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Authors
Bernardini, Wesley
Schachner, Gregson

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The Bonito Factor: How Unique Was Pueblo Bonito?

Wesley Bernardini and Gregson Schachner

Wesley Bernardini, Dept. of Sociology and Anthropology, University of Redlands, 1200 E. Colton Ave., Redlands CA 92373, wesley_bernardini@Redlands.edu

Gregson Schachner, UCLA Dept. of Anthropology, 341 Haines Hall – Box 951553, Los Angeles, CA 90095 -1553, gschachner@ucla.edu

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Abstract

Pueblo Bonito is the largest and most centrally located great house in Chaco Canyon. One of its most striking attributes is its abundance of "exceptional deposits" of rare and unusual objects. It is unclear, however, whether Pueblo Bonito's assemblage reflects its unique status in the Chaco world or whether it is a product of sampling bias. To answer this question, we use binomial probabilities to interpret the significance of both finding, and of failing to find, exceptional deposits in other great houses. Our analysis suggests that excavated great houses can be grouped into three categories with respect to exceptional deposits: those that likely contain frequencies comparable to Pueblo Bonito; those with frequencies substantially less than Pueblo Bonito; and those that have been insufficiently sampled to make strong inferences. Variation and uncertainty in the presence of exceptional deposits have important implications for interpreting great house functions and Chacoan sociopolitical organization.

Pueblo Bonito es la más grande y céntrica de las "grandes casas" del Cañón del Chaco. Uno de sus atributos más llamativos es la abundancia de "depósitos excepcionales" de objetos raros e inusuales. Sin embargo, no es claro si el conjunto de Pueblo Bonito refleja su estatus único en el mundo del Chaco o si es producto de un sesgo de muestreo. Para responder a esta pregunta, usamos probabilidades binomiales para interpretar qué significa encontrar o no depósitos excepcionales en otras grandes casas. Nuestro análisis sugiere que las grandes casas excavadas pueden ser agrupadas en tres categorías con respecto a la presencia de depósitos excepcionales: aquellas que probablemente contienen frecuencias comparables a las de Pueblo Bonito; aquellas

con frecuencias sustancialmente menores a las de Pueblo Bonito; y aquellas que no han sido suficientemente muestreadas para hacer inferencias sólidas. La variación e incertidumbre en la presencia de depósitos excepcionales tiene importantes implicaciones para interpretar las funciones de las grandes casas y la organización sociopolítica de la región de Chaco.

Key Words

Chaco Canyon, Pueblo Bonito, sampling, Chacoan great houses, binomial probability

The Bonito Factor: How Unique Was Pueblo Bonito?

"Pueblo Bonito is quite clearly in a class entirely its own" (Toll 1991:85).

"The Pueblo Bonito bias...plagues virtually all attempts to address questions about Chaco great houses" (Plog 2018:240).

Pueblo Bonito was the largest and most centrally located great house in Chaco Canyon, which itself was the center of a regional phenomenon spanning more than three centuries and 75,000 km^2 (Figure 1). Perhaps the most striking attribute of Pueblo Bonito is the abundance of rare and unusual objects found within its walls. For example, more than 60,000 pieces of turquoise were found at Pueblo Bonito – more than four times the amount reported for all other Southwestern sites *combined* (Neitzel 2003a; Snow 1973:35). Pueblo Bonito also has the most macaws, jet artifacts, shell artifacts, and cylinder vessels of any great house, again by large margins (Neitzel 1989:190-194; Neitzel 2003a).[1] A large percentage of these rare and unusual objects tend to be found in a small number of exceptional deposits. Pueblo Bonito's Room 33 alone, for example, contained more than 50,000 pieces of turquoise. The remarkable concentration of rare and unusual material at Pueblo Bonito plays a significant role in interpretations of the Chaco phenomenon, especially the degree of social hierarchy present in great house communities (e.g., Judge and Cordell 2006; Kantner 2004; Lekson 2009; Mills 2002, 2008; Plog and Heitman 2010; Watson et al. 2015) and the relationship of Pueblo Bonito to other great houses (Kennett et al. 2017; Mathien 2003; Mills 2015; Plog and Heitman 2010; Van Dyke 2007:118).

[1] Some researchers consider Wupatki to be a Chacoan great house, but we do not include it as a great house in this study. Wupatki has more whole or partial remains of macaws than Pueblo Bonito (Plog et al. 2022; Schwartz 2022).

Pueblo Bonito was undoubtedly important given its size and location, but a critical question remains: to what extent is Pueblo Bonito's apparently unique assemblage of rare and unusual objects a product of sampling bias (e.g., Toll 1991:86)? Pueblo Bonito is by far the largest and most extensively excavated great house in Chaco Canyon and its assemblage is often the primary focus of artifact-based analyses of Chacoan sociopolitical organization.[2] Yet, in light of vastly different sampling fractions at great houses, how surprised should we be that comparable deposits have not been found elsewhere? How likely is it that exceptional deposits lie undiscovered in other great houses? How careful should we be in extrapolating conclusions based on analyses of Pueblo Bonito to other great houses?

[Figure 1 near here]

To answer these questions, we use data from Pueblo Bonito - which is essentially completely excavated - to determine the *expected* probability of finding exceptional deposits in Chacoan great houses if the frequency in Pueblo Bonito were the norm. We then use binomial probabilities to consider whether the excavations that have taken place in other great houses are sufficient to have discovered Pueblo Bonito-like deposits if they were in fact present. The results of this analysis help us to interpret the significance of both finding, and of failing to find, exceptional deposits in Chacoan great houses. We group excavated great houses into three categories with respect to exceptional deposits: those that likely contain frequencies comparable to Pueblo Bonito; those with frequencies substantially less than Pueblo Bonito; and those that have been insufficiently sampled to make strong inferences. A clearer understanding of the current state of the Chaco Canyon archaeological record helps us assess the plausibility of

[2] Kin Kletso, a much smaller, McElmo phase great house, was also nearly completely excavated yet receives very little attention due to the paucity of artifacts recovered (Vivian and Matthews 1965). We consider Kin Kletso further below.

various interpretations of Chacoan sociopolitical organization and highlights aspects that remain uncertain (also see Crown and Wills 2018).

The Pueblo Bonito assemblage

The fact that Pueblo Bonito was nearly completely excavated and yielded numerous exceptional deposits explains both why it has received so much attention and why it is so difficult to compare to other sites. The appeal of a complete assemblage is not hard to appreciate. The full excavation of Pueblo Bonito makes it possible to see patterns in the distribution of individual artifact classes that would otherwise be obscured, revealing valuable information about social groups, ritual practices, and status at the site (e.g., Bishop and Fladd 2018; Mattson 2016; Watson et al. 2015). Full excavation also makes it possible to examine the totality of relationships among artifact classes across the site, an approach developed by Neitzel (2003a) and extended by Giomi and Peeples (2019) using network analysis. Analyses of human remains from Pueblo Bonito have enabled studies of a range of status differences, social/ceremonial roles, and genetic relationships (e.g., Akins 2003; Gruner 2015, 2019; Kennett et al. 2017; Schillaci and Stojanowski 2003). These remarkable data sets make it easy to understand why scholars have focused an inordinate amount of attention on Pueblo Bonito.

The lack of comparably scaled excavations at nearly all other great houses in the canyon, however, makes direct comparisons among great house assemblages difficult. While it is common for Chaco scholars to point out the unusual nature of Pueblo Bonito's assemblage, few have directly addressed the implications of uneven sampling. Plog's (2018:240-241) cautionary note that, because most other great houses do not have remotely comparable excavation records, a "Bonito bias… is largely unavoidable" is one of the more explicit statements on the subject. It was Toll (1991:85-86) who first coined the term "the Bonito factor" to highlight the uniqueness

of Pueblo Bonito's assemblage. In that discussion, Toll (1991:86, emphasis in original) noted that Gwinn Vivian felt strongly that "the 'Bonito Factor' *is* the result of excavation sampling error: the rooms containing great quantities of material are relatively few, and Pueblo Bonito has had the largest number of rooms excavated."

Exceptional deposits at Pueblo Bonito

Pueblo Bonito (Figure 2) consists of approximately 300 ground-floor rooms[3] (with an estimated additional 300 upper story rooms), up to four great kivas (of which only two [Kivas A and Q] are well documented), and at least 37 excavated small kivas (Crown and Wills 2003:519), of which 28 have sufficient data to be included in this study.

All of the exceptional deposits in Pueblo Bonito (as we define them; see below) are found in an arc of about 74 rooms that were built early in the site's occupation, ca. A.D. 850-930.[4] As Pueblo Bonito grew, these early rooms became increasingly enclosed and difficult to access - a quality which, along with their association with foundational events and individuals (Ashmore 2007; Heitman 2015; Marden 2015; Mills 2015; Plog and Heitman 2010), may have encouraged their use for special deposits (Crown and Wills 2003; Weiner 2015). Most notable in this regard are two sets of rooms used as "burial crypts" in which several generations of individuals and associated funerary and ceremonial goods were interred (Plog and Heitman 2010). If other great

[3] We exclude small corner rooms from blocked-in kiva complexes in this total and in all other great house room estimates presented here.

[4] The earliest rooms, potentially built as early as A.D. 775-825 (Stephen Plog, personal communication 2022) were located in the area around the northern burial crypt. Wings of more regularly shaped rooms were added to the east and west of this core as early as A.D. 825-850 (Room 317, located in the western wing, has a cutting date of A.D. 828 [TRL# JPB-104, Chaco Research Archive 2022a]). Most of the rooms of the eastern wing were destroyed by later construction. It is possible – perhaps even likely - that exceptional deposits were also present in the original rooms of the eastern wing. Our count of 74 "early" rooms includes all surviving rooms from these early stages.

houses follow the Pueblo Bonito pattern, we might expect exceptional deposits to occur most often in the early (ca. A.D. 850-930) components.

[Figure 2 near here]

The placement of exceptional deposits in early rooms at Pueblo Bonito does not, however, mean that the deposits themselves were all early. A few relatively well-dated instances suggest that emplacement of these deposits was more complicated. Burials and associated objects were placed in the burial crypts across almost three centuries (Kennett et al. 2017), though the bulk of the rare and unusual objects from the northern crypt date to early in this sequence (Plog 2018). Other exceptional deposits appear to have been placed in early rooms by later occupants during ritual decommissioning events over the course of the great house's use-life, such as the cache of cylinder jars in Room 28 intentionally destroyed by fire around A.D. 1100 (Crown 2020:170). AMS dating of macaws in Room 38 suggest that the birds were placed in the room over the course of at least several decades in the late A.D. 900s and early 1000s (Watson et al. 2015). Finally, while Kiva R was initially constructed around A.D. 860, contemporaneous with the early arc of rooms, it was remodeled four times and its turquoise and shell deposits probably date to the early A.D. 1000s (Lekson 1984:59; Mathien 2001:112). For most other exceptional deposits in Pueblo Bonito, no clear dating of the deposition event(s) is available.

In our assessment of exceptional deposits at Pueblo Bonito, we consider the distribution of eleven different rare and unusual artifact classes: turquoise, jet and other colored stone, shell, fossil shell, projectile points, ceremonial sticks, cylinder vessels, jar covers, pipes, macaws, and

manos/metates.[5] Data on the distribution of these artifacts at Pueblo Bonito are drawn from Neitzel (2003a), supplemented by kiva data collected by Giomi and Peeples (2019) and Heitman (2011), macaw data collected by Bishop (2019; Plog et al. 2022), and the Chaco Research Archive (www.chacoarchive.org). We limit our analysis to architectural contexts (rooms, kivas, and great kivas) and exclude extramural areas such as plazas and middens.

There are several important caveats to make explicit. First, we acknowledge that Pueblo Bonito is not, in fact, "fully excavated." All or nearly all standing architecture has been dug, but a component predating the early arc is known to be buried beneath the plaza (and likely elsewhere) that has only been lightly sampled (Crown and Wills 2018; Vivian 1990:58). Second, we do not have a record of everything that entered the Pueblo Bonito archaeological record. The site was looted before and during the earliest professional expeditions, actions which removed an unknown quantity of material.[6] Looting was widespread and extensive in Chaco Canyon (Akins 1986:7-9), affecting nearly all major sites including Peñasco Blanco and Una Vida (Pueblo Bonito's two most comparable early great house peers). Third, Pueblo Bonito underwent substantial and nearly continuous remodeling during its occupation (Crown and Wills 2018), which invariably affected the locations and existence of some earlier exceptional deposits. Finally, in our analysis we count only the number of ground floor rooms, assuming that everything in the "column" of rooms at that location was excavated. Counting ground floor rooms in this manner has the advantage of sidestepping the complex stratigraphy of multi-storied sites with long occupation histories (like Pueblo Bonito) and enables us to count rooms in both

[5] We exclude from analysis some artifact categories used in previous studies (e.g., Neitzel 2003a; Giomi and Peeples 2019) that are either primarily utilitarian in use, found in relatively small quantities, or both, specifically: bowls and jars, total whole ceramics, cordage/basketry/textiles, worked bone, food/plants; copper, spindle whorls, crystals, and other stone jewelry.

[6] For example, Akins and Schelberg (1984:91) relate a story by Marietta Wetherill (wife of Richard Wetherill), who "told of a large square room on the west side of the pueblo, where in the center of the room was the extended burial of a man with strands of turquoise beads wrapped around his forehead, looped around his shoulders and hung down to his waist. She recalled that there was almost a bushel of turquoise on him. Around the wall of the room were 13 skeletons of women, none with any ornaments."

excavated and unexcavated portions of sites using the same method. Nevertheless, this practice oversimplifies the reality of great house deposits and excavations.

Identifying exceptional deposits

The total number of rare and unusual artifacts at Pueblo Bonito is high because complete excavation has uncovered both the handful of exceptionally rich deposits *and* the many small deposits scattered across the site. Small deposits are relatively common at Pueblo Bonito. A total of 168 excavated rooms, 26 small kivas, and two great kivas at Pueblo Bonito contained at least one of the eleven classes of rare and unusual artifacts considered here. In the analyses below, we focus on *exceptional* deposits at Pueblo Bonito rather than on cumulative artifact totals across the entire site. We employ this focus because most other excavated great houses in Chaco Canyon lack the detailed, room-by-room data that would be necessary to generate trustworthy cumulative totals of small deposits. Exceptional deposits, on the other hand, tend to be reported (at least anecdotally) even when they were discovered by non-professional excavation, enabling comparison across all great houses.

To systematically identify exceptional deposits at Pueblo Bonito, we consider the eleven artifact categories individually. For each category, we focus on deposits that contain a quantity that falls in or above the 98th percentile for counts of that artifact across all rooms and kivas at Pueblo Bonito (Figure 3, Table 1). The purpose of this approach is to set a sufficiently high bar that the discovery of a single, above-threshold deposit at another great house would justify the conclusion that exceptional, Pueblo Bonito-like deposits are present there. The rare and unusual objects included in the analysis, and the exceptional deposits at Pueblo Bonito that meet the 98th percentile threshold, are discussed below and listed in Table 2.

[Figure 3 and Table 1 near here]

Turquoise at Pueblo Bonito is found as jewelry (beads and pendants), mosaic inlays, debitage, and unworked material. For the purposes of this analysis, we do not discriminate among these categories, though especially for turquoise it can be important to distinguish between manufacturing debris and finished objects (e.g., McKenna and Truell 1986). Most recovered turquoise at Pueblo Bonito is in the form of finished objects such as beads, pendants, and mosaic inlays. Jet and other colored stone and shell artifacts at Pueblo Bonito consist primarily of beads, in addition to pendants, bracelets, and mosaic pieces. Fossil shell was found in its natural, unmodified form and likely functioned as a ceremonial object (Agostini and Notterpek 2020; Neitzel 2003a:112). Projectile points are ordinarily utilitarian items, but many of those recovered from large deposits at Pueblo Bonito show no signs of use and appear to have been made specifically for placement in a mortuary or ceremonial deposit (Lekson 1997). Ceremonial sticks are modified wooden objects that are thought to have had ceremonial and status functions (Vivian et al. 1978), and some were possibly used in ritualized gaming (Weiner 2018). Cylinder jars are tall, narrow pottery vessels that were used for drinking cacao (Crown 2018). Cylinder jar covers are sandstone disks thought to have been used as lids for cylinder jars. Pipes are short, generally L-shaped forms made of clay or steatite that are sometimes painted and are thought to have been used during ceremonies. Scarlet macaws (*Ara macao*) and thick-billed parrots are native to humid tropical forests and were valued across the ancient American Southwest for their colorful feathers. Forty-five macaws/parrots have been recovered from Chaco Canyon, 37 of which were found at Pueblo Bonito (in ten different rooms; three are from extramural contexts excluded from this analysis) (Bishop 2019:160). Finally, while manos and metates are typically utilitarian objects, some rooms contain such large numbers of them that

these items "may have been given sacred or social value through deposition in Pueblo Bonito" (Neitzel 2003a:122).

[Table 2 near here]

Burial crypts

For the purposes of this analysis, we consider the rooms that were part of the two "burial crypts" at Pueblo Bonito to be exceptional deposits even if they do not meet the 98th percentile threshold for an individual object category. Each crypt comprised a suite of four rooms in which large numbers of burials and associated ceremonial objects were interred. The northern burial cluster consists of four rooms (32, 33, 53, and 56), three of which (32, 33, and 53) contained deposits that met the 98th percentile threshold for at least one artifact category. Room 56 was badly disturbed by Warren K. Moorehead (1906), with the contents scattered into adjacent rooms, but Crown's (2020) careful reconstruction suggests that Room 56 may have originally contained several thousand pieces of turquoise, shell, jet, and shale, and up to 14 cylinder jars.[7]

The western burial cluster comprises rooms 320, 326, 329, and 330[8], of which only Room 320 contained sufficient quantities of a single artifact class to meet the 98th percentile threshold. The other rooms in the western burial cluster nevertheless contained a large number of burials and a wide variety of objects that, in the aggregate, qualify them as exceptional deposits. Room 326 contained the remains of 10 adults and an infant, 89 ceramic vessels, 1 cylinder jar, 16 turquoise, shell, and jet ornaments, and 13 baskets. Room 329 contained about two dozen burials along with 43 ceramic vessels, 5 cylinder jars, and 10 jet, shell, and turquoise ornaments. Room

[7] The original context of objects found in rooms 53 and 56 are uncertain as a result of Moorehead's careless excavations. Neitzel's (2003a) artifact counts from these rooms derive from Pepper's excavation of Moorehead's backdirt, plus Pepper's excavations of intact deposits in Room 56 missed by Moorehead.
[8] Room 365, contiguous to Rooms 320 and 326 and connected by doorways, remains unexcavated.

330 contained between 23 and 32 burials in addition to 49 ceramic vessels, 6 cylinder jars, and 22 ornaments of turquoise, jet, and shell (Chaco Research Archive 2022b).

Summary

We identified a total of 18 discrete contexts at Pueblo Bonito (17 rooms and one kiva) that contained exceptional deposits. Roughly half (eight) of these contexts were part of burial crypts consisting of four adjacent rooms each. Of the remaining nine contexts, all but two (Room 42 and Kiva R) are adjacent to at least one other exceptional deposit. Exceptional deposits at Pueblo Bonito are thus relatively clustered. All of the 18 deposits are associated with the early arc of rooms built ca A.D. 850-930, though as noted above not all of the objects found in these deposits were actually placed during this interval.

Binomial Probabilities

Having defined and identified exceptional deposits at Pueblo Bonito, we now assess how likely it is that similar deposits were present in other great houses. One rough way to explore this issue is to use Pueblo Bonito's complete assemblage to determine the *expected* probability of finding exceptional deposits in Chaco Canyon great houses. Binomial probabilities can then be used to evaluate whether the excavations that have taken place in other great houses are sufficient to have discovered exceptional deposits if they were present in the same frequencies as documented at Pueblo Bonito.

A binomial distribution provides the probability of an event with two possible outcomes (e.g., "present" or "absent"). Given a fixed probability of an event, the binomial distribution makes it possible to estimate the probability of a particular outcome (a "success") given a specified number of trials. For this study, we use the binomial distribution to calculate the

probability of finding exceptional deposits in the excavated rooms and kivas of a great house, where the excavation of each room or kiva is treated as an independent trial and the discovery of an exceptional deposit represents a "success."

The probabilities of discovering exceptional deposits at great houses beyond Pueblo Bonito (discussed below) should probably be viewed as upper bounds, for two related reasons. First, almost all of the exceptional deposits at Pueblo Bonito occurred in small clusters. Second, excavations conducted at other great houses were also typically clustered. Such non-random sampling makes it less likely to discover rare deposits, especially if the deposits themselves were clustered. Because binomial probabilities assume independent samples, the probabilities discussed below probably overestimate the likelihood of finding exception deposits.

Binomial probabilities are calculated as

$$P = \binom{n}{k} \cdot p^k \cdot (1-p)^{(n-k)}$$

where P is the probability of exactly k successes in n independent trials where the probability of success in each trial is p. To calculate binomial probabilities, we use the BINOMIAL program in Kintigh's (2002) *Tools for Quantitative Archaeology* software toolkit which, in addition to providing probabilities of a specific number of outcomes, also provides probabilities of getting ≤k or ≥k outcomes.

We estimate p by dividing the number of exceptional deposits at Pueblo Bonito by the total number of excavated contexts. We use two different values of p for comparison with other great houses. For great houses containing components contemporaneous with Pueblo Bonito's early arc (ca. A.D. 850-930) we use p = .243 (18 contexts in Bonito's early arc which contain exceptional deposits divided by 74 total rooms in the arc; that is, a 24.3% chance of finding an

exceptional deposit in a given trial). In this scenario, we assume that exceptional deposits in other great houses would be preferentially placed in early rooms, as they were in Pueblo Bonito. For great houses (or components of a great house) built after A.D. 930, we use p = .055 (18 total exceptional deposits at Pueblo Bonito divided by 300 ground floor rooms plus 28 kivas and great kivas present at that site; that is, a 5.5% chance of success in a given trial). In this scenario, given the absence of early rooms that might be preferentially used for exceptional deposits, we assume that exceptional deposits were equally likely to have been placed in any room or kiva. Binomial probabilities for each great house considered in this study are presented in Table 3 and discussed below (note that, for Peñasco Blanco, we model multiple scenarios given uncertainties about the number of excavated rooms and exceptional deposits).

[Table 3 near here]

Evaluating great houses with early components

Chaco Canyon great houses with known construction events in the A.D. 850-930 interval include Pueblo Bonito, Peñasco Blanco, and Una Vida. Early great house components are also likely present at Kin Bineola, East Community, Kin Nahasbas, Padilla Well, Casa del Rio, and possibly Pueblo Pintado (Lekson, Windes, and McKenna 2006:74). Of these sites, only Pueblo Bonito has had significant professional excavation. A small number of rooms at Una Vida were professionally excavated (though with limited documentation), and non-professional excavations occurred at Peñasco Blanco and Una Vida, both of which have anecdotal documentation. At Kin Nahasbas, which consists of a great kiva and associated 25-room roomblock, only the great kiva has been professionally excavated (Luhrs 1935). Since only this single context was excavated

(no exceptional deposits were uncovered), Kin Nahasbas is not included in the analysis below.[9] No documented excavations have occurred at the other early great houses.

Una Vida

The earliest construction at Una Vida (Figure 4), dating to the mid-A.D. 800s was a small, two-story arc containing at least six ground-floor rooms (Chaco Research Archive 2022c; Lekson 1984:90). Additional rooms and a kiva may lie to the east of the arc, and rooms extending to the south may be buried beneath or incorporated into later construction (William Gillespie, personal communication, 2022). Additions between A.D. 930-950 created an L-shaped block of 31 rooms to the south of the original core, but the rest of the architecture post-dates A.D. 1050. Undocumented excavations in the early 1900s exposed three rooms (Lekson 1984:87-88), probably located in the northern corner of the site (William Gillespie, personal communication, 2022), but nothing is known about their contents. Gordan Vivian excavated fifteen rooms in the northern corner of the site in 1960, probably including the three rooms disturbed by earlier looting. Vivan's excavations did not include any rooms from the mid-AD 800s component at Una Vida. Seven of Vivian's excavated rooms date to the A.D. 930-950 interval; three to the A.D. 950s; and two to A.D. 1050-1095 (Lekson 1984:90-93). No report on Vivian's work was prepared, though Akins and Gillespie (1979) did review Vivian's notes and recorded exposed features in excavated rooms. No indication of exceptional deposits was found.

Binomial probabilities

The 15 rooms excavated by Vivian at Una Vida all post-date the A.D. 850-930 component of Pueblo Bonito. If Una Vida contained a Pueblo Bonito-like frequency of

[9] Excavations in the great kiva at Kin Nahasbas uncovered one pipe, ten manos, three metates, six black beads, 13 white beads, three turquoise beads, and one fossil shell (Luhrs 1935).

exceptional deposits, using a p of .055, the most likely single outcome in 15 trials would be zero successes (43%), while the probability of one success is 37%. The probability of one or more successes is 57%. Thus, while it would not be surprising to find one success in 15 trials, it would not be unreasonable to miss an exceptional deposit even if it were present. In short, the sample of excavated rooms at Una Vida is too small to draw particularly strong inferences about the likely presence of exceptional deposits at the site as a whole.

[Figure 4 near here]

Peñasco Blanco

The earliest portion of Peñasco Blanco (Figure 5) was an arc of about 47 ground-floor rooms built around A.D. 900-915 (Lekson 1984:104). After this construction there seems to have been a building hiatus until ca. A.D. 1050. Poorly documented excavations by local Navajos in the late 1890s (including men employed by Richard Wetherill and George Pepper at Pueblo Bonito) opened a number of rooms at Peñasco Blanco (Pepper 1903; Lekson 1984:104). At least two of the excavated rooms contained human remains from multiple individuals (Pepper 1903, 1920:378). Perez's (2012:163) careful reanalysis of these remains suggests "a secondary burial practice or a postmortem ritual process." Thus, it is possible that the human remains uncovered at Peñasco Blanco were subject to sequential interments and post-mortem disarticulation similar to practices identified in Pueblo Bonito's northern burial crypt (see Akins 2003).

Pepper's (1903:R3_008) notes indicate that human remains were recovered from two separate areas of Peñasco Blanco: "one of the Western Rooms," and "one of the N.E. rooms." If, as Lekson (1984:104) suspects, the diggers targeted rooms with intact roofs, the affected areas could include Rooms 1, 2, 3, 7, 8, 31, 41, 46, 51, 61, 95, and 98 (these are the rooms plotted in

Figure 5). Rooms 46, 51, 61, and 98 were located in the early, A.D. 900-915 arc (the remainder are in post-A.D. 1050 areas); Rooms 1, 2, 3, 7, 8, and 41 are in what could be described as the northeastern portion of the site.

[Figure 5 near here]

The digging by Navajo workmen at Peñasco Blanco also uncovered a significant quantity of turquoise beads (though again, the specific provenience of these finds is unknown). An elderly Navajo resident of Chaco Canyon named Hosteen Beyal, interviewed by Neil Judd in the 1920s, said that the workmen excavated "two boxes of turquoise" from the site in 1898 (Judd 1954:345). While Beyal indicated that the boxes used by the workmen to hold the turquoise were equivalent in size to wooden cartons that held two dozen 20-ounce peach cans, Judd found this implausible, and other Navajos interviewed by Judd described the quantity of turquoise as "two cigar boxes full" (Judd 1954:345). Estimates of the number of beads that could be held in two wooden cigar boxes of the type in circulation in 1898 range from 4,000 – 60,000 beads, with a most-likely range of about 16,000 - 36,000 beads.[10] Even the lowest bead estimate would

[10] Cigar boxes were ubiquitous storage containers in the 19th and early 20th centuries. Most boxes from this era were made of nailed wood and served as lightweight but sturdy containers with use-lifespans much longer than the cigars that they contained. The most common cigar box in the 1860-1960 era was the Nailed Wood (NW) 50/13, which held fifty cigars. Other common box sizes include the NW 25/5 and the NW 25/13. The NW 25/5 was the most common 25-cigar box size from the 1830s to the late 1880s and measured 4"x3"x3". Inside dimensions of a "typical" NW25/13 box are 7.5" x 4 3/8" x 1" with a range of up to 1.5" on the first two dimensions and .25" on latter (Tony Hyman, personal communication 2021). NW50/13 boxes were 1" taller than the NW25/13 boxes. Information on historic cigar boxes is drawn from the Cigar History Museum website (http://cigarhistory.info/Site/NCM_HOME.html) and consultations with the Museum Director, Tony Hyman.

To calculate the number of beads per box, we assume an average bead diameter and thickness of 4mm (Peregrine 2001:43). The volume of a single bead, calculated as a cylinder, is $V=\pi r^2 h$ = 50.2 cubic mm. We assume a packing capacity of 50% (similar to the density of pennies or buttons in a jar). Finally, we assume that the cigar boxes were only filled three-quarters full to prevent spillage. The lowest turquoise bead estimate (for two NW25/13 boxes with dimensions of 6" x 2.875" x 1") is about 4,200 beads. Two typical NW25/5 boxes would hold about 8,800 beads. Two average sized NW25/13 boxes would hold about 16,000 beads. Two average NW50/13 boxes would hold about 36,000 beads. Two of the largest NW50/13 boxes (measuring 9" x 6.875" x 2") would hold about 60,000 beads. Two boxes of two dozen, no. 2 peach cans would hold an implausible total of 456,000 turquoise beads.

represent four times the quantity of turquoise beads found in the Chetro Ketl great kiva cache (see below), which is the largest single deposit of finished turquoise from a professional excavation in Chaco Canyon outside of Pueblo Bonito. A cache of tens of thousands of beads would be second in scale only to Pueblo Bonito for the entire American Southwest. While the second-hand description of the quantity of turquoise and the inability to know if the turquoise was associated with human remains makes the case for a Pueblo Bonito-type burial crypt at Peñasco Blanco circumstantial at best, it nevertheless seems very likely that these early, poorly documented excavations disturbed at least one exceptional deposit at the site.

Binomial probabilities

Up to twelve rooms were excavated at Peñasco Blanco (the number of rooms with intact roofs that would likely have been targeted), though the actual total is probably not that high (Stephen Plog, personal communication, 2022). We model scenarios in which two or four rooms were excavated in the early component and four or eight rooms were excavated in the late component. At least one (and possibly two) of the excavated rooms likely contained an exceptional deposit, but it is not clear where these rooms were located. If the early component of Peñasco Blanco contained Bonito-like levels of exceptional deposits, using a p of .243, the most likely outcome of four trials would be one success (42%), followed by zero successes (33%) and two successes (20%). If only two rooms in the early section were excavated, the most likely outcome would be zero successes (57%), followed by one success (37%) and two successes (6%). If the exceptional deposit(s) were found in the post-A.D. 1050 component of Peñasco Blanco, using a p of .055, the most likely outcome of eight trials would be zero successes (64%), followed by one success (30%). The probability of two successes is quite low, only 6%. If only

four rooms were excavated in the late component, the most likely outcome would be zero successes (80%), followed by one success (19%) and two successes (2%).

In sum, if Peñasco Blanco contained a Bonito-like density of exceptional deposits, it would be somewhat surprising to find one deposit in the limited excavations at the site, and even more surprising to find two (especially if they came from the post-A.D. 1050 component). These results suggest that Peñasco Blanco may in fact contain a frequency of exceptional deposits comparable to Pueblo Bonito, supporting a scenario in which Peñasco Blanco was a peer of sorts to Pueblo Bonito as some scholars have proposed (Windes and Van West 2021:75-76).

Evaluating great houses with later components

Several great houses in Chaco Canyon were founded after the A.D. 850-930 period, most built during the heyday of Chacoan construction in the A.D. 1000s. These great houses post-date the era of venerated founding individuals such as those buried in Pueblo Bonito's burial crypts. The placement of exceptional deposits in Pueblo Bonito did continue past the A.D. 850-930 period, however, suggesting that similar practices may have occurred in later great houses as well.

Pueblo Alto

Pueblo Alto (Figure 6) contains 130 ground-floor rooms and 15 kivas, constructed between A.D. 1020 – 1140. Eleven rooms were excavated, all dating to the A.D. 1020-1050 period.[11] No exceptional deposits were found. Only 278 pieces of turquoise were recovered from the entire site, despite extensive excavations in the midden (Mathien 1987:383). More than 1,000

[11] Two rooms dating to a late A.D. 900s component were exposed below the floors of later rooms. In keeping with our practice of counting everything within a "column" of rooms together, we do not add these rooms to the total of 11 that were excavated.

pieces of gypsite were encountered in the Pueblo Alto excavations, but only 12 were modified (3 pendants and 9 beads); the rest were unmodified soft pieces that were likely collected for use as white pigment (see Mathien 1987:418). The most substantial deposit of exotic material was found in a pit exposed in a trench through the plaza containing 23 pieces of turquoise, 63 shale beads, 22 calcite beads, and five Glycymeris bracelet fragments, among other artifacts (Mathien 1984:179). Room 142 also contained 123 pieces of turquoise inlay, perhaps once part of an inlaid object (Mathien 1987:408). In her assessment of ornaments and minerals at Pueblo Alto, Mathien (1987:427) observed that the great house "did not have as many ornaments as those at Pueblo Bonito" nor "as few as those in Chetro Ketl and Kin Kletso."

Binomial probabilities

If Pueblo Alto contained Bonito-like levels of exceptional deposits, using a p of .055, the most likely outcome of eleven trials would be zero successes (54%); the probability of one success is 34%. These results indicate that it is unsurprising to have found zero successes and that our confidence that exceptional deposits are truly absent should not be very strong given the limited excavations.

Pueblo del Arroyo

Pueblo del Arroyo (Figure 7) contains approximately 193 ground floor rooms[12] and 21 kivas. Approximately 64 ground floor rooms plus 15 kivas (including the tri-wall "kiva") were excavated, all post-dating A.D. 1050. No exceptional deposits were found in these excavations. Judd (1959:124, 125), in fact, noted the "meager assortment of ornaments" and conspicuous

[12] We do not include the rooms in the tri-wall complex in this total, considering them analogous to the "corner rooms" in blocked-in kivas, which primarily served as architectural support and show little signs of use. Including them in the total would only make the absence of exceptional deposits at Pueblo del Arroyo more striking.

absence of turquoise at the site (fewer than 200 pieces [Chaco Research Archive 2022d]). Pueblo del Arroyo contained four cylinder jars (one white ware and three undecorated red wares [Judd 1959:156]). No rooms contained large deposits of ground stone (Judd 1959:135).

Binomial probabilities

If Pueblo del Arroyo contained Bonito-like levels of exceptional deposits, using p = .055, the probability of zero successes in 79 trials would be very small (1%), while the odds of one or more successes are 99%. Thus, enough rooms have been excavated at Pueblo del Arroyo to be confident that if exceptional deposits were present, they should have been found. These results indicate that Pueblo del Arroyo is almost certainly fundamentally different from Pueblo Bonito in its frequency of exceptional deposits.

[Figure 7 near here]

Chetro Ketl

Chetro Ketl (Figure 8) contains approximately 225 ground floor rooms, of which 122 rooms, 10 kivas, one court kiva, and one great kiva have been excavated (Hewett 1936; Vivian et al. 1978), for a total of 134 trials. All of the excavated contexts post-date A.D. 1035. Compared to Pueblo Bonito, Edgar Hewett found Chetro Ketl to be a "dry hole" in terms of artifacts (Lekson 1983:317).[13] Nevertheless, two exceptional deposits were found. The first, from niches in the great kiva, contained 1,045 black and white beads, about 1,000 pieces of turquoise mosaic, and 17,454 shell, onyx, and black beads (Hewett 1936:87-98). The second deposit was found in a second-story room that was excavated in 1947 to prevent collapse after flooding had weakened

[13] It is possible that Hewett would not have commented on concentrations of more common objects such as fossil shell, manos and metates, and projectile points - objects that we include in our inventory of exceptional deposits.

the great house's back wall. More than 200 fragments of carved and painted wood were recovered from this room consisting mostly of "zoomorphic forms, primarily birds and possibly serpents, as well as plume or petal forms, plaques, slats, and disks" (Vivian et al. 1978:1). Vivian et al. (1978:60) concluded that the objects "had been removed from their primary cultural context" and placed as "either storage or refuse." The room containing the cache of wooden artifacts dates to the late Chacoan occupation of Chetro Ketl, presumably sometime in the early A.D. 1100s.

Binomial probabilities

If Chetro Ketl contained a Bonito-like level of exceptional deposits, using a p of .055, binomial probabilities suggest that in 134 trials we should have expected more than two successes. The probability of four successes is 94%, and the probability of six or more successes is 75% (Table 3). These results support prior scholars' observations that exceptional deposits were likely less common at Chetro Ketl than they were at Pueblo Bonito.

[Figure 8 near here]

Kin Kletso

Kin Kletso (Figure 9), located about a half mile northwest of Pueblo Bonito, contains about 65 rooms ground floor rooms and 5 kivas. Tree ring dates suggest relatively rapid construction ca. A.D. 1125-1130. Kin Kletso is classified as a "McElmo" (Vivan and Mathews 1965) great house, a style characterized by compact, symmetrical layouts, uniform room sizes, tower kivas, and a lack of great kivas, among other features.

Kin Kletso's architecture was fully excavated in 1951 (Vivian and Mathews 1965), making it the only comparably excavated great house to Pueblo Bonito (though it tends to be

overlooked by Chaco researchers). No exceptional deposits were found, perhaps explaining the scarce attention it receives. The total inventory of rare and unusual objects included one macaw, 23 pieces of turquoise, and 129 pieces of shell. No jet, ceremonial sticks, cylinder jars, pipes, or clusters of projectile points or groundstone were recovered. Only six burials were encountered, none with abundant associated objects. Vivian and Mathews (1965:110) concluded that "If Kin Kletso is typical, the McElmo Phase in Chaco was particularly poor in both total inventory and diversity."

Binomial probabilities

If Kin Kletso contained a Bonito-like level of exceptional deposits, using a p of .055, binomial probabilities suggest that in 70 trials we should have expected multiple successes. The odds of zero successes are 2% and the odds of one or more successes are 98%. The failure to find any exceptional deposits in 70 trials (which includes essentially all architectural contexts at the site) convincingly demonstrates that they were not present at Kin Kletso.

[Figure 9 near here]

Evaluating selected outliers

We also analyze two large Chacoan outliers contemporaneous with the main great houses in Chaco Canyon: Salmon Ruins and Aztec West. The style of construction and material culture of these great houses indicate strong continuities with Chaco Canyon (Van Dyke 2008; Lekson et al. 2006; Toll 2006; Van Dyke 2008), potentially including construction and occupation by immigrants from Chaco Canyon itself (e.g., Baker 2008; Reed 2011). These two great houses are also among the very few that are comparable to the canyon great houses in terms of size and architectural complexity.

Salmon Ruins

Located 45 miles north of Chaco Canyon, Salmon Ruins (Figure 10) contains about 160 ground floor rooms built between ca. A.D. 1088 and 1094, though occupation continued into the A.D. 1200s. Of the Chaco-era architecture, 46 rooms, one tower kiva, and one great kiva were excavated (Reed 2006) for a total of 48 trials. No exceptional deposits were found in these excavations (nor from the 100+ excavated extramural burial contexts [Espinoza 2006]).

Binomial probabilities

If Salmon Ruins contained a Bonito-like level of exceptional deposits, using a p of .055, the probability of zero successes in 48 trials would be very low (7%) and the probability of one or more successes very high (93%). Thus, the failure to find any exceptional deposits at Salmon is probably indicative of the fact that they were not present at the site.

[Figure 10 near here]

Aztec West

Located 57 miles north of Chaco Canyon, the majority of Aztec West's rooms (Figure 11) were built from A.D. 1110-1115, with a smaller construction episode from A.D. 1118-1130 (Brown et al. 2008), though occupation continued through the AD 1200s.[14] The site contains a total of about 205 ground floor rooms dating to the Chacoan era, of which Morris (1919, 1924, 1928) excavated about 99, in addition to 8 small Chaco-era kivas and one Chaco-era great kiva, for a total of 108 Chaco-era trials. The post-Chacoan occupation of Aztec West (ca. A.D. 1150-1280) comprised about 270 rooms, of which about 71 were excavated, in addition to 15 small

[14] Kiva L has a cutting date of 1072 (Chaco Research Archive 2022e), suggesting that Aztec West could have an earlier component contemporaneous with Salmon Ruin.

kivas, for a total of 86 post-Chaco-era trials. Most of the post-Chaco occupation involved reuse and modification of existing Chaco-era structures, including the construction of kivas within rooms. The extensive reuse of Chaco-era structures likely disturbed many deposits associated with the earlier component, and the potential for "up-cycling" of Chaco-era exotic material into post-Chacoan deposits is high.

Information on rare and unusual artifacts from Aztec West is drawn from Baxter (2016), which focuses on burial contexts. Exotic objects seem to be concentrated primarily in burial contexts at Aztec West (Erin Baxter, personal communication, 2022), though the lack of a complete, room-by-room inventory makes this difficult to fully assess. Excavations uncovered six exceptional deposits[15]:

- Room 41, which contained the burials of two adults and three children, along with a mass of olivella shells, 31,000 black beads, 200 quartzite projectile points, and 8,500 pink beads, in addition to organic material that was poorly preserved. According to Morris (1924), "Had Room 41 been protected from fire and moisture, it would have yielded a close rival to Pepper's unprecedented finds at Pueblo Bonito."[16]
- Room 52, which contained 13-15 burials of infants/children, along with 19,700 black beads, several hundred bird bone tubes, and 65 turquoise beads.
- Rooms 110 and 111, which contained the burials of two adults associated with more than 7,500 beads of black stone and white stone, at least 59 pottery vessels, and roughly 60

[15] A case could be made to consider the "warrior" burial (no. 8070) in Room 178 of Aztec West as an exceptional deposit even though its contents do not meet the standards we set here. The individual was buried with a basketry shield, a wooden "sword", two stone axes, and five ceramic vessels (Harrod 2012; Morris 1924). If this deposit was included as an exceptional deposit, Aztec West's frequency of such deposits would be even higher than we report.

[16] Morris' statement notwithstanding, turquoise, shell, and jet objects are notably less common at Aztec West than at Pueblo Bonito. Turquoise in particular seems to be associated with early stages of Chaco Canyon (Plog 2018).

ceremonial sticks, a deposit "almost precisely comparable to Pueblo Bonito [Room 33] in accouterments and location" (Baxter 2016:191).

- Room 141, which contained approximately 10 burials, most of which were badly looted. Burial 83, which was intact, included a shield, six pottery vessels, two axes, and a bracelet of 29 beads (including turquoise, white, and red stone).
- Room 72, which contained caches of painted dance paraphernalia and altar parts (Morris 1919).

Many of these contexts were looted, so artifact totals are incomplete and likely under-counted. Ceramic dating of exceptional deposits at Aztec West indicates that all six are associated with the post-Chaco phase (post-A.D. 1140) (Mattson 2016:125-126; Morris 1924). None of the seven Chaco-era burials at Aztec West were associated with significant deposits of exotic goods.

Binomial probabilities

For the Chaco era at Aztec West, if we assume a Bonito-like level of exceptional deposits, using a p of .055, the probability of zero successes in 108 trials is 0.2% and the probability of one or more successes is 99.8%. Thus, enough excavation of Chaco-era contexts has taken place to be confident that if exceptional deposits were present in the Chaco-era architecture of Aztec West, they should have been discovered. The Chaco-era component of Aztec West thus either lacked exceptional deposits, or their contents were "up-cycled" for reuse in the post-Chaco era.

For the post-Chaco component of Aztec West, using a p of .055, the most likely outcome of 86 trials would be one to three successes (Table 3). The probability of exactly six successes is relatively low (34%). In other words, it is somewhat surprising to have found so many

exceptional deposits in the post-Chaco architecture at Aztec West given their expected frequency. Exceptional deposits may thus have been even more common at post-Chaco era Aztec West than they were in Pueblo Bonito (when considered across the entire site).

[Figure 11 near here]

Discussion

Binomial probabilities allow us to sort the great houses examined in this study into three main categories with respect to exceptional deposits. The first category includes great houses that likely contain frequencies of exceptional deposits *comparable* to Pueblo Bonito. Into this category we can place two sites: Peñasco Blanco and the post-Chaco component of Aztec West. Peñasco Blanco has long been suspected as a possible "peer" to the early component of Pueblo Bonito based on its size and strategic location within Chaco Canyon (e.g., Windes and Van West 2021:75-76). Though we must rely on secondhand accounts for evidence, very limited digging at Peñasco Blanco may have exposed rooms containing multiple burials and thousands of turquoise beads, suggesting that exceptional deposits may be present in frequencies comparable to Pueblo Bonito itself. Pueblo Bonito and Peñasco Blanco are two of the three earliest great houses, and both overlie and/or neighbor substantial earlier Basketmaker III sites (Crown and Wills 2018; Judd 1964; Windes 2018). These early histories may have been a key source of social importance.

The situation at Aztec West is more complex, and perhaps more surprising. Here, the evidence suggests that exceptional deposits are absent from the Chaco-era component but present in the post-Chaco component in potentially an even higher frequency than at Pueblo Bonito (albeit of a more heavily mortuary-focused character and lacking the turquoise and shell that is

so abundant at Pueblo Bonito). It is possible, however, that the artifacts found in post-Chaco contexts originated in Chaco-era deposits that were reused in the later component.

Together, the results from Peñasco Blanco and Aztec West suggest that claims about the uniqueness of Pueblo Bonito need to be qualified, and that Gwinn Vivian may have been correct in attributing at least some of the "Bonito factor" to disproportionate amounts of excavation. The results also support arguments that view Aztec West as a successor to Pueblo Bonito (e.g., Lekson et al. 2006; Stein and McKenna 1988; Van Dyke 2008) at least in terms of the concentration of exceptional deposits, though perhaps a generation or more later than expected.

The second category includes great houses that likely contain frequencies of exceptional deposits *lower* than Pueblo Bonito. Into this category we can place three great houses from Chaco Canyon (Pueblo del Arroyo, Chetro Ketl, and Kin Kletso) and two outliers (the Chaco-era occupation of Aztec West [discussed above] and Salmon Ruin). Chetro Ketl contains exceptional deposits, but probably not in the frequency found in Pueblo Bonito. Pueblo del Arroyo, Kin Kletso, and Salmon probably lack exceptional deposits altogether, though Pueblo del Arroyo and Kin Kletso do have macaws, which are apparently absent at Chetro Ketl. These results confirm the suspicions of many scholars that not all Chaco Canyon great houses were created equal, and that Pueblo Bonito ranked in the top tier of these buildings (Neitzel 2003b; Schelberg 1984).

Finally, the third category includes great houses that have not been sampled sufficiently to make strong inferences one way or the other about the frequency of exceptional deposits they might contain. Into this category we can place Una Vida and Pueblo Alto. The limited excavations at Una Vida makes its ambiguous status unsurprising. At Pueblo Alto, it might be assumed that the 10% excavation of the site would have been sufficient to gauge the abundance

of exceptional deposits, but in fact binomial probabilities suggest that the excavated sample is too small to judge their frequency with confidence.[17]

Conclusion

Pueblo Bonito plays an outsize role in Southwestern archaeology. Its size, central location, and extraordinary artifact assemblage make it a critical reference point for any discussion about the Chaco world, an essential case study for analyses of hierarchy, status, and ritual practice, and an inescapable point of comparison to ethnographically documented Pueblos. Yet, as Crown and Wills (2018) caution, Pueblo Bonito is to some extent inscrutable. The building's long occupation and incredibly complex history of remodeling, coupled with its uneven record of excavation, present enormous interpretive challenges. In this paper, we have focused on an additional, perhaps underappreciated challenge – the fact that Pueblo Bonito's assemblage is unique in large part because no other comparable great house has been excavated as fully as it has.

Our analysis moves the understanding of exceptional deposits in Chacoan great houses from the relatively abstract and speculative to the more concrete and probabilistic. Using binomial probabilities to quantify the confidence we can have about the presence of exceptional deposits helps us to make the best interpretive use of existing evidence, as flawed and incomplete as it is. This approach also highlights gaps in the available evidence, perhaps pointing the way for future data collection. The exercise suggests that archaeologists will have to accept a certain level of ambiguity in our interpretations of Chaco Canyon simply due to the current state of

[17] There are reasons to suspect that Pueblo Alto might contain buried exceptional deposits. First, an unusually large number of road segments converge at the site, suggesting a special function. Second, Pueblo Alto is repeatedly identified as the residence of The Gambler (a wealthy and powerful figure) in Diné oral histories (Weiner 2018).

archaeological knowledge. While this is nearly always true of archaeological interpretation (Gero 2007), it is especially important to recognize this reality given the "heft" of Chaco in general (and Pueblo Bonito in particular) in Southwest archaeology, Indigenous history, and cross-cultural archaeological studies of social complexity.

The analysis also encourages Chaco scholars to attend to the variation present in Chaco great houses. Shared architectural characteristics across a vast territory, roads, and intervisible features attest to important common practices and connections throughout the Chaco world (e.g., Van Dyke 2007), but great houses were not isomorphic. Our analysis demonstrates that there were substantial differences in the frequency of rare and unusual materials among great houses even within Chaco Canyon, and that the situation is more complicated than just Pueblo Bonito versus "everything else." Current evidence suggests the presence of exceptional deposits may have been influenced by whether or not a canyon great house was occupied in the foundational early interval from ca. A.D. 850-930. At Pueblo Bonito, early structures (and some individuals associated with them) clearly held special status long after their initial appearance, and some exceptional deposits were later intentionally placed within these foundational spaces and with these venerated people (Kennett et al. 2017; Plog and Heitman 2010). Great houses that were not in use during the A.D. 850-930 interval lacked the contexts that may have been necessary for the placement of certain types of exceptional deposits. The length of great house occupation is also relevant, with occupation into the post-Chacoan era increasing the odds that Chaco-era deposits were disturbed or recycled (e.g., Aztec West), decreasing our chances of detecting the original exceptional deposits. The size and location of great houses within and beyond the canyon no doubt also affected access to rare and unusual objects. Exploration of these and other factors

influencing the creation of exceptional deposits will enhance the initial interpretations presented here.

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Figure captions

Figure 1. The location of Chaco Canyon, the extent of the Chaco Phenomenon (hatched), and the location of sites mentioned in the text.

Figure 2. Pueblo Bonito, showing the location of excavated rooms and exceptional deposits (after Windes 2003:Figure 3.4 and Chaco Research Archive 2022f).

Figure 3. Box plots of each artifact category. The top and bottom of the black box marks the 25th and 75th percentiles; "X" marks the mean value; the top whisker marks the local maximum, which is 1.5 times the interquartile range; black dots mark outliers (values beyond the whisker); red dots mark values in or above the 98th percentile.

Figure 4. Una Vida, showing the location of excavated rooms (after Chaco Research Archive 2022g).

Figure 5. Peñasco Blanco, showing the probable locations of excavated rooms (after Chaco Research Archive 2022h).

Figure 6. Pueblo Alto, showing the location of excavated rooms (after Chaco Research Archive 2022i).

Figure 7. Pueblo del Arroyo, showing the location of excavated rooms (after Chaco Research Archive 2022j).

Figure 8. Chetro Ketl, showing the location of excavated rooms and exceptional deposits (after Chaco Research Archive 2022k).

Figure 9. Kin Kletso, showing the location of excavated rooms (after Chaco Research Archive 2022l).

Figure 10. Salmon Ruin, showing the location of excavated rooms (after Reed 2006:Figure 1.2).

Figure 11. Aztec West, showing the location of excavated rooms and exceptional deposits (after Chaco Research Archive 2022m).

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Object Type	Mean	Std. Deviation	Range	98th Percentile
Turquoise	595	5,171	1-53,114	≥2,446
Jet	238	970	1-4,000	≥2,726
Shell	76	528	1-6,000	≥449
Fossil shell	60	218	1-1,000	≥662
Projectile point	10	39	1-340	≥140
Ceremonial stick	11	46	1-266	≥119
Cylinder jar	10	27	1-111	≥83
Cylinder jar cover	6	16	1-121	≥30
Pipe	3	4	1-20	≥14
Macaw/parrot	3	4	1-14	≥12
Manos/metates	10	19	1-140	≥58

Table 1. Rare and unusual object types at Pueblo Bonito.

Object type	Provenience	Quantity
Turquoise	*Room 33* *Room 53* *Room 320* Kiva R	53,114 4,000 2,644 2,691
Jet	Room 38	4,000
Shell	*Room 33* Room 28 Kiva R	6,000 531 2,256
Fossil shell	Room 12	1,000
Projectile point	Room 39 Room 10 Room 48	340 180 154
Ceremonial stick	*Room 32*	266
Cylinder jar	Room 28	111
Cylinder jar cover	Room 28 Room 39B	121 31
Pipe	Room 10	20
Macaw/parrot	Room 38	14
Mano/metate	Room 42 Room 54	140 68

Table 2. Exceptional deposits at Pueblo Bonito. Rooms that are part of burial crypts are in italics.

Great House	n (number of excavated contexts)	Probability of finding exceptional deposit(s)
Una Vida	15	P(0) = 43% P(1) = 37% P(≥1) = 57%
Peñasco Blanco early	2	P(0) = 57 % P(1) = 37% P(2) = 6%
Peñasco Blanco early	4	P(0) = 33% P(1) = 42% P(2) = 20%
Peñasco Blanco late	4	P(0) = 80% P(1) = 19% P(2) = 2%
Peñasco Blanco late	8	P(0) = 64% P(1) = 30% P(2) = 6%
Pueblo Alto	11	P(0) = 54% P(1) = 34%
Pueblo del Arroyo	79	P(0) = 1% P(≥1) = 99%
Chetro Ketl	121	P(2) = 99% P(3) = 98% P(4) = 94% P(5) = 87% P(≥6) = 75%
Kin Kletso	70	P(0) = 2% P(≥1) = 98%
Salmon	48	P(0) = 7% P(≥1) = 93%
Aztec West - Chaco era	108	P(0) = 0.2% P(≥1) = 99.8%
Aztec West - post-Chaco era	86	P(0) = 1% P(1) = 99% P(2) = 95% P(3) = 86%

		P(4) = 70% P(5) = 51% P(6) = 33% P(7) = 19%

Table 3. Binomial probabilities for great houses. Peñasco Blanco includes scenarios in which two or four rooms were excavated in the early component and four or eight rooms were excavated in the late component

Figure 1

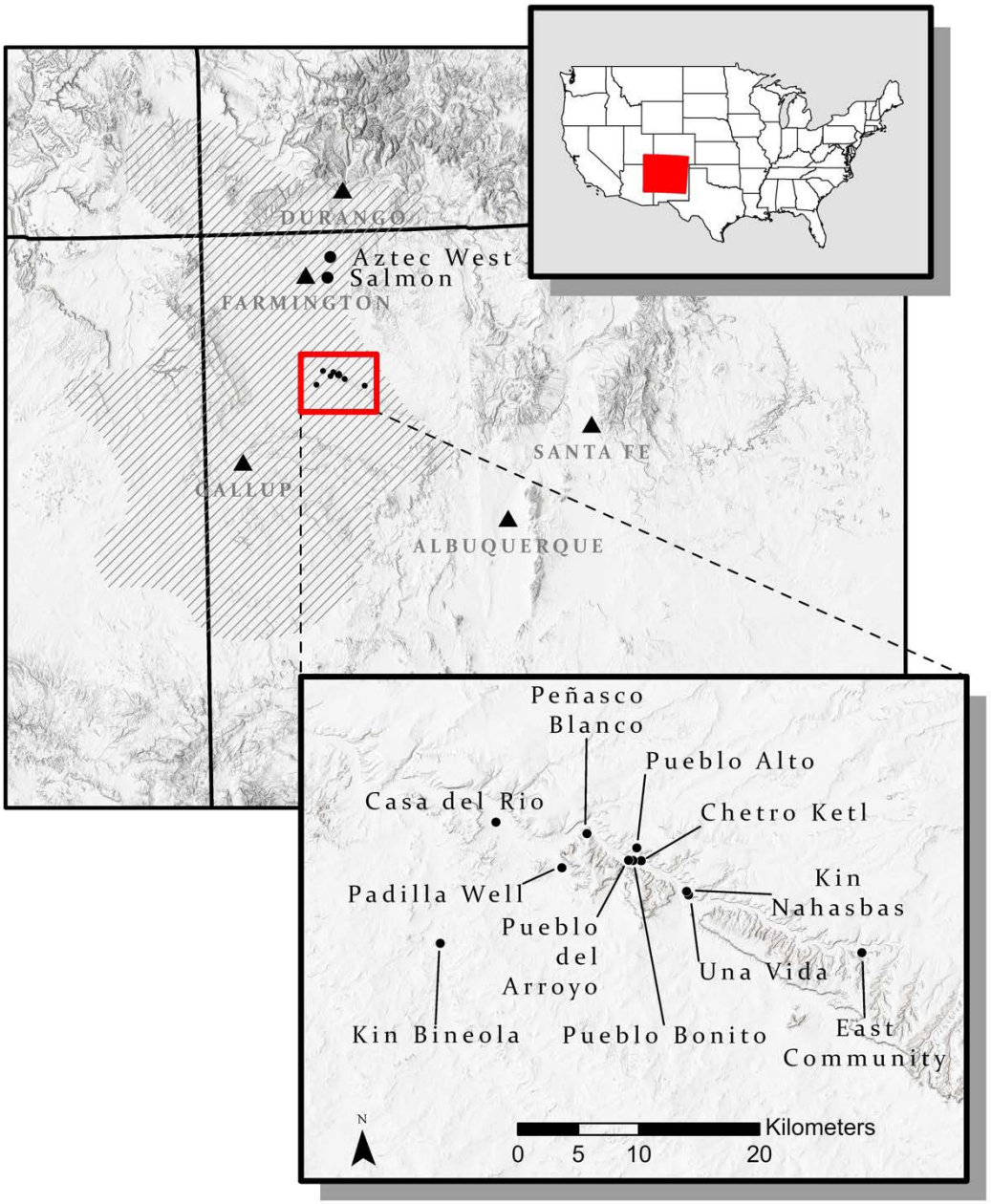

DURANGO
Aztec West
Salmon
FARMINGTON
SANTA FE
CALLUP
ALBUQUERQUE
Peñasco
Blanco
Pueblo Alto
Casa del Rio
Chetro Ketl
Padilla Well
Kin
Nahasbas
Pueblo
del
Arroyo
Una Vida
Kin Bineola
Pueblo Bonito
East
Community
N
Kilometers
0 5 10 20

Figure 2

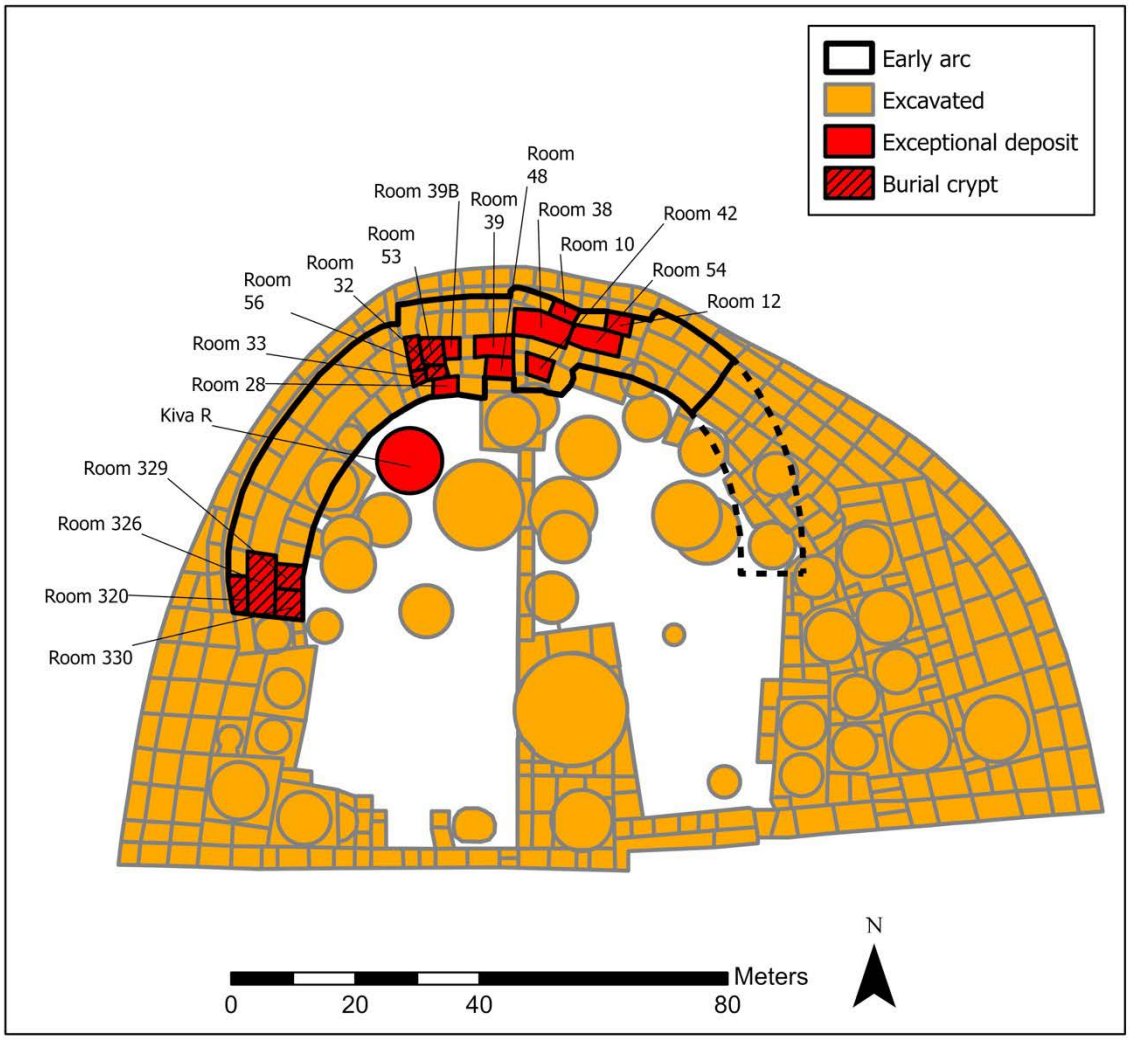

Early arc
Excavated
Exceptional deposit
Burial crypt
Room 48
Room 39B
Room 39
Room 38
Room 42
Room 53
Room 10
Room 32
Room 54
Room 56
Room 12
Room 33
Room 28
Kiva R
Room 329
Room 326
Room 320
Room 330
N
Meters
0
20
40
80

Figure 3

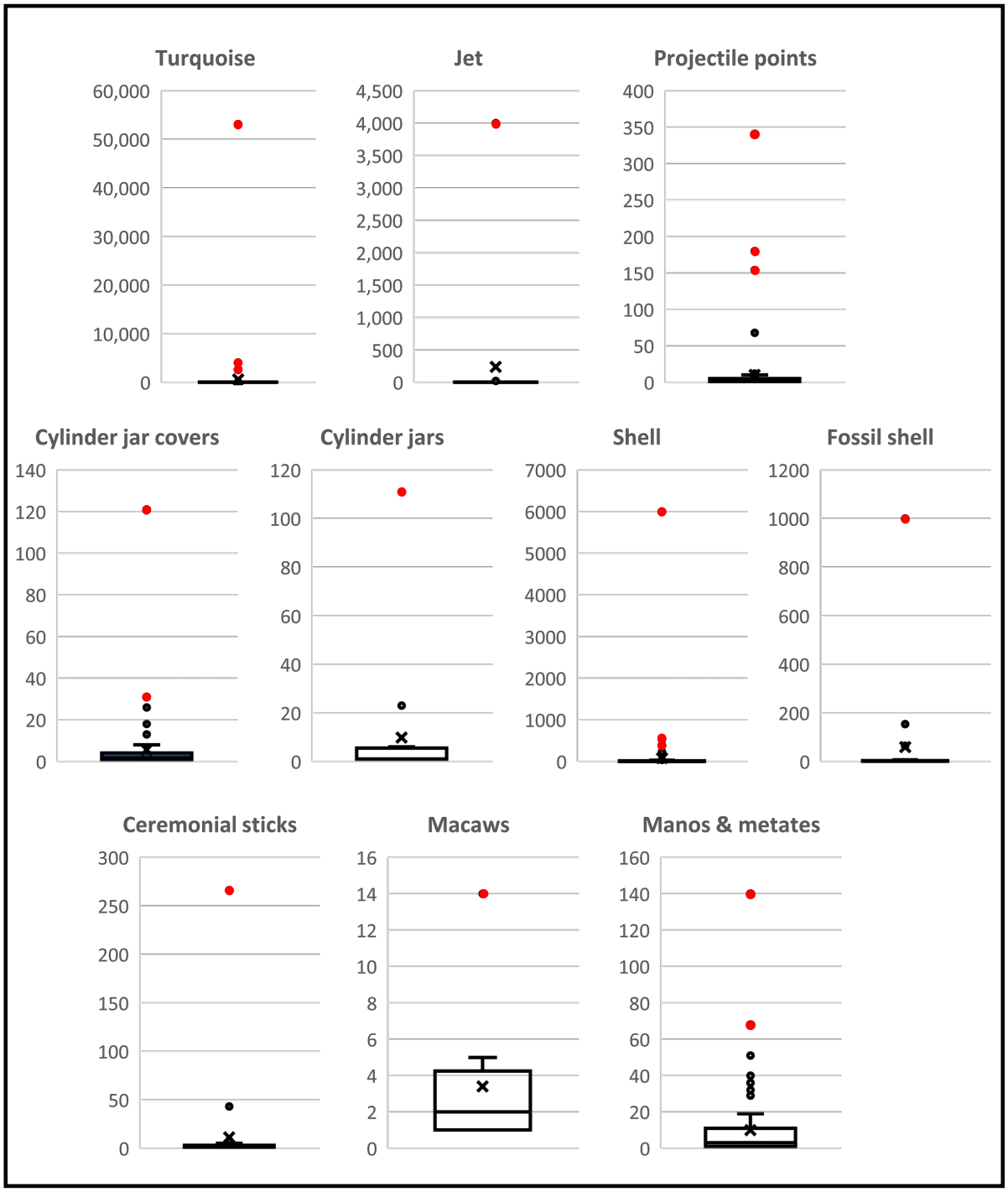

Turquoise
60,000
50,000
40,000
30,000
20,000
10,000
0
Jet
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Projectile points
400
350
300
250
200
150
100
50
0
Cylinder jar covers
140
120
100
80
60
40
20
0
Cylinder jars
120
100
80
60
40
20
0
Shell
7000
6000
5000
4000
3000
2000
1000
0
Fossil shell
1200
1000
800
600
400
200
0
Ceremonial sticks
300
250
200
150
100
50
0
Macaws
16
14
12
10
8
6
4
2
0
Manos & metates
160
140
120
100
80
60
40
20
0

Figure 4

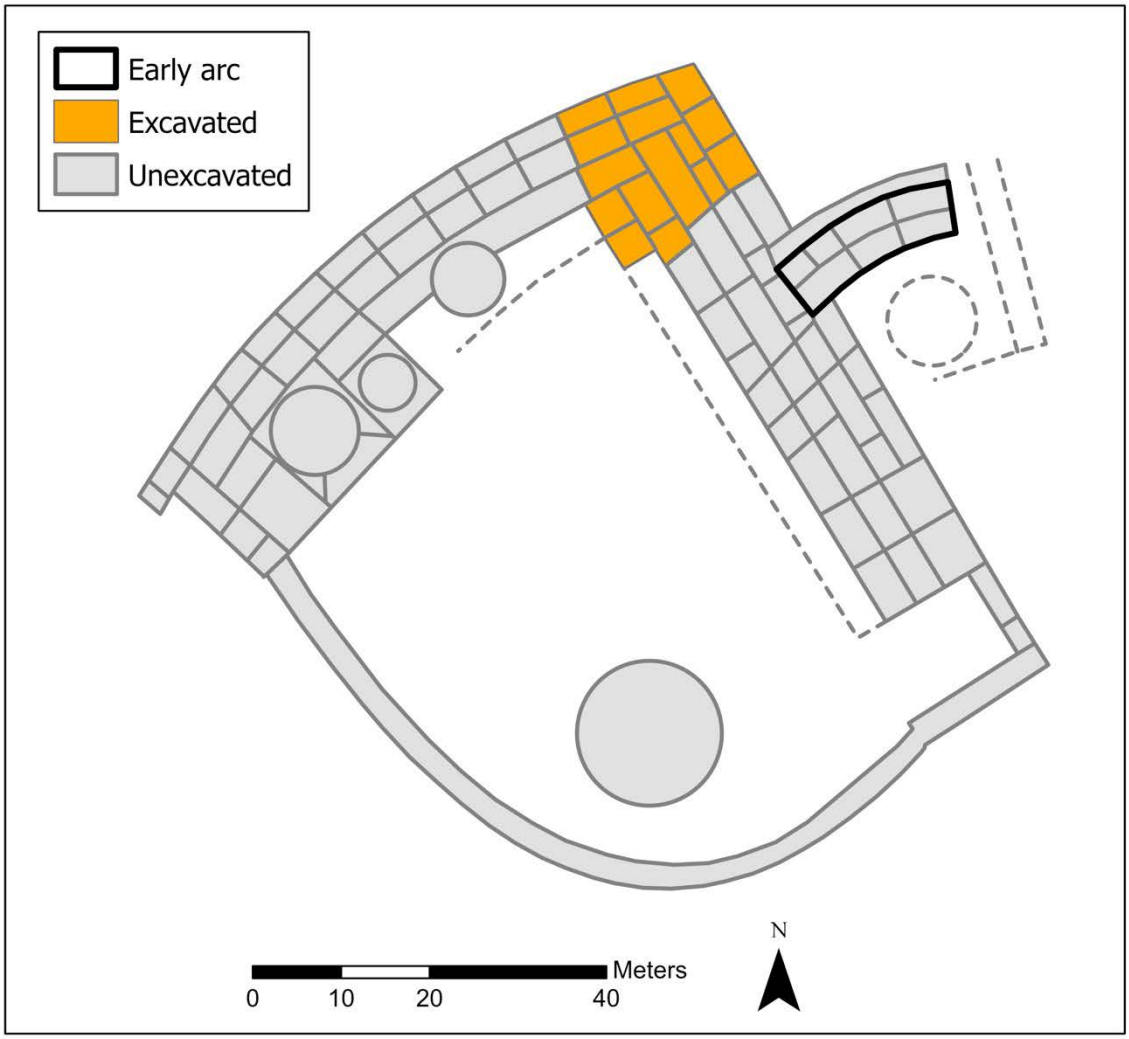


Figure 5

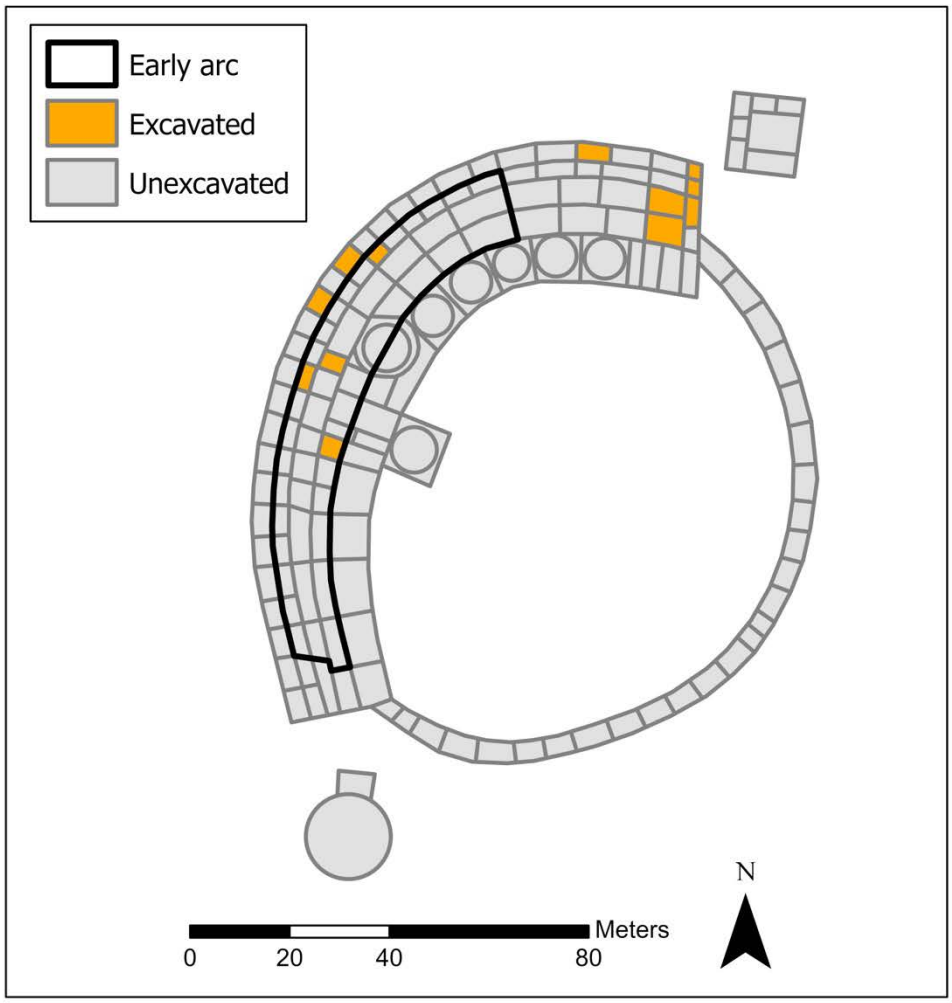


Figure 6

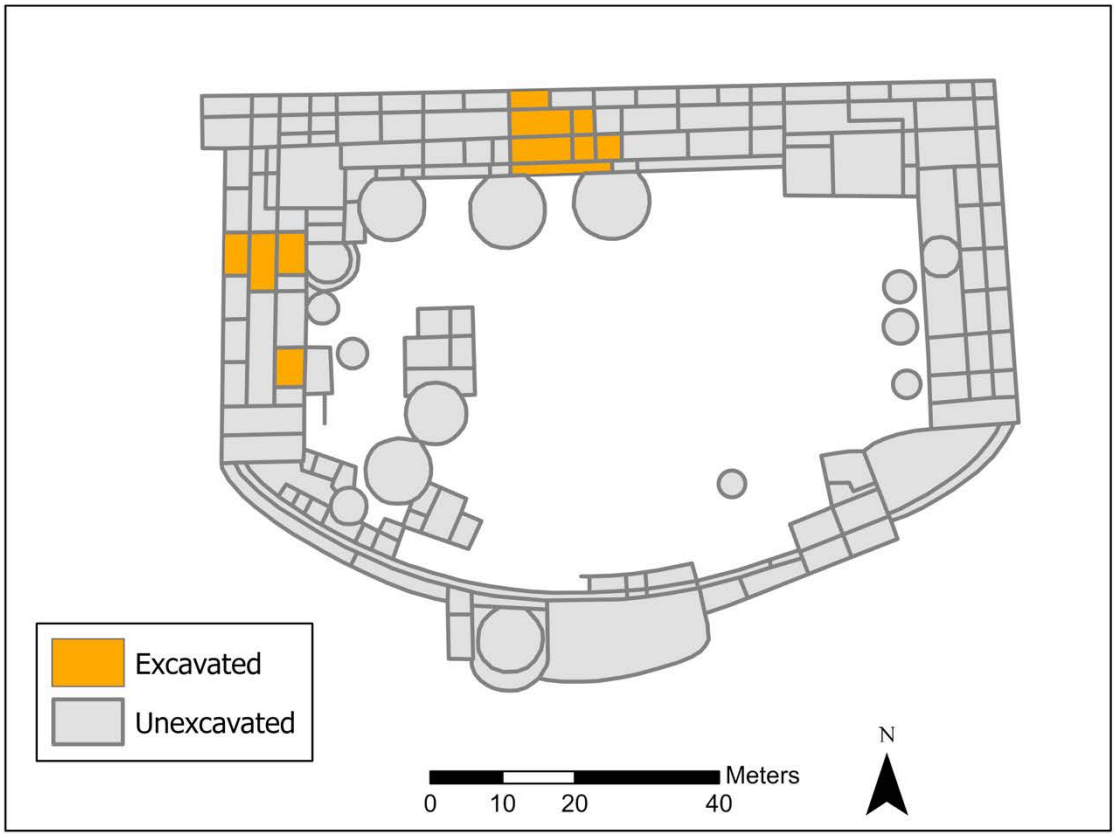


Figure 7

Figure 8

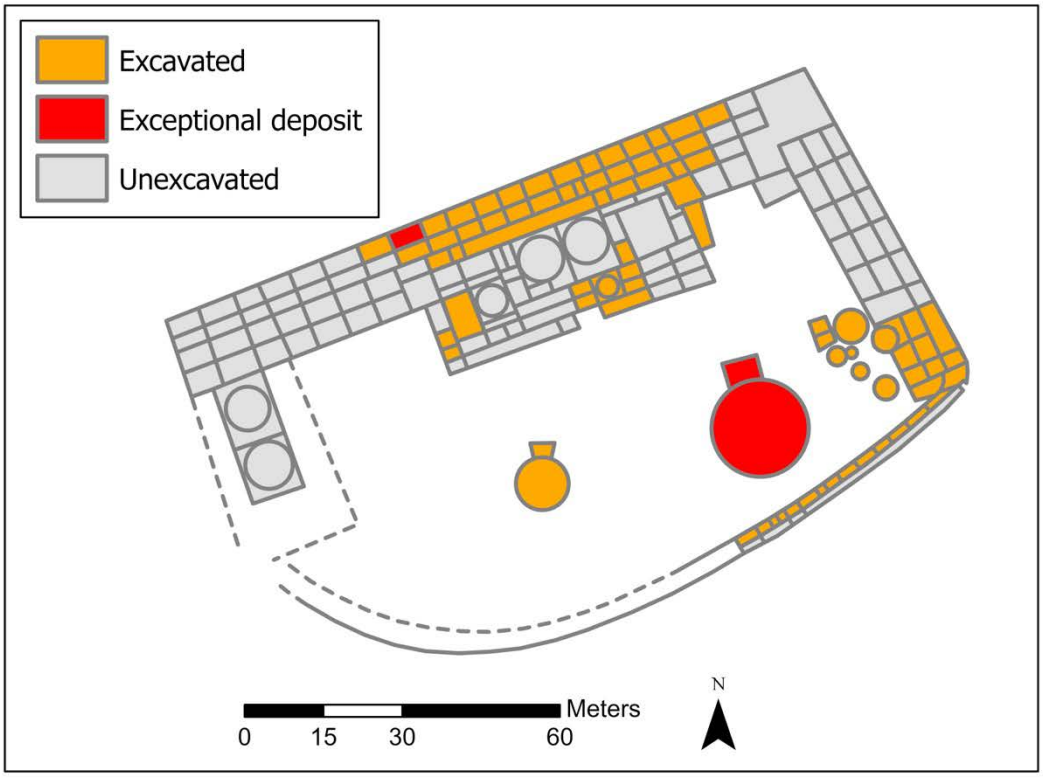

Excavated
Exceptional deposit
Unexcavated
Meters
0
15
30
60
N

Figure 9

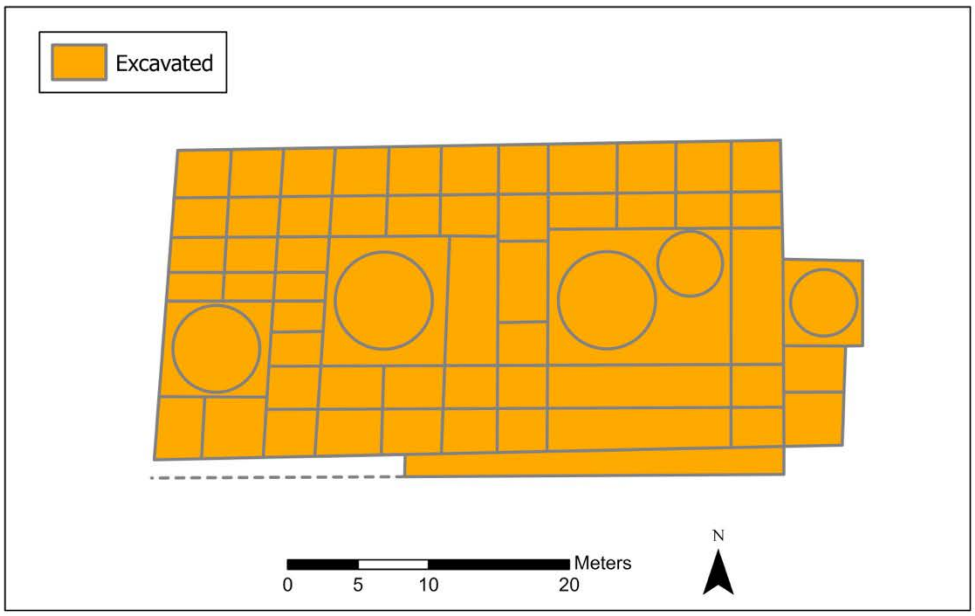
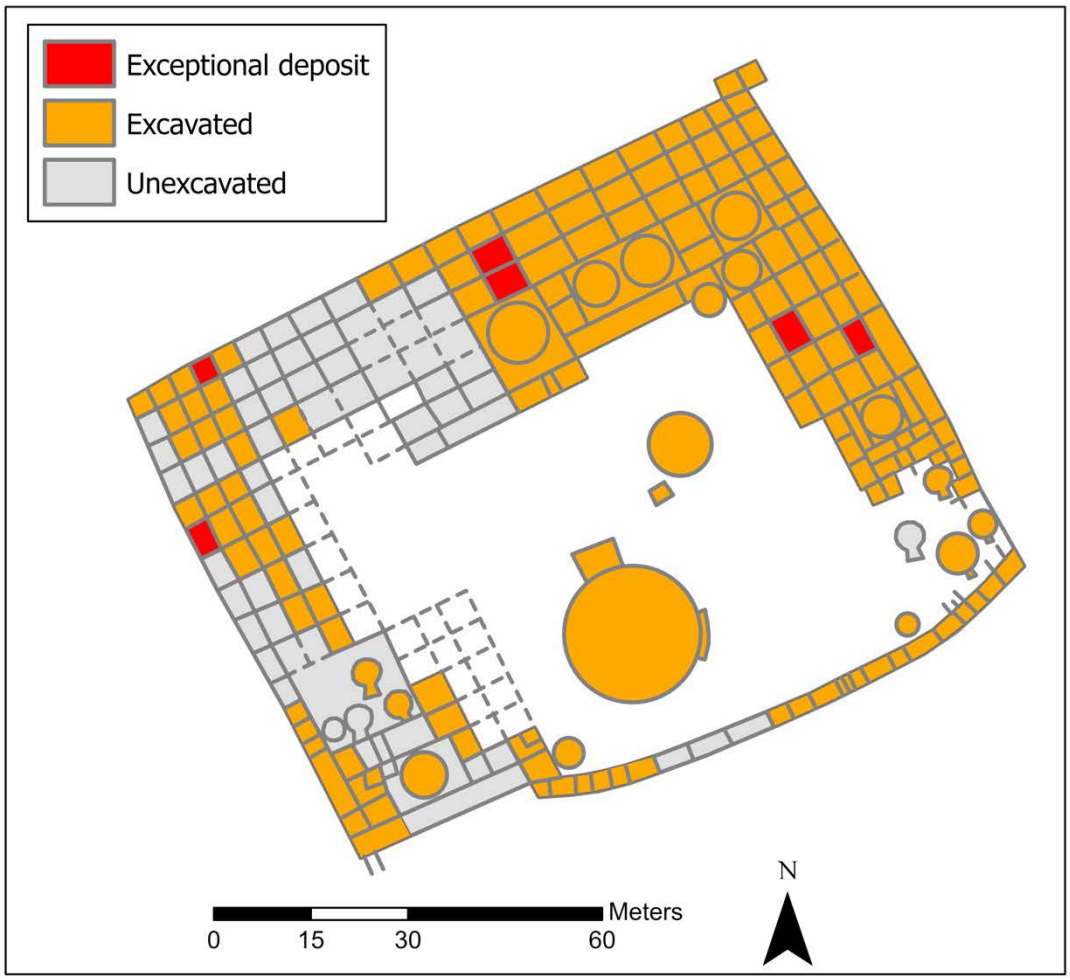


Figure 10

Figure 11


Exceptional deposit
Excavated
Unexcavated
Meters
0
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