Radiocarbon (2025), pp. 1–13
doi:10.1017/RDC.2024.131

Selected Papers from the 2nd Latin American Radiocarbon Conference, Mexico City, 4–8 Sept. 2023

CONFERENCE PAPER

Possibilities and limitations of new radiocarbon dating for the Maucallacta site, dep. Arequipa, Peru

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Received: 30 January 2024; **Revised:** 24 June 2024; **Accepted:** 12 September 2024

Keywords: Bayesian chronology; bones; Inca culture; Maucallacta; radiocarbon dating

Abstract

With the development of radiocarbon dating methods in the last decade, the Andean archaeological community has successfully leaned into the problem of the chronology of the expansion of the Inca State. While this chronology was based on ethnohistorical accounts (Rowe 1945), it has been possible to verify its foundations precisely in the last decade. The results from the Maucallacta region are part of these discussions and are intended to add new data from the Inca province of Kuntisuyu, which was neglected in this debate until now. The project encompasses archaeological investigations near the snow-covered volcano Coropuna, frequently mentioned by chroniclers of the 16th and 17th centuries as an oracle worshiped since pre-Inca times. This includes a large complex known as Maucallacta-Pampacolca, located approximately 170 km northwest of Arequipa in the southern highlands of Peru, within the District of Pampacolca, Province of Castilla, Department of Arequipa (LS; 3750 m asl). Due to its location, it holds a unique relationship with the Coropuna landscape. The site is a vast administrative center featuring over three hundred stone buildings, tombs, and ceremonial structures. Among them, the most important is the large ceremonial platform with ushnu and the dumps deposited beneath it. The analysis of ceramics and animal bones, combined with stratigraphic analysis and the results of new calibrations and interpretations of radiocarbon dates, provides a comprehensive picture of the formation and use of ceremonial dumps at the site, making them one of the most thoroughly examined collections in this regard.

Introduction

The Inca Empire is characterized by rapid growth over just a few generations, conquering a vast territory inhabited by several million people. This social mosaic was unified by cultural codes universal to this region of the world, primarily related to beliefs and ceremonial practices. The Spanish conquest led to the rapid decline of the Inca state. In light of recent research into the chronology of the development of the Inca State, the generally applicable chronology of events based on the findings of John Rowe in 1945 have been called into question (Rowe 1945). Rowe, in creating what he called a histrionic chronology, based it on Miguel Cabello Balboa's 1586 ethnohistorical accounts, according to which the Inca State was supposed to have developed over about a hundred years. Other researchers later questioned this chronology (Burger 2007; Zuidema 1982); nevertheless, it successfully challenged it by developing precise radiocarbon dating methods. Data from various parts of the Inca imperium from the area of present-day Ecuador (Ogburn 2012), Argentina (Marsh et al. 2017), or the center of the Empire (Burger et al. 2021; Ziółkowski et al. 2021) indicate that, indeed, the development of the Inca State took place over a longer period and not 100 years as was long assumed. The text we present is part of a lively discussion on the true chronology of events during the Inca period in the Andes. Along with the data presented, we want to bring into the discussion information from the area of the Inca province of Kuntisuyu, which has not appeared in the discussions surrounding the radiocarbon dating of Tawantinsuyu, or the Inca State.

In the Coropuna volcano region, at the Maucallacta site (which was a temple complex and the seat of an oracle), archaeological material from selected areas tells us the history of changes in the ceremonial organizations of this sanctuary, as well as its developmental trajectory and decline. Unfortunately, the precision of older ^{14}C dating, especially for events closely spaced on the timeline, is often insufficient to establish chronological changes in archaeological layers accurately. Therefore, we attempted to refine earlier dating using a combination of two calibration curves (IntCal and SHCal) (cf. Ancapichún et al. 2022; Ziółkowski et al. 2020). Due to the proximity of the Coropuna volcano—one of the most revered high peaks (called Apus) by the Incas—the Maucallacta-Pampacolca site attracted thousands of pilgrims during festive periods from different parts of the Inca State who came to make offerings, confess, or seek advice from the gods (Siemianowska and Sobczyk 2020; Sobczyk 2022). In written sources (Pedro Cieza de Leon 2005 [1553]; Cristobál de Albornoz 1989 [1584]; Felipe Guaman Poma de Ayala 1615), the name Coropuna is mentioned in the context of dwellings of imperial priests, serving as a meeting place for pilgrims in the province of Kuntisuyu in the vicinity of Coropuna were herds of llamas, alpacas, and wool storage (Siemianowska and Sobczyk 2020; Sobczyk 2022). Maucallacta, situated between 3700–3800 m above sea level, comprises six different archaeological sites covering a total area of 67 ha, with 25 ha falling within its central part—Maucallacta-1. The main ceremonial and administrative complex includes 250 structures of various kinds. Most of these structures are irregular buildings arranged around squares, creating a characteristic open ceremonial space (Sobczyk 2022, see Figure 1).

Thanks to the previous stages of work, 32 radiocarbon dates were obtained based on samples from various layers of selected constructions (Michczyński et al. 2007; Sobczyk 2022). All of them were collected from layers below the level of volcanic material associated with the eruption of Huaynaputina on February 19, 1600 (Guaman Poma 1980 [1583–1615], 973, 975). This establishes the *terminus ante quem* for prior activities at the site, providing irrefutable proof that the stratigraphy has not been manipulated. The objects from which the datings were obtained are important for reconstructing the processes of changes in the organization of ceremonial spaces. In the new interpretation, the obtained dates enable us to understand better when priorities change in religious ceremonies.

The aim of the new research and this article is to attempt to answer the following questions: When did Coropuna become an imperial oracle, and when did Maucallacta transform from a local center into one of the most important religious centers of the Inca state mentioned by Spanish chroniclers? Do the obtained radiocarbon dates related to the reconstruction period of the main square (Plataforma I) and the altar (ushnu) located therein correspond in any way to the appearance of ceremonial middens at their foot? Do the obtained radiocarbon dates provide new information about the fall of the Inca Empire? Did the arrival of the Spanish definitively end the functioning of Maucallacta, or did the site continue to function for some time?

To answer the questions above, the archaeologists and physicists focused on reconstructing the site's chronology using Bayesian modeling methods supplemented by precisely selected calibration curves. The analysis was based on precise archaeological data from excavations at the Maucallacta site. The results obtained, in turn, made it possible to place the issue raised in the pan-Andean discussion of the chronology of events in the Inca period.

Sample and methods

For the analysis presented here, samples from archaeological excavations in different parts of the Maucallacta site were included. Samples for radiocarbon tests were taken from the following structures (see Figure 1, Table 1, Table S.1).

Figure 1. Maucallacta site at the foot of the Coropuna volcano. The location of the structures discussed in the text is marked (photo by M. Sobczyk). CH1- free-standing tomb Chullpa 1. PL – Platform I, main square. B – ceremonial middens Basural 1 and Basural 2. U – altar ushnu. K- Kallanka building at plaza 20. M – Mausoleum. PL7 BUILD. D, F – square 7 and buildings D and F. The black arrow next to the map of Peru gives the approximate lo Results of OxCal modeling for cation of the Maucallacta site.

Sample sites

Chullpa 1. The site preserves remains from at least 69 different types of tombs scattered in sectors surrounding the central complex. Unfortunately, they all suffered devastation and looting, resulting in a mix of cultural and anthropological material. The dating of the material from Chullpa 1 Ma5 was conducted during the preparation of samples for DNA analysis. Long bone fragments were collected for radiocarbon dating. As the largest free-standing chullpa tomb, the preserved structure, along with remains of material and bones, signifies its importance. The foundation of this tomb may be associated with the early stage of the Maucallacta complex's operation.

Plaza 7. The buildings associated with Square (Plaza) 7 feature high-quality stonework, and various phases of reconstruction of the square and buildings are discernible. In structure D, beneath the Huaynaputina ash, a layer (capa 3) was found containing about 2,000 fragments of pottery, predominantly in the local Inca and Chuquibamba styles. Within the building, seven cultural layers were identified, and samples for radiocarbon dating were taken.

Kallanka, Plaza 20. The Kallanka building, nearly 60 m long and 12.55 and 11.7 m wide, is located in the eastern part of Square 20. It features five entrances evenly distributed on the façade, with the middle one being the largest. During exploration, as many as 40 layers were recorded, covering several utility levels, most likely six. The excavations revealed, within the small collapses, the level of the Huaynaputina ashes, which appeared irregularly (Sobczyk 2022, see Figure 2 A).

Mausoleum (Building F, Square 5). This is the most complex building in Maucallacta. It comprises four parts, each differing in design and function. The mausoleum likely fell out of use in the early

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Table 1. *Radiocarbon dating results and chronology modeling results for Maucallacta sites. Agreement index A was given in the last column only when it was lower than 60%*

Excavation unit	Radiocarbon dates (BP)	Calibrated ranges (BC/AD)	Modeled range (BC/AD)
Basural 1	Basural 1		
capas 2,3,6	2) 125 ± 65 (Gd-15997)	2) 1671 – modern 95.4%	1519 – 1593 95.4%
Basural 2	6) 265 ± 45 (Gd-12936)	6) 1504 – modern 95.4%	A = 0.6%
capas 2,4-6	3) 930 ± 70 (Gd-15007)	3) 1023 – 1268 95.4%	1488 – 1576 95.4%
	Basural 2	2) 1327 – 1446 95.4%	A = 48%
	2) 555 ± 30 (GdC-671)	4) 1306 – 1444 95.4%	1031 – 1271 95.4%
	4) 585 ± 45 (GdC-667)	5) 1301 – 1483 95.4%	1440 – 1457 95.4%
	5) 545 ± 60 (GdS-1345)	6) 1425 – 1625 95.4%	1433 – 1452 95.4%
	6) 440 ± 40 (GdS-1346)		1428 – 1448 95.4%
			1415 – 1443 95.4%
Basural 2	1.1) 406 ± 19	1.1) 1453 – 1621 95.4%	1455 – 1606 95.4%
capas 1-6	(UGAMS-58652)	1.2) 1457 – 1623 95.4%	1458 – 1605 95.4%
	1.2) 392 ± 17	2.1) 1445 – 1609 95.4%	1447 – 1482 95.4%
	(UGAMS-58653)	3.1) 1397 – 1433 95.4%	not used
	2.1) 441 ± 16	4.1) 1438 – 1481 95.4%	1437 – 1454 95.4%
	(UGAMS-58654)	5.1) 1409 – 1442 95.4%	1427 – 1446 95.4%
	3.1) 564 ± 18	6.1) 1434 – 1480 95.4%	1423 – 1444 95.4%
	(UGAMS-58655)		
	4.1) 456 ± 17		
	(UGAMS-58656)		
	5.1) 532 ± 16		
	(UGAMS-58657)		
	6.1) 464 ± 18		
	(UGAMS-58658)		
Platform 1	1) 415 ± 30 (GdA-2666)	1) 1446 – 1624 95.4%	1454 – 1567 95.4%
ushnu	2) 555 ± 30 (GdA-2667)	2) 1327 – 1446 95.4%	1395 – 1447 95.4%
floors 1,2	2.1) 410 ± 45	2.1) 1445 – 1630 95.4%	1431 – 1509 95.4%
	(Gd-12926)		
Chullpa 1	1) 425 ± 30 (GdA-2663)	1) 1441 – 1623 95.4%	1452 – 1509 95.4%
	2) 440 ± 30 (GdA-2664)	2) 1435 – 1619 95.4%	1439 – 1495 95.4%
	3) 380 ± 30 (GdA-2665)	3) 1458 – 1630 95.4%	1478 – 1567 95.4%
Kallanka	1) 240 ± 70 (GdS-1356)	1)1507 – modern 95.4%	1467 – 1599 95.4%
floors 1–3	2) 525 ± 40 (GdS-1355)	2) 1327 – 1459 95.4%	A = 48%
	2.1) 520 ± 30	2.1) 1405 – 1452 95.4%	1406 – 1456 95.4%
	(GdS- 2694)	3) 1326 – 1444 95.4%	1411 – 1452 95.4%
	3) 560 ± 30 (GdC-673)		1328 – 1437 95.4%
Plaza 7	House D:		
Muestras de	1) 510 ± 40 (GdC-669)	1) 1396 – 1480 95.4%	1398 – 1480 95.4%
los recintos	2) 380 ± 25 (GdC-677)	2) 1459 – 1629 95.4%	1458 – 1603 95.4%
	House F:	2) 1503 – 1801 95.4%	1524 – 1598 95.4%
	2) 285 ± 40 (GdS-1348)	3) 1502 – 1800 95.4%	1502 – 1590 95.4%
	3) 290 ± 40 (GdS-1347)		
Mausoleo	1) 475 ± 40 (Gd-12928)	1) 1408 – 1615 95.4%	1411 – 1607 95.4%
	2) 380 ± 45 (Gd-12927)	2) 1456 – 1635 95.4%	1455 – 1602 95.4%
	3) 400 ± 60 (Gd-19002)	3) 1441 – 1642 95.4%	1446 – 1602 95.4%
	4) 360 ± 25 (GdC-675)	4) 1481 – 1637 95.4%	1507 – 1606 95.4%

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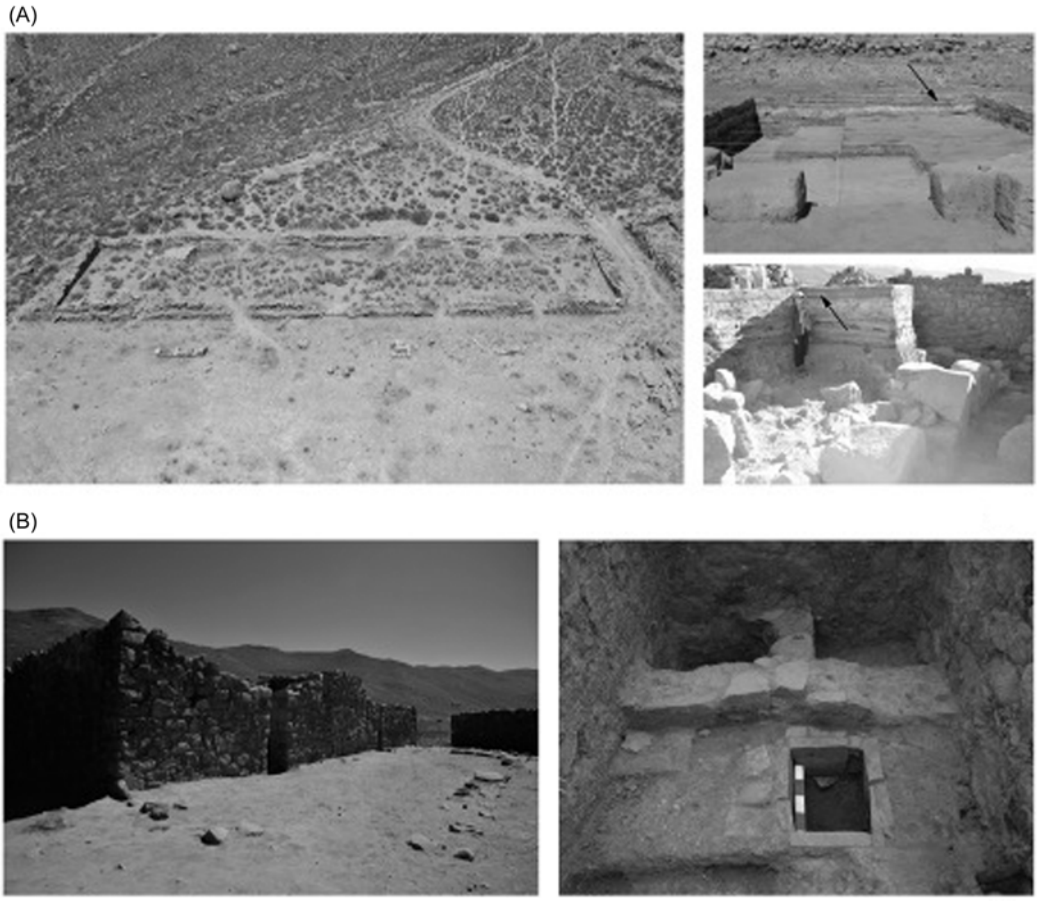

Figure 2. *(A) Kallanka—general view and photos of exposed profiles with a marked layer of ash from the eruption of the Huaynaputina volcano (on February 19, 1600) (photos by M. Sobczyk and S. Siemianowska). (B) Mausoleum, general view from the front located inside and the altar with the place (a rectangular hearth) of the last burnt offering (photos by M. Sobczyk).*

colonial period. The structure has gradually collapsed, as evidenced by a layer of volcanic ash from the eruption of the Huaynaputina volcano, located approximately halfway down the backfill. Within it, numerous ceramic vessels and the remains of a hearth containing ash and burnt-out organic remains were found (see Figure 2 B).

Plataforma I, ushnu and ceremonial middens: Basural-1 and Basural-2. In 2006, while clearing the northwestern part of the ceremonial platform and ushnu (see Figure 3 A) of plants and soil, a substantial dump (Basural-1) was discovered directly below the platform on its northwestern side (see Figure 3 B). The exploration (2006–2007) yielded 4,028 animal bones (mainly llamas and alpacas; Marciniak 2012), 21,006 pottery fragments (Siemianowska and Sobczyk 2020, Table 1, Table S.1), along with individual objects crafted from copper, wood, and other raw materials. Monumental stone stairs leading directly to the main square and ushnu were also unveiled (Siemianowska and Sobczyk 2020, Sobczyk 2022, 140). Subsequent excavations in 2007 led to the discovery of another dump (Basural-2) situated northeast of the ushnu, near Basural-1 (see Figure 3 C). Excavations in 2007, 2008, 2009, and 2011 resulted in the recovery of a vast amount of archaeological material: 73,333 pottery fragments (Siemianowska and Sobczyk 2020, Table 1, Table S.1), 6,918 animal bones—mostly camelids, interpreted as probable remnants of feasting (Kłaput 2021)—as well as individual artifacts

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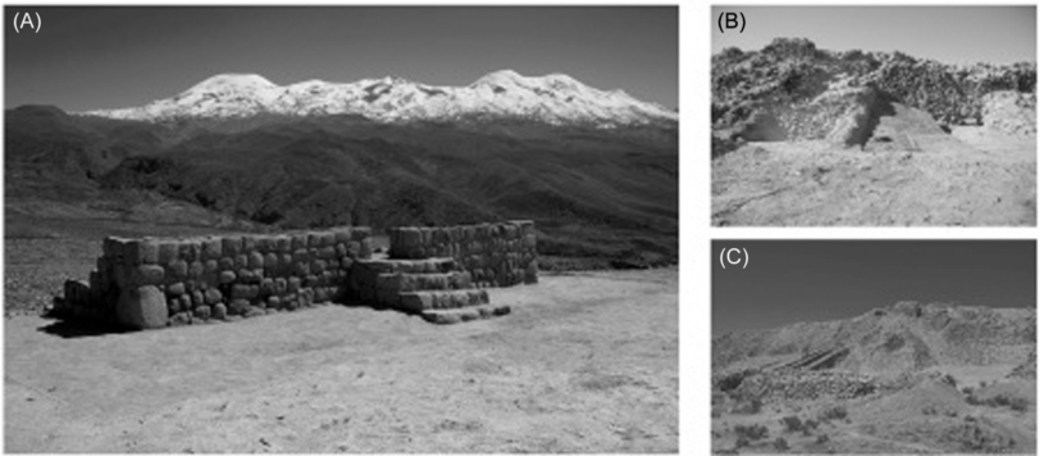

Figure 3. (A) Ushnu in the main square—Platform I, (B) Basural 1 during excavations, (C) Basural 2 during excavations (visible exposed stairs that were located under Basural 1) (photos by M. Sobczyk).

made of bone, copper, obsidian, and rock crystal (Buda et al. 2010; Siemianowska and Sobczyk 2020; Sobczyk 2022; Wołoszyn et al. 2010).

During the ceramic and bone material analyses, attention was given to the clear differentiation in the amount and degree of fragmentation present in the material. The upper layers of both dumps contained fewer finds than the lower levels and were more fragmented (Siemianowska 2021; Siemianowska and Sobczyk 2020). This is likely due to the nature and time of formation of individual deposit layers. The *terminus post quem* for the beginning of the formation of the ceremonial dumps was the discontinuation of the monumental stone stairs leading to the main square, probably related to the takeover and reconstruction of the center by the Incas. The *terminus ante quem* was in 1600, and Huaynaputina erupted, as evidenced by the ashes in layer 1. Considering that the Incas likely conquered this region in the mid-15th century, during the reign of Inca Pachacuti Yupanqui and Topa Inca, we are talking about almost a century and a half for the creation of the described dumps, with less than 100 years from the Inca conquest to the arrival of the Spaniards in the Pampacolca area (Siemianowska 2021). Comparing the archaeological material's type, quantity, and degree of fragmentation with the description of the individual layers of dumps, it can be assumed that they were created in at least five phases (Siemianowska 2021). Similar deposits are known from sites in Cusco (Delgado Gonzalez 2013), Huanuco Pampa (Monteverde Sotil 2011a, 2011b; Morris et al. 2011), Hualfin Inca in Argentina (Lynch et al. 2013; Paéz and Lynch 2012), Chena in Chile (Stehberg 2016), and Intinqala in Bolivia (Bray et al. 2019).

Method

All samples for radiocarbon dating underwent preparation in the Dendrochronological Laboratory at AGH University of Kraków. After selecting the appropriate material for radiocarbon analysis, all samples were cleaned and rinsed in deionized water. The chemical pre-treatment of wood and charcoal samples involved the acid-base-acid procedure (ABA, Jull et al. 2006; Wiktorowski et al. 2020). In the first step, all samples were treated with 2% HCl at 75°C, then rinsed with deionized water until neutral. Subsequently, the samples were treated with 1M NaOH at 75°C and rinsed with deionized water until neutral. Finally, the samples were treated again with 2% HCl at 75°C, then rinsed with deionized water until neutral. Following the ABA procedure, wood and charcoal samples were dried and prepared for the next step. Control samples from material with a known radiocarbon content were included in each

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prepared sample batch to maintain high-quality standards throughout the process. IAEA C2, C3 (Rozanski et al. 1992), and vitrinite samples (Krąpiec et al. 2018) controlled the entire procedure's background. All control samples were prepared using the ABA method. Bone samples were subjected to collagen extraction following a modified Longin method. We used a protocol adapted from the Leibniz Radiocarbon Laboratory in Kiel, Germany (Huels et al. 2017): 0.3M–0.8M HCl, then 0.3M NaOH, followed by 0.3M HCl at room temperature (20–25°C). Gelatinization was done at 85°C and pH 3 for 12–24 hr. The collagen was then filtered using a 0.45-μm Ag filter, and finally, the collagen samples were lyophilized.

For combustion to CO_2, samples were transferred into a pre-baked (900°C) quartz ampules along with CuO and Ag, evacuated to a pressure of 10^{-5} mbar, sealed, and combusted for 4 hours at 900°C in a muffle oven (Krąpiec et al. 2018). The resulting CO_2 was released under a vacuum and cryogenically purified for subsequent graphitization. Reduction of CO_2 to graphite was done using a 5-port vacuum system (Krąpiec et al. 2018) with H_2 and Fe powder as catalysts. About 200 mbar of CO_2 (equivalent to 1 mg C in this system) were used, and the H_2/CO_2 ratio for the reduction was ∼3 (by volume), and the Fe/C ratio was 2 (by mass). Water produced during this process was removed using a cryogenic trap.

The produced graphite was then pressed into the cathode and measured using the AMS system at the Center for Applied Isotope Studies at the University of Georgia, Athens, USA (Labcode UGAMS; Cherkinsky et al. 2010). The ^{14}C contents are reported as $\Delta^{14}C$ in per mil (‰) deviations from the standard sample, 0.7459 activity of NBS oxalic acid (SRM-4990C). Age correction, isotopic composition correction ($\delta^{13}C$, measured by the AMS system), and $\Delta^{14}C$ values were calculated using formulas presented by Stuiver and Polach (1977). The OxCal 4.4 software (Bronk Ramsey and Lee 2013) was used to determine the calendar age of the samples and construct the chronology of the site's occupation. The calculation was based on a mixture of Intcal20 and Shcal20 calibration curves (Hogg et al. 2020; Reimer et al. 2020).

A chronological model was created for each site using OxCal's Bayesian modeling capabilities. To build an accurate timeline, this modeling process involved radiocarbon dates, stratigraphic information, and historical data. The *Phase* command was used to define the phases of each site, while the *Sequence* command (Bronk Ramsey 2008) was utilized to define the succession of events. The *Boundary* command (Lee and Bronk Ramsey 2012) was also employed to describe the boundaries of event occurrence. In all cases, radiocarbon dates were assumed to be no younger than AD 1600±5. To mix the Southern and Northern radiocarbon calibration curves, we applied the *Mix_Curve* OxCal command. All input scripts for OxCal are included in the appendices.

Geographical provenance (GP) of air parcels

During the preindustrial period (before ∼1850), the NH calibration curve (IntCal20; Reimer et al. 2020) exhibited higher radiocarbon levels than the SH calibration curve (SHCal20; Hogg et al. 2020). This difference arises from the ocean-atmosphere $^{14}CO_2$ exchange in the Southern Ocean (Braziunas et al. 1995; Rodgers et al. 2011). The ocean absorbed the 14C initially formed in the atmosphere and transported through its interior via thermohaline circulation for centuries to millennia (Braziunas et al. 1995; Weaver et al. 1993). As a result of the natural radioactive decay of ^{14}C, the Southern Ocean deep water masses have a low ^{14}C:^{12}C isotopic ratio relative to the atmosphere (Key et al. 2004). Consequently, the upwelling of ^{14}C-depleted deep water to the Southern Ocean surface, along with the subsequent ocean-atmosphere CO_2 exchange, decreases the ^{14}C:^{12}C isotopic ratio of the SH's atmosphere. Therefore, to radiocarbon date archaeological samples from tropical latitudes, where there is a confluence of NH and SH air masses with high and low atmospheric radiocarbon levels, respectively, it is necessary to combine NH and SH calibration curves (Ancapichún et al. 2022; Marsh et al. 2018).

To radiocarbon date samples from Maucallacta, we combined NH and SH calibration curves using the methodology in Ancapichún et al. (2022). HYSPLIT (Stein et al. 2015) assessed the GP of the air

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parcels that potentially transported the $^{14}CO_2$ subsequently fixed and assimilated by the local biosphere. The NCEP/NCAR reanalysis data served as input data for the HYSPLIT model (Kalnay et al. 1996). On the other hand, the backward trajectories calculated using HYSPLIT are generated as a set of longitudinal, latitudinal, and altitudinal data based on a window of an arbitrary number of hours into the past, for a given hour of the day (Draxler and Taylor 1982). Considering that October, November, December, January, February, and March (ONDJFM) are the main growing season months for plants, which fix atmospheric $^{14}CO_2$ concentration in their tissues, we modeled the ONDJFM from the years 1949 to 2019 following Ancapichún et al. (2021, 2022) (Figure S.1). This approach allowed us to obtain the percentage of air parcels derived from the NH and SH, enabling the combination of NH and SH calibration curves.

Results and discussion

The first attempts to determine the exact chronology of the ceremonial platform with the ushnu rising on its edge, as well as the ceremonial dumps piled up at its foot, were carried out shortly after their excavations (Presbitero et al. 2000/2001; Sobczyk 2022). The obtained calibrated dates indicate the functioning of two usable levels of the square in this place—one associated with its earliest phase and the Late Transitional Period—and the second falling during the reign of the Incas and the Late Horizon (Presbitero et al. 2000/2001; Siemianowska 2021; Siemianowska and Sobczyk 2020; Sobczyk 2016, 2022). The layers of the dumps from which the samples were taken were loose and water–permeable. It cannot be ruled out that much older items were burned during various ceremonies held in the square, which could explain the dating back to the 11th–13th and 14th centuries (see Sobczyk 2016, 2022). It is possible that some accumulations in the dump, specifically layer 3, are not related to Inca sacrifice but result from reconstruction or thorough cleaning of the square. The first dating obtained from it, with over 95% probability, points to the period 990–1246 cal AD (Sobczyk 2016, 2022), while the pottery found in this layer corresponds to Late Horizon pottery and the Inca Empire. It is also possible that the material from the platform was not always removed after each ceremony, but occasionally (Siemianowska 2021).

The new radiocarbon dating was based on camelid bone material. For these purposes, 7 bone fragments (Table S.1), characterized by a relatively good state of preservation, representing each of the 6 stratigraphic layers of the second sacrificial midden (Basural 2), were selected from the bone material collected in Basural 2. All the bones are from Andean camelids, most likely llamas or alpacas (the degree of preservation of the material does not allow the taxonomic affiliation to be determined precisely as to the exact species).

We found that 75% of air parcels originated from the Southward of the Tropical Low Pressure Belt (TLPB; Hua et al. 2022), whereas 25% came from the Northward of the TLPB, with a standard deviation of 11.2%. All chronology modeling results for the Maucallacta site were obtained using mixed SH and NH radiocarbon calibration curves in a ratio of 75%/25%, with a standard deviation of 11%, and a normal probability distribution describing the proportion of curves. The normality of distribution was tested with Shapiro-Wilk, yielding a p-value of 0.215.

Figure 4 and Table 1 summarize the final modeling results. The appendices provide detailed modeling results.

The modeling results for Basural I show (Figure 4, Table 1, Supplementary Table S.1) that no reliable site chronology can be constructed based on the available information. The large dispersion of dates between the dates poses challenges in formulating reliable conclusions based on modeling.

Modeling results for Basural II (Figure 4, Table 1, Supplementary Table S.2) suggest that the site may have been used between AD 1425 and AD 1609. The modeling for Basural II likely presents the most reliable and consistent chronology for this part of the site. Moreover, given that the dating from these excavation units reflects events in the main ceremonial part of Maucallacta, the plaza, it is reasonable to assume that they resulted from activity throughout the site. The nature of this human activity, whether they were residents, pilgrims, or people living near the site, remains unclear.

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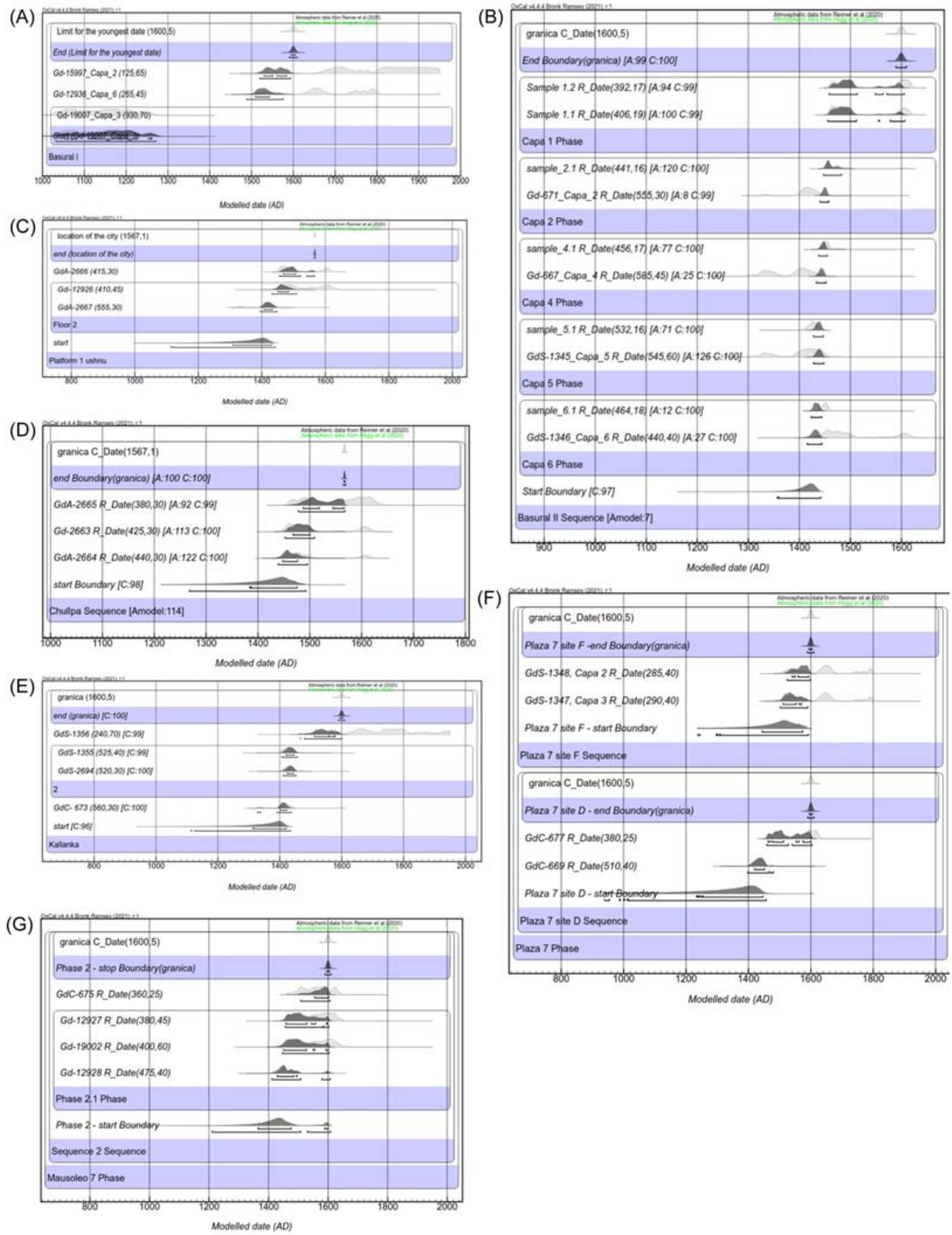

Figure 4. *Results of OxCal modeling for Maucallacta site: (A) – Basural 1, (B) – Basural 2, (C) – Platform I, (D) – Chullpa, (E) – Kallanka, (F) – Plaza 7, (G) – Mausoleo. All the modeling details are presented in the Supplementary Material.*

Nevertheless, it is possible to outline the timing of Maucallacta's functioning throughout Inca domination up to the early colonial period. These findings concurrently confirm the authenticity of ethnohistorical records.

The chronology model for the site Platform I ushnu (Figure 4, Table 1, Supplementary Table S.4) indicates a possible site use between AD 1395 and AD 1569. Modeling for this element reveals that the ushnu, or the area around it, already had a ritual character from the beginning of the site's setup, even before its architectural modifications associated with the Inca presence. This early dating for the Inca presence may indicate that Maucallacta fits into the general trend of questioning the historical chronology developed by Rowe in 1945 (Covey 2006; Marsh et al. 2017; Ogburn 2012; Ziółkowski et al. 2020; Zuidema 1982). Assuming that the oldest dating, which comes from the level of the original Inca floor, represents the moment of Inca appearance in the region, we can infer a verification of Rowe's historical chronology assumptions for the entire Kuntisuyu area.

The chronology model for the Chullpa 1 site (Figure 4, Table 1, Supplementary Table S.3) suggests that the site may have been in use between AD 1448 and AD 1567. This aligns with the general site operation during the Inca period demonstrated by Basural II. Interestingly, the Chullpa remained in use for some time after the Spanish invasion, although not enough to reach the final collapse of the Inca State, which was identified with the fall of the Vilcabamba capital in 1572.

The chronology model for the Kallanka site (Figure 4, Table 1, Supplementary Table S.5) suggests a possible site use between AD 1411 and AD 1599. The Kallanka, as a type of building characteristic of Inca architecture, was likely used intensively throughout Maucallacta's prosperity. Modeling for these dates indicates that the target building was erected during the general architectural changes identified with Inca supremacy in the region. Simultaneously, the end of the use of this space is associated with the general abandonment of the site by its inhabitants and the obligatory resettlement to the valley near Pampacolca (Sieczkowska and Sobczyk 2018).

The chronology model for Plaza site 7 (Figure 4, Table 1, Supplementary Table S.6) suggests a possible site use between AD 1398 and AD 1598. This area also aligns with the general period of the site's operation in the Inca State. Like the examples above, it leads us to assume that the original historical chronology does not apply to this area or requires a general revision of general guidelines.

The chronology model for the Mausoleo site (Figure 4, Table 1, Supplementary Table S.7) allows us to determine the site's use between AD 1411 and AD 1606. Modeling for the mausoleum similarly demonstrates its function in Maucallacta's ritual activities since the beginning of the Inca presence. Of particular interest are the dates for the last ceremonies that took place there—around the same time as the last ceremonies on the main plaza, reflected in the material in Basural II. The cause of the recent ritualistic events at the site remains unknown. Nevertheless, we are dealing with the same historical moment. Although the Mausoleum lacks testimony to the ritual closing of the space by the Inca, it is still possible that the reason for the ceremony was Inca beliefs. It is worth noting that by this time, there had already been the repartimiento in Pampacolca for nearly two decades. Therefore, it is particularly interesting that despite the already imposed (and accepted) Christian faith, we have clear testimony of the cultivation of Inca rituals at the Maucallacta site (Sieczkowska 2015; Sieczkowska and Sobczyk 2018).

Conclusions

Although the individual dates for specific parts of the Maucallacta site are not precise, appropriate modeling and analysis of the archaeological context have yielded valuable conclusions. Comparing the data obtained so far has revealed that the general observations about the site widening during the Inca arrival are accurate. Historical sources have provided us with several precisely dated events that are important for determining the completion of the Maucallacta temple's functioning. These events can serve as reference points for the data under analysis.

It can be assumed that some type of large-scale organized ceremonial activity likely took place during and immediately after the fall of the Inca Empire. However, this activity and investments in the expansion of architecture ceased during the reduction associated with resetting the indigenous population to the newly established Spanish settlements.

Therefore, the dating results for the structural layers associated with ushnu and Plataforma I can safely be limited to no younger than 1575, the end of Viceroy Toledo's census. Pampacolca was already founded, and parish documents appear from 1592, which should also mark the end of the tradition of burials in chullpas (Cook et al. 1975; Sieczkowska 2015; Sieczkowska and Sobczyk 2018).

The earliest radiocarbon dates come from layer 3 in Basural 1. This extraordinarily early date may indicate various ceremonial activities associated with ushnu have occurred. It is possible that much older objects were burned, possibly contemporaneous with the construction of Plataforma I, given the calculations mentioned from lichenometric studies (Sobczyk 2022). Basural 1 is younger than Basural 2, and the layers covered the steps of the stone stairs that led to the square and the ushnu. Unfortunately, the available data does not provide more information about Basural 1 (see Figure 3 B–C).

The dates obtained from the utilitarian layers in the D enclosures of Plaza 7 and C of Plaza 20 are characterized by Inca-style stone elaboration and likely indicate the time of site reconstruction after the arrival of the Incas. These dates precede those of Chullpa 1 or those related to ceremonies in the Mausoleum. The following two dates are associated with two types of activity in the corresponding enclosures. One represents the date of the last burnt-out offering in the Mausoleum (enclosure F, Plaza 5) in a rectangular hearth before the altar in the vestibule (see Figure 2 B), and the other indicates the latest works carried out in the copper workshop (Building F, Plaza 7). The last ceremony in the Mausoleum, connected with the burnt-out offering, was sealed by the collapse of the walls, probably after an earthquake. It took place before the eruption of the Huaynaputina volcano because there is a layer of ash above it.

Based on the modeling of dates for individual parts of the site and given the overall distribution of dates for the entire Maucallacta, it is evident that we are dealing with another example of a site that does not fit into the general theory of historical chronology published by John H. Rowe (1945). Based on ethnohistorical data from chronicles, Rowe hypothesized that the area described by Kuntisuyu was conquered by Topa Inca somewhere between 1471 AD and 1493 AD (Rowe 1945). The presented dating for Maucallacta primarily comes from the architectural structures identified with the Inca presence and the floor layers associated with the Inca foundation activities for individual buildings. Since we are, in most cases, dealing with Inca remains, we assume that the historical chronology, in this case, can no longer be applied to Maucallacta, and any research should be based on absolute radiocarbon chronology.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/RDC.2024.131

Acknowledgments. The project's research was carried out as part of a long-standing collaboration between the University of Warsaw and the Catholic University of Santa Maria in Arequipa, to which we are extremely grateful for their tremendous support. The research project to establish the chronology of the development of Incan domination in the is funded by the National Science Centre of Poland, within the framework of the OPUS grant entitled *Chronology of the Inca expansion in Cordillera de Vilcabamba (Peru)* grant number 2020/37/B/HS3/01622. We are very grateful to the two anonymous reviewers who helped improve the manuscript.

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Cite this article: Sobczyk M, Rakowski AZ, Siemianowska S, Kłaput J, Pawlyta J, Sieczkowska-Jacyna D, Olaya Cotera C, and Ancapichun S. Possibilities and limitations of new radiocarbon dating for the Maucallacta site, dep. Arequipa, Peru. *Radiocarbon*. https://doi.org/10.1017/RDC.2024.131