Kukuipahu Heiau, TU-1 Excavation Results

and Radiocarbon Dating

Patrick V. Kirch

From March 14-18, 2022, test excavations were carried out at Kukuipahu Heiau by archaeologists from the State of Hawai‘i Parks Division (team headed by Tracy Tam Sing) and from the University of Hawai‘i, Mānoa (team headed by Patrick V. Kirch). Following an entry protocol ceremony, and after an initial on-site discussion as to the best locations for two initial test units (TU), it was agreed that TU-1 would be positioned on the east side of the structure, adjacent to one of the large scoria blocks that define the eastern edge of the heiau. TU-2 would be situated on the west side of the structure, adjacent to two large cut-and-dressed basalt slabs that make up part of an intact portion of the original western façade of the structure. TU-1 would be excavated by the UH Mānoa team, while TU-2 would be excavated by the State Parks team. The UH Mānoa excavation team consisted of Patrick V. Kirch, assisted by Kirsten Vacca (UH West O'ahu), and by Kylie Tuitavuki (UHM graduate student). The TU-2 excavation results have been presented by Tam Sing (MS 2022); this preliminary report deals with the results from TU-1, along with the results of radiocarbon dating of samples from both test units.

Excavation of TU-1

The location of TU-1 was chosen with the goal of obtaining information regarding the large cut-and-dressed scoria blocks that are one of the unique architectural features of Kukuipahu Heiau. By positioning the test unit adjacent to one of these scoria blocks, we aimed to determine the subsurface dimensions of the block and its stratigraphic relationship to any buried cultural deposits or features. Due to the concentration of large boulders that at some point in time were pushed up or dumped against the eastern façade of the structure (presumably during the sugarcane plantation era), finding an open space in which to place TU-1 was difficult. We were able to locate a small space (less than 1 m square) adjacent to the southernmost scoria block in the alignment of such blocks that forms the eastern façade of the structure (see Fig. 1). As initially laid out, TU-1 measured 75 cm north-south and 50 cm east-west, with the west side of the test unit abutting the eastern side of the large scoria block. After the first two levels were excavated, however, we found it difficult to work in this confined space, and the unit was expanded 30 cm to the east, for an overall size of 75 x 80 cm. The presence of the large surrounding boulders (not part of the original heiau) made it impossible to expand the unit any further.

When digging an initial test excavation, one is always proceeding "blind," because the stratigraphic sequence is not yet known. For this reason, and to maintain vertical control, excavation of TU-1 proceeded in *levels* of approximately 10 cm or less. Such levels are distinct from stratigraphic *layers*, which are units of deposition and can only be defined properly once the entire test unit has been completed. In TU-1 there were nine levels, which are correlated with

four stratigraphic layers, as indicated in Table 1. Digging was done using a small archaeologist's hand pick and Marshalltown trowel. All excavated sediment was passed through a 1/8" mesh, and all charcoal, lithics, and faunal material found in the screens was retained for analysis in the laboratory. Concentrations or large pieces of charcoal noted in situ were point-plotted and collected separately for radiocarbon dating. Notes were taken using standardized level forms, drawings of the unit were made at the beginning and end of each level, and a digital photographic record was maintained throughout the excavation.

Table 1. Correlation of stratigraphic layers and excavation levels in TU-1.

Layer	Level	Depth cm (b.s.)	Description
I	1	0-7	Yellowish-red (5YR3/3) clay loam with abundant angular to subangular basalt cobbles.
	2	7-16	Very dark grayish brown (10YR3/2) clay loam; angular to subangular basalt cobbles and dispersed charcoal throughout.
	3	0-16	This level was an extension of TU-1 30 cm to the east, to expand the area of excavation.
	4	16-29	Dark brown (10YR3/3) clay loam with angular and subangular basalt cobbles, charcoal flecks.
	5	29-35	Dark brown (7.5YR3/2) clay loam with a sharp contact and textural change at the base (transition to Layer II).
II	6	35-42	Dark reddish brown (5YR3/3-4) deposit of scoria gravel derived from working the adjacent scoria block in situ.
III	7	42-49	Very dark brown (10YR2/2) silty clay with considerable charcoal.
	8	49-59	Dark yellowish brown (10YR3/4) compact silty clay, charcoal decreasing in quantity.
IV	9	59-71	Dark yellowish brown (10YR3/4) silty clay, very compact and mostly lacking in charcoal.

Layer I. Layer I extends from the surface down to approximately 35 cm below surface, and was excavated in five levels (see Table 1). The sediment consists of a clay loam with distinct ped structure, with color varying somewhat but typically dark brown. Angular to subangular basalt clasts were present throughout, ranging from fist-sized to some larger cobbles with diameters up to 20 cm. Finely dispersed charcoal was also present throughout. Between 18-26 cm below surface we began to find a few larger pieces of charcoal and a few basalt flakes were also recovered. In level 5, just above the contact with underlying Layer II, we came down on a surface with seven waterworn pebbles *(ʻiliʻili*), and one larger waterworn cobble that had been flaked and exhibits signs of use as a tool for working the scoria block (this is described in further detail below). Larger pieces of charcoal were also present in level 5.

The jumbled nature of the Layer I sediment in levels 1-4, with abundant angular and subangular cobbles, suggests that it was deposited during the sugarcane plantation era, when

fields adjacent to Kukuipahu Heiau were periodically plowed and cultivated. The small, dispersed charcoal is likely to have derived from the regular burning of the cane fields. The surface at the base of Layer I (level 5), however, is an intact surface containing pre-contact artifacts that was buried under the later accumulation of sediment.

Layer II. Layer II, approximately 7 cm thick and excavated as a single level (level 6), is a deposit of dark reddish-brown, fine red scoria gravel containing some larger scoria pieces that clearly derives from the working of the adjacent scoria block in situ. The top and bottom contacts with Layers I and III are sharp and distinct. At the bottom of Layer II we were able to discern the base of the large scoria block, and the tops of two large waterworn cobbles that appeared to extend underneath the block were exposed. There was considerable charcoal flecking. A pig incisor was recovered along the east wall of TU-1 at 46 cm below surface during final cleaning of level 6.

Once Layer II had been excavated, the entire outer (eastern) face of the red scoria block was now exposed, revealing that it had been extensively worked and smoothed. This smooth surface has been protected by the accumulated sediment of Layers I and II. In contrast, exposed parts of the scoria block, such as its upper surface, are rough and pitted, the result of exposure to the elements over a considerable period of time. The accumulation of fine scoria gravel and cinder that comprises Layer II is also evidence that the block was worked and finished after it had been hauled to the site and put into position. This corresponds with evidence from TU-2 that the basalt slabs making up the structure's façade were similarly worked and shaped on site.

Layer III. Consisting of a dark yellowish-brown silty clay loam, Layer III extends from 42 to 59 cm below surface, and was excavated as levels 7 and 8 (see Table 1). During the excavation of Layer III, the two large waterworn cobbles at the base of the large scoria block were completely exposed (see Fig. 2); it became clear that these cobbles had been placed under the block at the time that the scoria block was moved into position, presumably to brace the block and hold it in place. It was also now evident that Layer III extends under the scoria block, thus predating the construction of the heiau.

Layer III contains abundant charcoal, basalt and volcanic glass flakes, along with fragmented bone faunal remains [shell?], as described further below. This cultural content indicates that Layer III is a midden deposit deriving from residential use of the area prior to heiau construction. Most notable was the discovery of a complete bone two-piece fishhook point with notched base (i.e., early Ka Lae or South Point style), at 56 cm below surface.

Layer IV. There was a gradual transition from Layer III to IV, marked by a decrease in the frequency of charcoal and lack of faunal remains or other artifacts in the final level 9. Layer IV consists, like Layer III, of silty clay, but is noticeably more compact, and is the original ground surface upon which the habitation episode indicated by Layer III began.

The completed excavation of TU-1 at the bottom of level 9 is shown in Figures 3 and 4. The stratigraphic section of the south face of TU-1 is depicted in Figure 5.

Cultural Content of TU-1

The cultural content of TU-1 is summarized in Table 2. Charcoal was most heavily concentrated in the lower levels 7-9; samples of charcoal are currently being taxonomically identified by Gail Murakami of IARII, and will be reported separately. The basalt flakes were mostly small and of poor quality material; rather than flakes derived from adze production, most of these flakes are likely to be fire-cracked rock spalls. Two very tiny volcanic glass flakes were also recovered.

Table 2. Cultural content of TU-1 by excavation level.

Level	Charcoal (g)	Basalt Flakes	Volcanic Glass Flakes	Other Materials
2	0.3	2		
3	2.3	9	1	
4	11.5	12		
5	4.5	6		1 waterworn cobble with flakes removed; waterworn cobble core tool
6	1.8			1 pig incisor; 1 waterworn pebble
7	71.8		1	13 small fragments of mammal bone, very decomposed
8	85	1		1 bone fishhook point
9	52.8			4 tiny fragments of bone, unidentifiable

There was no invertebrate faunal material, such as marine shell or sea urchin. In level 6 a rather degraded pig incisor was recovered. In level 7 there were 13 small fragments of what appear to be mammal bone, likely of either dog or pig, that are very decomposed. Level 9 yielded 4 tiny bone fragments, one of which may be fish, again in poor condition.

In level 5 we found an elongated waterworn cobble, 99 mm maximum length, with several flakes removed from one end. More interesting was a second waterworn cobble, some 92 mm long, that had been bifacially flaked at one end so as the produce a sharp point (Fig. 6). The pointed end had traces of red scoria on it, indicating that the core tool had been used to work the large scoria block. The opposite end of the cobble has a flat surface that also showed traces of wear, probably due to use as a polisher to smooth the scoria block. Similar core tools were recovered from the TU-2 excavation.

Finally, from level 8 we recovered a nearly complete two-piece fishhook point, 41 mm long, with inner point barb and notched base (3 parallel notches), illustrated in Figure 7. The point is of mammal bone, probably pig bone, and is rather fragile due to the moist soil condition

in which it was found. This style of notched two-piece fishhook point was noted by Emory, Bonk, and Sinoto to be geographically restricted almost exclusively to the South Point (Ka Lae) region of Hawai'i Island, where the style is in its highest frequency in earlier strata (Emory, Bonk, and Sinoto 1959:26).

Radiocarbon Dating

Determining the age of Kukuipahu Heiau, including the probable time of its initial construction and subsequent use, was a primary objective of the test excavation program. To that end suitable pieces of charcoal found in situ in both test units were piece-plotted and separately recorded; in addition, all charcoal recovered in the 1/8" mesh screens was also retained, for possible radiocarbon dating.

Eight samples were selected for radiocarbon dating, five from TU-1 and three from TU-2. Because the first four levels in TU-1 (i.e., Layer I) were regarded as most likely dating to the plantation era, no samples were selected from those levels. One sample each was selected from levels 5 through 9 of TU-1, representing Layers II, III, and IV. For TU-2, one sample was selected from Layer II and two samples from Layer III, including a sample from a secure context at the very base of the excavation.

With two exceptions, all of the samples selected for dating were of carbonized endocarp (nut shell) of candlenut, *kukui* (*Aleurites moluccana*). As *kukui* nuts are produced annually and were collected and utilized by the Hawaiians for light and other purposes they provide an ideal dating material, one that circumvents the problem of "in-built age" that can occur with hardwoods, for example. The two exceptions are the samples from TU-1, Levels 5 and 6. The sample from Level 5 was regarded as likely to be *kukui*, but the small size of this fragment made definitive identification impossible. For Level 6, no *kukui* nut shell was available; therefore, a small piece of charcoal with a round cross section and diameter of about 2mm was selected. This was clearly from a twig and thus it was presumed that no in-built age issue would be associated with this sample.

The eight selected samples were sent to the radiocarbon dating laboratory at the Keck Carbon Facility at the University of California, Irvine, where AMS (accelerator mass spectrometry) radiocarbon dating was carried out under the supervision of Dr. John Southon. The measured ^{14}C ages were corrected for $\delta^{13}C$ as part of the Keck Facility's standard procedure. The results of this AMS dating are provided in Table 3, first as measured ^{14}C ages BP (before present, i.e. before 1950), and second as AD calibrated age ranges at two standard deviations (2σ), representing a 95.4% probability. The calibrated ages were determined using the on-line Oxcal 2.4.4 calibration program. It will be noted that each calibrated age range consists of two possible interval ranges, each with a different associated probability. This is the result of a "wiggle" in the calibration curve for this particular time interval, in which the radiocarbon ages intersect with the calibration curve more than once.

With one exception, the results presented in Table 3 are highly consistent, with seven samples returning measured radiocarbon ages between 300 and 355 ± 15 years BP. The one exception is the sample from Level 6 of TU-1, which returned a measured age of just 110 ± 15 BP. Reviewing the excavation notes for Level 6, this sample was piece-plotted as coming from 35 cm below surface, which is at the very top of the level (Level 6 extended from 35-42 cm below surface). In light of the much younger age of this sample, it should probably be attributed to the base of Layer I, rather than to Layer II. Similarly, the sample from Level 5 likely derived from the surface at the bottom of Layer I (which contained the waterworn cobbles and flaked cobbles) or the very top of Layer II, given that its age is consistent with all of the other samples from Layers II and III. In other words, both of these samples came from a few centimeters at the interface of Layers I and II, and the apparent "inversion" in samples ages is thus not surprising. In the Bayesian calibration of these samples that follows, we therefore assign the TU-1 Level 5 sample to Layer II, and the TU-1 Level 6 sample to Layer I.

Table 3. Radiocarbon dating results from TU-1 and -2.

Lab No. UCIAMS-	Provenience	Material	Measured ^{14}C Age BP	Calibrated Age AD (2σ)*
268343	TU-1, Level 5, Layer I (assigned to Layer II)**	Charcoal, possibly *Aleurites* nut	330 ± 15	1494 (76.2%) 1602 1610 (19.2%) 1637
268344	TU-1, Level 6, Layer I/II (assigned to Layer I)**	Twig size wood charcoal	110 ± 15	1693 (24.4%) 1727 1810 (71.0%) 1919
268345	TU-1, Level 7, Layer III	Carbonized *Aleurites* nut	315 ± 15	1507 (76.7%) 1595 1617 (18.8%) 1642
268346	TU-1, Level 8, Layer III	Carbonized *Aleurites* nut	340 ± 15	1481 (32.5%) 1529 1544 (62.9%) 1635
268347	TU-1, Level 9 Layer IV	Carbonized *Aleurites* nut	355 ± 15	1472 (44.7%) 1525 1558 (50.8%) 1632
268348	TU-2, Layer II	Carbonized *Aleurites* nut	300 ± 15	1520 (72.4%) 1587 1622 (23.1%) 1647
268349	TU-2, Layer III	Carbonized *Aleurites* nut	305 ± 15	1516 (74.8%) 1591 1620 (20.6%) 1645
268350	TU-2, Layer III	Carbonized *Aleurites* nut	345 ± 15	1479 (36.7%) 1527 1554 (58.8%) 1634

* Calibrations made with Oxcal version 4.4.4 (Bronk Ramsey 2021), 95.4% probability ranges.

** See explanation in text.

Bayesian Modeling of Site Chronology

Bayesian modeling and calibration of radiocarbon dates has become standard practice in Hawaiian and Pacific archaeology (e.g., Athens et al., 2014; Burley et al., 2015; Dye, 2015). The

advantage gained through Bayesian modeling is that stratigraphic relationships can be incorporated (Bronk Ramsey, 2009; Hamilton and Krus, 2018). Incorporating the relative stratigraphic position of dated samples (the prior probabilities) with the *likelihood* probabilities resulting from the actual ^{14}C measurements in a Bayesian model yields *posterior* probabilities (or, "highest posterior density [HPD] regions"). Bayesian modeling of the radiocarbon dates from Kukuipahu Heiau was conducted using the Oxcal program, version 4.4.4, with calibration using the IntCal13 curve. We used Oxcal's Sequence, Phase, and Boundary commands to construct the model.

The seven radiocarbon dates from Layers II, III, and IV in both TU-1 and -2 were combined in a Bayesian model in which the dates were grouped into two phases: the stratigraphically lower midden deposit (Layers III and IV) as Phase I, and the construction phase (Layer II) as Phase II. Results of the Bayesian calibration and modeling as produced by the Oxcal program are presented in Figure 8. Table 4 presents the modeled dates or "posterior probabilities."

Table 4. Modeled age ranges (AD) for radiocarbon dates and phase boundaries (95.4% probability).

Dates and Boundary Ranges	**From AD**	**To AD**
Boundary start Phase I midden	1448	1632
UCIAMS-268346	1487	1633
UCIAMS-268347	1484	1631
UCIAMS-268349	1502	1633
UCIAMS-268350	1485	1633
Boundary transition to Phase II construction	1507	1637
UCIAMS-268343	1516	1640
UCIAMS-268345	1518	1640
UCIAMS-268348	1521	1643
Boundary end Phase II construction	1520	1665

As is evident from Figure 8 and Table 4, the total time range represented by both the underlying midden (Phase I) and the main construction (Phase II) is quite short, no more than

two centuries maximum but most likely considerably shorter than that. The modeled dates from the Phase I midden range from AD 1484-1631 to 1485-1633. For Phase II, the period during which the cut-and-dressed slab construction took place, the modeled dates range from AD 1516-1640 to 1521-1643. Thus, the Phase I midden began to be deposited no earlier than the second half of the fifteenth century (AD 1484), whereas the construction Phase II was completed before the middle of the seventeenth century (AD 1640). In reality, however, the actual time span is likely to have been more compressed, probably spanning the sixteenth century. While statistically these modeled age ranges show considerable overlap, we also know that the Phase I midden was deposited prior to the onset of construction of the main structure. In general terms, then, we can conclude that the occupation that resulted in the deposition of the Phase I midden most likely occurred in the earlier part of the sixteenth century, while the construction of the main structure most likely followed in the latter part of the sixteenth century.

References Cited

Athens, J. S., T. M. Rieth, and T. S. Dye, 2014, A Paleoenvironmental and Archaeological Model-Based Age Estimate for the Colonization of Hawai'i: *American Antiquity* 79:144–155, doi: 10.7183/0002-7316.79.1.144.

Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51, 337-360.

_____. 2021.

Burley, D., K. Edinborough, M. I. Weisler, and J. X. Zhao, 2015, Bayesian modeling and chronological precision for Polynesian settlement of Tonga: *PLoS ONE* 10:1–14, doi: 10.1371/journal.pone.0120795.

Dye, T. S., 2015. Dating human dispersal in Remote Oceania: A Bayesian view from Hawai'i. *World Archaeology* 47:661-676.

Emory, K. P., W. J. Bonk, and Y. H. Sinoto, 1959. *Hawaiian Archaeology: Fishhooks*. Bernice P. Bishop Museum Special Publication 47. Honolulu: Bishop Museum Press.

Hamilton, W. D. and A. M. Krus, 2018. The myths and realities of Bayesian chronological modeling revealed. *American Antiquity* 83:187-203.

Figure 1. TU-1 at the beginning of the excavation. Note the large red scoria slab adjacent to the unit on the west side.

Figure 2. TU-1 at the end of level 7, with the two large basalt cobbles under the base of the red scoria slab exposed. Note the clean, smooth face of the red scoria slab.

Figure 3. The west face of TU-1 at the completion of level 9.

Figure 4. The south face of TU-1 at the completion of level 9. Layer II, the deposit of red scoria detritus from working of the red scoria block, stands out very clearly.

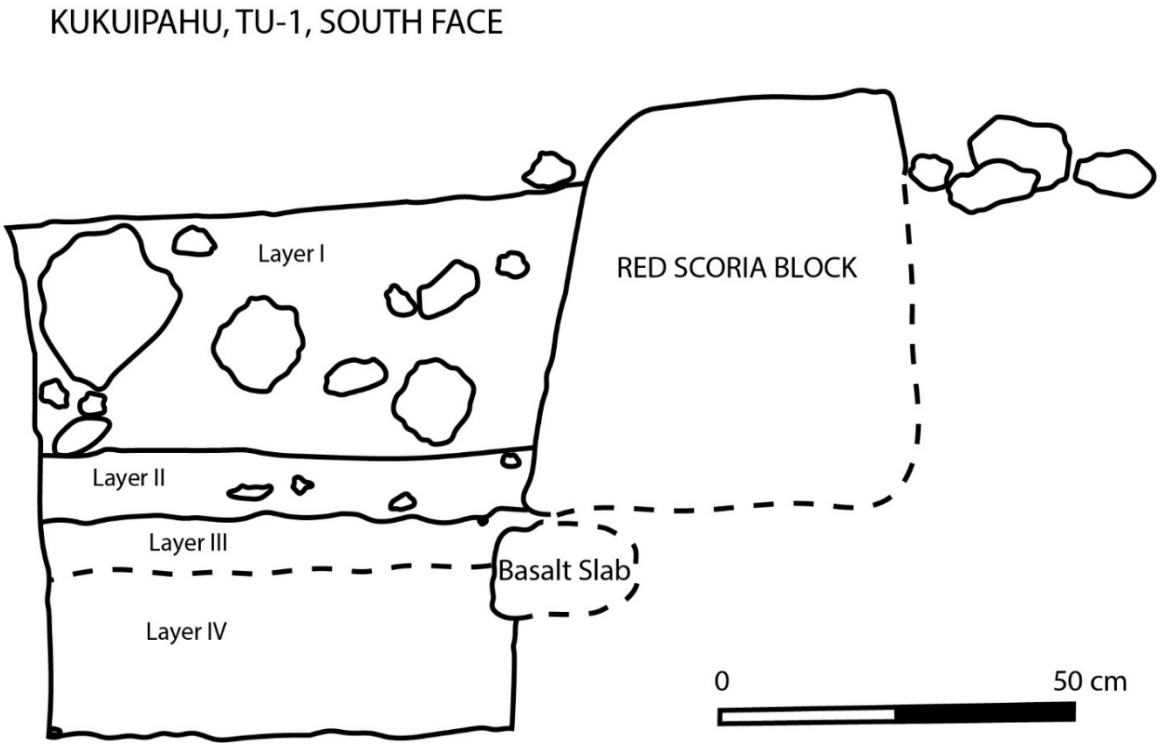

Figure 5. Stratigraphic section of the south face of TU-1.

Figure 6. Cobble core tool from Level 5.

Figure 7. Bone two-piece fishhook point with notched base from Level 8.

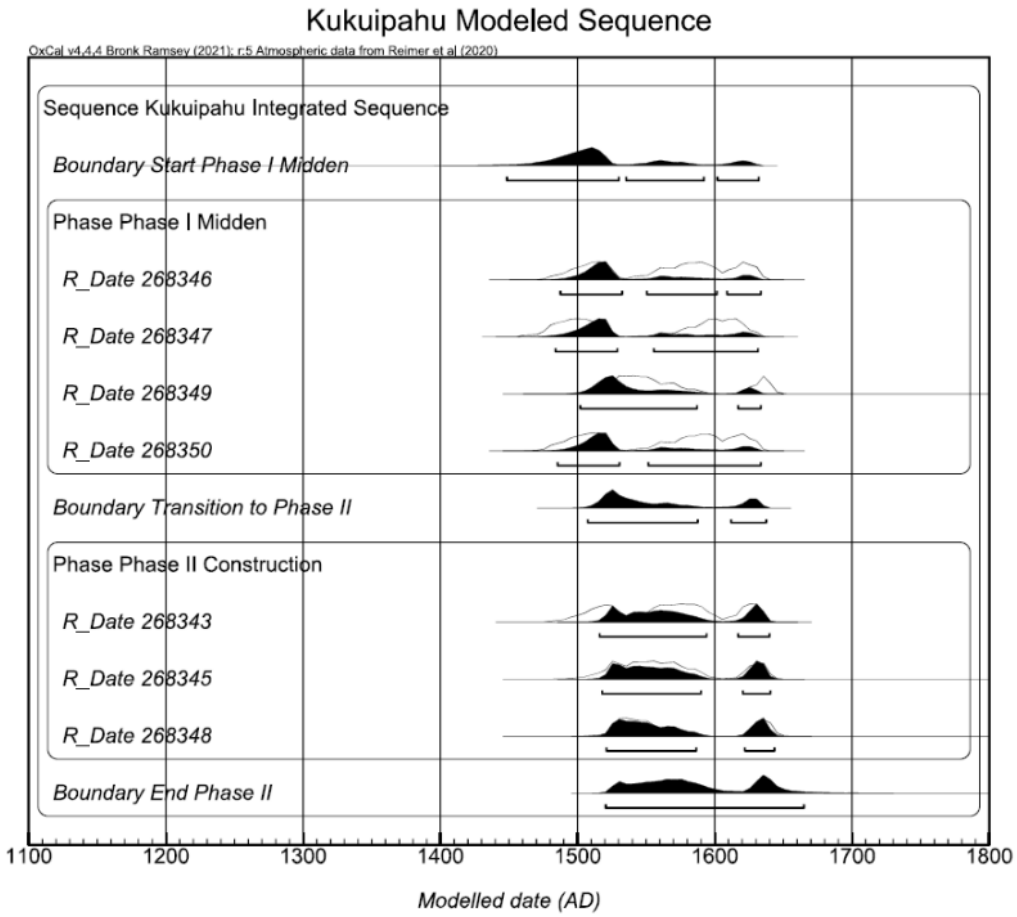

Figure 8. Integrated Bayesian model of the chronological sequence in both TU-1 and TU-2.