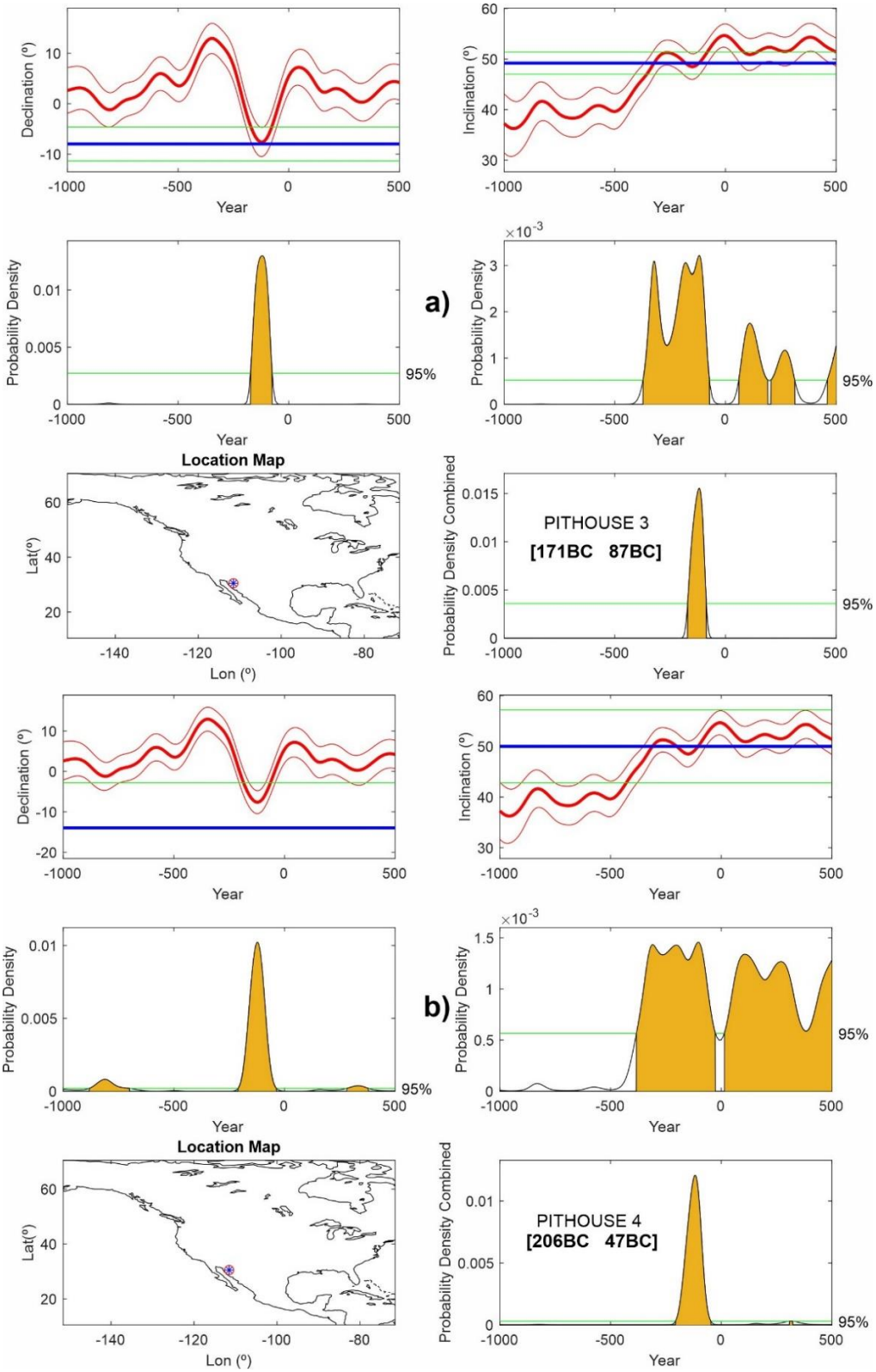

Figure 8. Archaeomagnetic dating using SHA.dif.14k global geomagnetic model [33,34] for Pit House 3 and 4.

Probably, the most interesting archaeological features at La Playa are semi-preserved Pit Houses. Regarding the construction techniques with which the houses were built, up to now, we can say that the walls were excavated with a circular cutting instrument—surely some wooden stick, judging by the marks left. This instrument was one of the tools used in the excavation of the area destined for the element where the marks of the "excavator stick" are perceptible.

It is now known that residents of the Tucson Basin used wooden shovels and pottery shards. These elements were apparently used to dig the floor to a depth of 50 or 60 cm from the surrounding ground level. The technique used to build this type of house consisted, once the required depth was achieved, of assembling the main structure with mesquite or ironwood trunks that allowed the roof to be supported; between these main posts, ocotillo rods were placed to shape the exterior walls of the house. It seems that the roof was formed by reeds, or there was probably a kind loft inside the house. It is very possible that, in the central part of the floor, there was a stove just aligned with the entrance of the house; however, the erosion of almost half of the structure does not allow us to confirm the above. It is evident that this house corresponds to the Ciénega—Late Phase of the Early Agriculture Period due to the association with the four Ciénega Larga style points found, which has been confirmed with radiometric dates (28 $\pm$ 14 AD). The age estimation was carried at AMS facilities of Arizona University. Laboratory code—UA-AA93711, Material dated—wood, uncalibrated ^{14}C date—1900 $\pm$ 30 BP, ^{13}C o/100–121, calibrated age interval using OxCal 4.2–28 AD (95.4%) 215 AD.

If the house was preserved due to an unplanned fire or if there was a ritual closing of this element, it is something that we will hardly be able to corroborate, although we are inclined towards the latter due to the presence of the four Ciénega Larga style points placed towards the north of the entrance of the house. What seems important to us to highlight is that we do not believe that it was just any house but, rather, the place of residence of a member of the community who had access to ritual-related paraphernalia. In any case, simultaneous intentional burning of different Pit Houses revealed by the present archaomagnetic survey reinforce the ritual closure hypothesis. Whether this event may be considered as abandonment of site needs more precise analysis in order to make any firm conclusions. Still, the poorly documented post Cienega phase seems to have significantly reduced activities and far fewer archaeological features.

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