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LATE CHRONOLOGY IN HUALFÍN VALLEY (CATAMARCA, ARGENTINA): A REVISION FROM $_{14}$C DATING

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ABSTRACT

In this paper we address chronological problems about archaeological sites traditionally associated with "Belén culture" from Hualfín Valley (Catamarca, Argentina), analyzing background research, radiocarbon dates obtained by A. Rex González before 1970, and those made since 1996. First, we critically review the chronological sequence built by González for "Belén" sites, which include Late Period (1100-1480) and Inka Period (1480-1536 AD), subdivided into three phases. Methodological problems that could affect results of first radiocarbon dates are discussed. Based on this review, we present new $_{14}$C dating considering extraction contexts, types of samples, calibration curve, the laboratory where each date was obtained and their methods of measuring, characteristics of sites of origin and associated archaeological materiality. Finally, using calibrated ranges for 1σ and 2σ, and a Bayesian single phase model, we suggest different groups of events that would correspond to different times in the history of late occupations in the valley.

INTRODUCTION

In the late 40s, North American archaeologist Wendell Bennett and contributors (1948) published a paper called "North West Argentine Archaeology" consisting in a mainly bibliographic analysis of ceramic styles and "cultural" associations. The first goal for such research was to establish the basis for a periodization. The classification of styles and the conformation of archaeological contexts led them to define four periods for farmer and potter cultures: Early, Middle, Late and Inka. A few years later, in 1952, Alberto Rex González started his own excavations in Northwestern Argentina continuing in the same line purposed by Bennett. González considered essential to establish relative and absolute chronologies, given that, until that moment, interpretations were mainly based on ethno-historical chronicles, denying the temporal depth in the development of local societies and intermixing cultural materials, without an attempt to explain their differences. At first, Gonzalez used relative chronology built from some overlapped tombs,

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seriation of these tombs and typological correlations (González 1955). Seriation was established mainly base on pottery classification taken from tombs of Hualfín Valley (Dept. of Belén, Catamarca, Argentina) (Figure 1) from Muñiz Barreto collection (Museum of La Plata), considering technical and stylistic features, and in some cases settlement pattern (González 1955).

González, a pioneer in the application of the radiocarbon dating method in Argentina, started to compare his sequence with absolute chronology data (González 1959, 1960a, 1960b, 1964). In the First National Congress of Argentinean Archaeology, in collaboration with George Cowgill, he exposed a compilation of the results of more than 20 years of work, having already a lot of radiocarbon dates and the possibility to process the data using computers (González and Cowgill 1975). These results produced the master sequence for Northwestern Argentina and were based on archaeological materials from Hualfín Valley. The last three phases in the sequence were called "Belén I", "Belén II and "Belén III", and correspond to the "Late" and "Inka" periods. For these phases, González obtained nine radiocarbon dates made in different laboratories (Table 1) (Olsson 1960; Stuiver et al. 1960; Olson and Broecker 1961; Hakansson 1971; Valastro et al. 1972). González warned that these results were contradictory with the proposed phases, so he decided to maintain the original sequence. Time proved him right about their precautions, since the development of the method led to the discovery and correction of experimental and sampling errors. Beyond the cautions, he established precise chronological limits for their phases: Belén I (1100-1300 AD); Belén II (1300-1480 AD) y Belén III (1480-1535 AD).

In recent years, diverse research has been developed for late archaeological settlements and new radiocarbon ages were obtained, some of them from the same sites González excavated and dated by González, and others in known but non previously worked or recently found settlements (Figure 1) (Wynveldt 2009; Balesta et al. 2011; Wynveldt and Iucci 2013). With the aim of contributing to the problem of the chronology of "Belén" occupations in Hualfín Valley, in this paper we critically analyze the "old" radiocarbon dating, looking at probably causes that led to inconsistencies between these dates and González's Belén phases. We also present the analysis of the new ^{14}C data, evaluating the contexts where samples were extracted, the different types of samples, the calibration curve, the lab where each date was obtained and their methods of measuring and characteristics of the sites. Finally, using calibrated ranges for 1σ and 2σ, and a Bayesian single phase model, we suggest different groups of events that would correspond to different times in the history of late occupations in the valley.

"OLD" RADIOCARBON DATING AND BELÉN PHASES

"Belén culture", defined by González, was subdivided into three phases according mainly to a series of architectural and ceramics features. "Belén I" was defined by the presence of Belén pottery and communal large "pit houses", arranged in groups of 3 or 4. This type of architecture, lacking stone walls was detected in a site called Corral de Ramas, which gave name to this phase.

"Belén II" showed changes in housing construction; dwellings were built in stone walls, configured in more or less independent and scattered units, as Gonzalez exemplified by means of defensive site Cerrito Colorado.

Later –not clear if still in phase II or already in phase III–, changes would have been more pronounced, with significant changes in cultural and social organization of Belén communities. These changes would be seen, for example, in the complex defensive sites of El Molino and Pueblo Viejo de El Eje, associated by González with phases II and III (González and Cowgill 1975), or in the ability to undertake important collective tasks, as the cultivation terraces built in Asampay, that González ascribed to Inka moments. El Shincal was proposed as the type site for this phase; regarding to pottery, the presence of Inka influence on vessels was an indicator to recognition of "Belén III" phase.

In summary, Belén phases were characterized by having a progressive evolution of architectural patterns, from communal "pit houses" to fortified and aggregated sites with Inka influences. After González proposal, this culture was characterized as a chiefdom or "señorío", in a geopolitical model with its hegemonic core in Hualfín Valley (Sempé 1999). According to Sempé, Belén settlement pattern was organized in a site hierarchy —aggregated villages, disperse or open villages, and villages with houses between terraces for farming. This pattern would reflect the complexity of social organization. Sempé's proposition had a different perspective from González's ideas which included not only settlement pattern but also political aspects; moreover, in the nineties, chronological problems still remained because almost no new radiocarbon dates were obtained to establish sites temporality. In spite of these restrictions and differences regarding the process complexity outlined by González Sempé kept Belén's phases intact.

With reference to González's radiocarbon dates –detailed in Table 1–, we can observe that dates were obtained before 1970/71, therefore some important methodological problems could affect these results, mainly the absence of intercomparison between labs, the type of the samples and their storage.

Intercomparison became effective just since 1980 (Otlet et al. 1980) and only in 1990 was significantly extended, including a relevant number of participants (Scott et al. 1990). Regarding to the samples, archaeologists did not consider the way to elude the "old wood" effect over dates; consequently samples sometimes were old woods, maybe re-used or old logs, which death age

didn't correspond with the event to date. Other error source in radiocarbon dating is possible contamination of the samples. While generally there is no register about possible contamination factors affecting the samples used to date before and during the extraction, problems may have been existed in its storage, in some cases for many years. Finally, a problem for some González's dating was the use of different contemporary standards by laboratories, that which were corrected according the international consensus currently employed (Carbonari et al. 2011).

Table 1. Radiocarbon dates for Belén phases (González and Cowgill 1975). *14C conventional date obtained by correction of reference contemporary standard used by Uppsala lab (Carbonari et al. 2011).

Site and structure of origin	Code	Extraction year	Measure year	Type of sample	14C Date BP	Calibración AD (Curva SHcal13)		Belén Phases		Concordance
						1 σ (68,2% prob.)	2 σ (95,4% prob.)	Phase	AD	
Cerrito Colorado, House 3	Y-560	1952	1959	Charcoal	240 ± 80	1630-1711 (23,2%) 1719-1812 (31,4%) 1836-1949 (12,9%)	1506-1587 (11,4%) 1618-1949 (84%)	II	1300-1480	No
Cerrito Colorado, House 8	L-476C	1952	1958/60	Charcoal	400 ± 100	1454-1529 (30%) 1531-1627 (38,2%)	1395-1688 (89,3%) 1728-1804 (6,1%)	II	1300-1480	No
Pueblo Viejo de El Eje, Room 72	Lu-371	1969	1969/70	Charcoal	520 ± 50	1410-1452 (68,2%)	1326-1340 (1,5%) 1390-1499 (92,7%)	II-III	1300-1535	Yes
Cerrito Colorado, House 3	U-154	1952	1959	*Prosopis* sp. and *Larrea* sp.	580 ± 80	1318-1352 (20,5%) 1384-1447 (47,7%)	1283-1497 (94,4%) 1602-1606 (1%)	II	1300-1480	Yes
					715 ± 115*	1232-1246 (4%) 1263-1401 (63,4%)	1053-1061 (0.4%) 1067-1078 (0.5%) 1147-1454 (94.4%)			
Corral de Ramas, Pit-house 1	Y-559	1952	1959	*Prosopis nigra* log	590 ± 50	1324-1343 (16,4%) 1389-1432 (51,8%)	1305-1362 (31,5%) 1377-1448 (63,9%)	I	1100-1300	No
Corral de Ramas, Pit-house 1	U-153	1952	1959	*Prosopis nigra* log	795 ± 80	1223-1320 (50,5%) 1350-1386 (17,7%)	1151-1416 (95,4%)	I	1100-1300	Yes
					930 ± 115*	1031-1228 (68.2%)	898-928 (16.2%) 963-1311 (92.5%) 1359-1379 (10.5%)			
El Molino, Room 68	Tx-989	1969	1969/71	Charcoal	930 ± 70	1046-1089 (20%) 1109-1120 (3,5%) 1130-1219 (44,7%)	1027-1266 (95,4%)	II-III	1300-1535	No
Pueblo Viejo de El Eje, Room 37	Tx-990	1969	1969/71	Charcoal	1040 ± 70	991-1053 (31,5) 1060-1068 (3,3%) 1078-1147 (33.4%)	895-935 (5,7%) 955-1201 (89,7%)	II-III	1300-1535	No
Pueblo Viejo de El Eje, Room 72	Tx-991	1969	1969/71	Charcoal	1090 ± 60	894-936 (17%) 954-1043 (51,2%)	885-1072 (78,2%) 1076-1149 (16,2%)	II-III	1300-1535	No

Considering these observations, we proceeded to analyze "old" radiocarbon dates. One of the most notorious contrariness is related with the oldest data, obtained in Texas lab (USA), corresponding to El Molino (Puerta de Corral Quemado) and Pueblo Viejo de El Eje. The contrast between complex architectural features of these sites and the old dates could not be accepted within González's scheme, considering for that time "Belén Culture" would still be conforming.

While in the published specifications for these dates there are not added details on the characteristics of the samples (Valastro et al. 1972) there is an internal coherence in the ages. However, as González assumed at the time, they are very old for phases II and III, taking into account the characteristics of the dated sites (González and Cowgill 1975). Instead, the age obtained in Lund (Lu) for Pueblo Viejo de El Eje (520 ± 50 BP), according to González is in line with his previous estimations and with historical information of Inkas arrival, being a good mark for the beginning of "Belén III" (Hakansson 1971: 355). Then, it is very likely that the observed wide difference between the three datings made in Texas and that obtained in Lund is due precisely to problems in the application of the method, especially considering that Lu-371 and TX-991 were extracted from the same room, so it would be expected a better match.

Radiocarbon dates for Corral de Ramas were also problematic. First, for one sample two very different ages were obtained in different labs (U-153: 930 ± 115 BP and Y-559: 590 ± 50 BP); on the other hand, this sample was extracted from an *algarrobo* (*Prosopis* sp.) log, therefore it might be affected by "old wood" effect.

Regarding to Y-560 (240 ± 80 AP) from Casa 3 in Cerrito Colorado site, that should correspond to phase II, there are no details about how the sample was composed. A comment about this date considered that the age for U-154 (715 ± 115) is more acceptable for "Belén II" (Stuiver et al. 1960). Neither L-476C (400 ± 100 AP), obtained for Casa 8 in Cerrito Colorado is concordant with a pre-Inka occupation.

THE NEW RADIOCARBON DATA

The newest research about the different archaeological late settlements located in Figure 1 allowed obtaining new archaeological and chronological information. Table 2 present 22 radiocarbon dates obtained since 1996 until today for late sites in the Hualfín Valley. Besides, AC-364 is included, an age made in 1986 in the INGEIS laboratory (Alberó y Angiolani 1985). Although this date is coherent with the oldest of the new set, we decided to exclude it from the analysis of the new dates, due to the laboratory where it was made didn't participate in international comparisons.

Table 2. Radiocarbon dates obtained since 1986, from samples of new excavations at late sites in Hualfín Valley and from samples extracted by González in the 50s and 60s.

Site and structure of origin	Code	Type of sample	^{14}C Conv. date BP	Calibration AD (SHcal13)	
				1σ (68,2% prob.)	2σ (95,4% prob.)
Loma de los Antiguos, Room 10	LP-872	Charcoal	220 ± 70	1648-1708 (20,4%) 1721-1811 (34,1%) 1837-1949 (13,6%)	1513-1546 (2,9%) 1623-1949 (92,5%)
Cerro Colorado, Room 35	LP-2760	Carbonized corn	290 ± 60	1509-1580 (26,6%) 1621-1672 (25,9%) 1743-1796 (15%)	1461-1700 (70,2%) 1722-1810 (23,6%)
Campo de Carrizal, Room 1	LP-1250	Charcoal	310 ± 60	1502-1593 (40,9%) 1613-1667 (25,9%) 1789-1791 (0,7%)	1459-1681 (81,4%) 1730-1802 (14%)
Loma de los Antiguos, Room 31	LP-1644	Human bone	320 ± 50	1506-1587 (45,7%) 1618-1654 (22,5%)	1463-1672 (90,8%) 1744-1759 (2%)
Lajas Rojas 2	LP-1793	Charcoal	320 ± 60	1502-1594 (42,6%) 1613-1661 (25,6%)	1459-1675 (85,6%) 1737-1798 (9,8%)
Loma de los Antiguos, Room 9	LP-937	Charcoal	330 ± 50	1505-1588 (48,8%) 1617-1649 (19,4%)	1460-1670 (94,1%) 1749-1752 (0,2%)
Loma de los Antiguos, Room 3	LP-1039	Charcoal	350 ± 50	1502-1593 (54,2%) 1613-1638 (14%)	1460-1654 (95,4%)
Loma de Ichanga, Room 9	LP-2667	*Camelidae* bone	360 ± 50	1500-1597 (56,3%) 1611-1632 (11,9%)	1460-1648 (95,4%)
Loma de Ichanga, Room 6	LP-1832	Carbonized corn	420 ± 50	1449-1510 (42,6%) 1578-1621 (25,6%)	1443-1629 (95,4%)
Cerrito Colorado, Room 8	LP- 2309	Charcoal	420 ± 70	1448-1512 (35,4%) 1548-1563 (5,5%) 1570-1623 (27,3%)	1427-1645 (95,4%)
Cerrito Colorado, Room 3	LP-1810	Charcoal	420 ± 70	1448-1512 (35,4%) 1548-1563 (5,5%) 1570-1623 (27,3%)	1427-1645 (95,4%)
Campo de Carrizal, NH2, Room 1, B2	LP-2330	Charcoal	430 ± 60	1443-1510 (43,3%) 1554-1556 (0,7%) 1576-1622 (24,2%)	1430-1633 (95,4%)
Cerro Colorado, Room 2	AA105209	Charcoal	446 ± 25	1447-1486 (68,2%)	1440-1504 (84,9%) 1591-1615 (10,5%)
Lajas Rojas 4	LP-2651	Carbonized corn	460 ± 50	1432-1500 (60%) 1597-1611 (8,2%)	1412-1515 (70,6%) 1540-1625 (24,8%)
Cerro Colorado, Room 35	AA100176	Carbonized corn	478 ± 38	1429-1465 (60%) 1467-1477 (8,2%)	1411-1502 (89,7%) 1593-1614 (5,7%)
Cerro Colorado, Room 2	AA94600	Carbonized corn	493 ± 34	1428-1456 (68,2%)	1408-1488 (95,4%)
La Estancia, Room 13	AA105210	Carbonized corn	512 ± 35	1422-1451 (68,2%)	1400-1464 (95,4%)
Loma de Palo Blanco, Room 34	AA105211	Carbonized *jarilla* (*Larrea* sp.)	523 ± 26	1421-1445 (68,2%)	1410-1452 (95,4%)
Loma de la Escuela Vieja, Room 6	AA88362	Carbonized corn	521 ± 36	1419-1447 (68,2%)	1401-1458 (95,4%)
Cerro Colorado, Room 36	AA85880	Human bone	539 ± 43	1409-1443 (68,2%)	1327-1340 (1,9%) 1390-1460 (93,5%)
El Molino, Room 110	AA88363	Human bone	585 ± 44	1328-1336 (6,8%) 1391-1433 (61,4%)	1315-1357 (23,5%) 1381-1448 (71,9%)

Pueblo Viejo de El Eje, Room 53	AA94601	*Lama* sp. Bone	602 ± 42	1323-1345 (22,8%) 1388-1421 (45,4%)	1308-1361 (36,3%) 1378-1441 (59,1%)
Cerro Colorado, Room 48	AC-364	Charcoal	760 ± 90	1223-1320 (50,5%) 1350-1386 (17,7%)	1151-1416 (95,4%)

In relation to the types of samples used for new dating, charcoal, carbonized corn, camelid remains, and human bones were selected. Both maize and faunal remains were associated to the occupation floor of the excavated structures, and charcoal is usually associated with fireplaces, branches or more or less concentrated remains, also found on floor rooms (Valencia et al. 2010; Valencia et al. 2013). In all these cases we assume that dated samples are reliable in relation to the proximity of death of the dated organism and the event of occupation. On the other hand, three of the new dates correspond to human burials found within rooms (LP-1644: 320 ± 50 AP; AA85880: 539 ± 43 AP and AA-88363: 585 ± 44 AP) and would be product of events that occurred after the effective occupation of the structure (García Mancuso and Iucci 2008; Wynveldt 2009; Balesta and García Mancuso 2010).

Other three dates having unexpected modern ages were excluded from the table; two of them correspond to rooms 11 (LP-976) and 29 (LP-1123) from Loma de los Antiguos de Asampay, and the other (LP-1822) to room 48 from Cerro Colorado de La Ciénaga de Abajo. In the first two cases the samples corresponded to disperse and undetermined charcoal, while the latter was based on a sample of charcoal stored for more than ten years in uncontrolled conditions.

Analyzing the whole set of ages obtained since 1996 it can be noted that, with the exception of LP-2651 and AA105209, the rest are grouped according to the laboratory where they were made. The oldest correspond to the Arizona (AA) set, and the latest to the set of La Plata (LP). An important point related with these differences has to do with dating techniques; Arizona ages were made by AMS, with age uncertainties of ± 25 y 44 years, while the ages of La Plata were made by radiometric dating, with age uncertainties of ± 50, 60 y 70 years. These margins significantly extend the calibrated ranges for La Plata dates. Further, calibrated ranges for ages closest to 400 BP are more affected by the irregularities of the calibration curve, that in that section present abrupt falls and spikes, that added to large errors produce a major scattering in the probabilities.

Otherwise, dates obtained with AMS were corrected based on the measuring of the $\delta^{13}C$ value of each sample, while the ages obtained by the radiometric method employed standard values (Table 3). The $\delta^{13}C$ values for the plants remains don't vary significantly; however, the calculated value for skeletal remains in AA-94601, AA-88363 and AA85880, differs significantly from the estimated value of -20 ± 2 ‰ used for corrections of LP-2667 and LP-1644. These discrepancies were analyzed by Greco (2012) for 124 radiocarbon ages from Northwestern Argentina, proving that the average calculated for $\delta^{13}C$ in faunal and human bones greatly deviate from the standard,

with values of -12.49 ‰ and -15.6 ‰ respectively, which would generate more ancient ages. While here we work with the corrected ages reported by laboratories, considering that a comprehensive rethinking of this problem imply deeper particular studies, these observations serve us as a warning to our dating interpretation.

Table 3. δ13C values for dating obtained since 1986. In italics, standard values; in bold, measured values.

Site and structure of origin	Code	Informed ^{14}C corrected age	Sample	Informed δ13C
Loma de los Antiguos, Recinto 10	LP-872	220 ± 70	Charcoal	*- 25 ± 2 ‰*
Cerro Colorado, Room 35	LP-2760	290 ± 60	Carbonized corn	*- 10 ± 2 ‰*
Campo de Carrizal, Room 1	LP-1250	310 ± 60	Charcoal	*- 24 ± 2 ‰*
Loma de los Antiguos, Room 31	LP-1644	320 ± 50	Human bone	*- 20 ± 2 ‰*
Lajas Rojas 2	LP-1793	320 ± 60	Charcoal	*- 24 ± 2 ‰*
Loma de los Antiguos, Room 9	LP-937	330 ± 50	Charcoal	*- 24 ± 2 ‰*
Loma de los Antiguos, Room 3	LP-1039	350 ± 50	Charcoal	*- 24 ± 2 ‰*
Loma de Ichanga, Room 9	LP-2667	360 ± 50	*Camelidae* bone	*- 20 ± 2‰*
Loma de Ichanga, Room 6	LP-1832	420 ± 50	Carbonized corn	*- 10 ± 2 ‰*
Cerrito Colorado, Room 8	LP- 2309	420 ± 70	Charcoal	*- 24 ± 2 ‰*
Cerrito Colorado, Room 3	LP-1810	420 ± 70	Charcoal	*- 24 ± 2 ‰*
Campo de Carrizal, NH2, Room 1, B2	LP-2330	430 ± 60	Charcoal	*- 24 ± 2 ‰*
Cerro Colorado, Room 2	AA105209	446 ± 25	Charcoal	**- 23.6 ‰**
Lajas Rojas 4	LP-2651	460 ± 50	Carbonized corn	*- 10 ± 2 ‰*
Cerro Colorado, Room 35	AA100176	478 ± 38	Carbonized corn	**- 9.9 ‰**
Cerro Colorado, Room 2	AA94600	493 ± 34	Carbonized corn	**- 10.3 ‰**
La Estancia, Room 13	AA105210	512 ± 35	Carbonized corn	**- 10.1 ‰**
Loma de la Escuela Vieja, Room 6	AA88362	521 ± 36	Carbonized corn	**- 8.4 ‰**
Loma de Palo Blanco, Room 34	AA105211	523 ± 26	Jarilla charcoal	**- 23.4 ‰**
Cerro Colorado, Room 36	AA85880	539 ± 43	Human bone	**- 10.1 ‰**
El Molino, Room 110	AA88363	585 ± 44	Human bone	**- 9.5 ‰**
Pueblo Viejo de El Eje, Room 53	AA94601	602 ± 42	Lama sp. bone	**- 12.7 ‰**
Cerro Colorado, Room 48	AC-364	760 ± 90	Charcoal	**- 18.5 ‰**

INTERPRETATION OF NEW DATING

The sum of the probabilities of the datings allow us to note that calibrated ranges are located most probably between XVth and XVIth centuries AD (Figure 2), that is, times when there were important socio-political changes in Northwestern Argentina, as were Inka and Spanish conquests. Today there is agreement on the fact that Late or Regional Developments Period extends from 1000 AD until the arrival of the Inkas (Nunez Regueiro 1974). Regarding the latter event, although classic versions have argued that the conquest of this region and Chile were undertaken by Topa Inka Yupanqui to 1470-1480 AD, a lot of new archaeological information in general –and chronologically in particular– indicates that it would have been performed decades earlier

(Williams and D'Altroy 1998; Schiappacasse 1999; Ogburn 2012). Greco (2012) analyzed a set of 33 dating associated to Inka contexts from Northwestern Argentina, using Bayesian models to define the temporal limits of the conquest. The results indicate a likely start towards late XIVth and early XVth centuries. Considering this, we establish the Inka conquest boundary in the interval between 1400 to 1450 AD, therefore, the dates that present probabilities within that time are considered Preinka-Inka. Inka period ends at the entrance of Diego de Almagro in 1536, when Hispanic-Indigenous period begins, characterized by Spaniards attempts to subdue the natives, who resisted until the mid-seventeenth century (1640-1670), when the region is definitely incorporated to the Spanish crown, and Colonial Period starts.

Regarding dated contexts, excavations have very little accumulation of materials, usually covered by collapsed roofs over a single occupation floor (Valencia et al. 2013). It is very likely that frequent cleaning of these floors have removed the remains of previous events, thus the dated events were closely to definitive abandonment of the structures. Similarly, dated human burials correspond surely to events produced after the abandonment of the rooms. This would explain the absence of dates that represent times closer to the beginning of Late Period (1000-1300 AD). In this sense, we assume that every village should have a deeper history in time.

Given these conditions we must define the criteria for the interpretation of calibrated ranges. In recent years, the Bayesian statistics applied to chronology has produced significant results as a tool for interpreting sets of radiocarbon dates (Bayliss 2015). In our case, its application is limited to modeling probabilities of the total set of dating, because of the lack of archaeological markers that may be used for determining phases or chronological limits.

Added to the inability to measure precisely in calendrical terms the time of the Inka conquest, is the lack of Inka elements associated with dated events (or features that indicate an Inka influence) that allow us to estimate a before and after. The same applies to Spanish conquest: although we accept the year 1536 AD as the beginning of Hispano-Indigenous period, we have not Hispanic elements that allow us to use this limit as a temporary marker in the Hualfín Valley.

Figure 3 shows the distributions of dates obtained since 1996, plotted with OxCal v4.2.4 (Bronk Ramsey and Lee 2013). In addition, a model with the Span tool was obtained using the same software, considering a hypothetical single phase (Figure 4). From the results, different proposals were generated for grouping the dated sites, considering the periods in which there would be located each of the dated events (Table 4).

Table 4. Interpretations for calibrated ages for 1σ and 2σ, and considering modeled dates as a single phase with OxCal v4.2.4. indicating the set, the greatest probability within the range and covered periods. References: P (Preinka), I (Inka), H (Hispano-indigenous); * radiocarbon age and its corresponding probability.

Site	Arquitectural pattern	Interpretation for 1σ			Interpretation for 2σ			Modeled data (95.4%)		Radiocarbon dates Code and Age BP
		Set	Prob (%)	Period	Set	Prob. (%)	Period	Set	Period	
Pueblo Viejo de El Eje	Aggregated-defensive	1	45,4	P-I	1	59,1	P-I	1	P-I	AA94601 (602 ± 42)
El Molino	Aggregated-defensive	1	61,4	P-I	1	71,9	P-I	1	P-I	AA88363 (585 ± 44)
Loma de la Escuela Vieja	Isolated pattern-protected	1	68,2	P-I	1	95,4	P-I	1	P-I	AA88362 (521 ± 36)
Palo Blanco	Isolated pattern-defensive	1	68,2	P-I	1	95,4	P-I	1	P-I	AA105211 (523 ± 26)
La Estancia	Isolated pattern	1	68,2	P-I	1	95,4	P-I	1	P-I	AA105210 (512 ± 35)
Cerro Colorado	Aggregated-defensive	1	68,2	P-I	1	93,5	P-I	1	P-I	AA85880 (539 ± 43)
	Aggregated-defensive	1	68,2	P-I	1	95,4	P-I	1	P-I	AA94600 (493 ± 34)
	Aggregated-defensive	1 2?	60 68,2	P-I	1	89,7 84,9	P-I	1	P-I	AA100176 (478 ± 38) AA105209 (446 ± 25)
Lajas Rojas 4	Isolated room	2	60	P-I	1	70,6	P-I	1	P-I	LP2651 (460 ± 50)
Loma de Ichanga	Isolated pattern-protected	2	42,6*	Inka	2	95,4	P-I-H	2	Inka	LP1832 (420 ± 50)* LP2667 (360 ± 50)
Cerrito Colorado	Isolated pattern-defensive	2	35,4	Inka	2	95,4	P-I-H	2	Inka	LP2309 (420 ± 70) LP1810 (420 ± 70)
Campo de Carrizal	Isolated pattern-farming site	2	43,3	Inka	2	95,4	P-I-H	2	Inka	LP2330 (430 ± 60)
Loma de los Antiguos	Aggregated-defensive	3	54,2	I-H	2	95,4	I-H	3	I-H	LP1039 (350 ± 50)
	Aggregated-defensive	3	48,8	I-H	2	94,1	I-H	3	I-H	LP937 (330 ± 50)
	Aggregated-defensive	3	45,7	I-H	2	90,8	I-H	3	I-H	LP1644 (320 ± 50)
Lajas Rojas 2	Isolated room	3	42,6	I-H	2	85,6	I-H	3	I-H	LP1793 (320 ± 60)
Campo de Carrizal	Isolated pattern-farming site	3	40,9	I-H	2	81,4	I-H	3	I-H	LP1250 (310 ± 60)
Loma de los Antiguos	Aggregated-defensive	4	34,1	Colonial	3	92,5	H-Colonial	3	I-H	LP872 (220 ± 70)

The analysis of the probabilities for 1σ, first allows to recognize a group of eight dates (Set 1) very probably dating from the late fourteenth century and the first half of the XVth century. The following six dates (Set 2) show a high probability of representing events in the second half of the XVth century and the first decades of the XVIth century, although there are also less probabilities to later periods. The date for Room 2 of Cerro Colorado located in this group (AA105209) should be revised particularly because it was obtained from a carbonized corn sample from the same context as AA94600, whose range for 1σ locates it in the first group. These two dates are statistically indistinguishable for 95%, and the average age for both is 462 ± 20 AP, with calibrated ranges between 1443-1463 AD for 1σ and 1437 to 1492 AD for 2σ with SHCal13 curve. A third group (Set 3) corresponds to dates with calibrated ranges covering mainly XVIth century, with some chances to XVIIth century. Also LP-2667 (Loma de Ichanga, Room 9) and LP-2760 (Cerro Colorado, Room 35) would be placed in this set, although these cases have characteristics that must be specially analyzed. LP-2667 was obtained from a camelid bone in Room 9 of Loma de Ichanga, placed a few meters from Room 6, where LP-1832 was obtained, which has more probabilities in the second half of XVth century. Both dates are statistically indistinguishable for 95%. Considering the observations mentioned above in relation to the measured and standardized values of d13C, we think that both dated events would be closer to the second half of XVth century. The case of date LP-2760 from Room 35 of Cerro Colorado is more complex to interpret because it was obtained in the same context of corncobs that AA100176, and both are statistically different. Since the rest of the dates obtained for the site are consistent with AA100176, we decided to refuse LP-2760 until no new dates on different materials from the same room are obtained. Finally, the date from Room 10 of Loma de los Antiguos de Asampay (LP-872) (Set 4) has a greater chance to be located in XVIIIth century, although it also shows a significant percentage to be assigned to XVIIth century.

Considering ranges for 2σ of probability (95%) the dates assembly was classified into three groups: Set 1 includes the ten oldest dates, which would comprise, most likely, the last decades of XIVth century and throughout the XVth century. Set 2 would be conformed by eight dates, also covering part of XVth century, although they have a high probability for XVIth and XVIIth centuries. And Set 3 –including only LP-872 date– according to the calibrated range has high probability to represent an event between XVIIth and XXth centuries.

The analysis of the model obtained with OxCal 4.2.4, using the Span tool, was based on a single stage to consider the whole of the radiocarbon dates (Figure 4), and is acceptable (> 60%) for both concordance indexes ($A_{overall}$ 85.1 y A_{model} 86.6). Distributions not significantly modify the lower limits of the ranges, adjusting dates to early XVth century. However, the upper limits are

reduced significantly, reaching most likely by mid-XVIth century, that is, early Hispano-Indigenous period.

Summarizing, three cases belonging to Set 1 represent events corresponding to the last pre-Inka occupations and the first moments of Inka conquest. These dates are of great interest considering that, although they are very recent in relation to the beginning of Late Period as it was traditionally defined (from 1000/1100 AD), they are the oldest obtained for the analyzed sites. Set 2 for 1σ of probability and for the modeled data, clearly corresponds to Inka period.

Inka presence in the valley is clear if we take into account installations –as Hualfín Inka, Quillay, El Shincal (Lynch 2012; Raffino 2004; Spina and Giovannetti 2014), as well as surface remains or tombs in which local materials are mixed with Inka provincial or objects showing Inka features (Wynveldt 2009b; Moralejo et al 2010). However, until now, very little material evidence of Cusco influence has been found in analyzed sites.

Set 3 for 1σ and for the modeled data corresponds to occupations that cover since the last years of Inka Empire to early years of Spanish presence in Northwestern Argentina, or Hispano-Indigenous period. With respect to these dates, no European elements or objects or representations depicting Hispanic influence on local groups have been observed. Set 4 for 1σ, comprised by LP-872, is linked to a hypothetical series of events in Colonial and Modern times, and perhaps linked to sporadic incidents of use of in abandoned spaces. The modeled distribution however, includes this age in Hispanic-Indigenous Period, and even in Inka times.

CONCLUSIONS

The pioneer work made by A. Rex González in Hualfín Valley constitutes a fundamental contribution to the knowledge for of chronology of Antique social groups of Northwestern Argentina. His relative sequence of three "Belén" phases, based on a supposed process of increasing complexity of this "culture" was the first attempt to explain the development of the late groups in Hualfín Valley. While Gonzalez could not corroborate this sequence with radiocarbon dates, he assumed that this problem would be solved with the progress in implementing radiocarbon method. However, neither the process was reflected in the dating, nor was confirmed with the new research done in many of the same sites in Hualfín Valley. In this sense, we saw the coexistence between late sites with very different patterns –and maybe, functions–: isolated rooms, villages with a scattered or conglomerate pattern, settled on protected hills or defended by walls, and scattered rooms between farming terraces. Moreover, the only residential sites where objects linked to the Inka conquest were found –it is worth clarifying that only on surface collections– are those with older dates (El Molino and Loma de la Escuela Vieja, in Puerta de Corral Quemado), while sites with

more recent occupations only have materials traditionally associated with local Late Period, even in the sites with dates most likely for Hispanic times.

With respect to pre-Inka times, we emphasized the absence of dating representing initial moments of "Belén culture" –Gonzalez´s phase I. In another paper (Wynveldt and Flores 2014) we compared late radiocarbon dating of the valley with dates from southern *puna* of Catamarca, a neighboring region with different resources and with strong cultural ties to Hualfín Valley, evidenced by the presence of Belén pottery. While different authors have postulated the *puna* socio-political dependence on a political "Belén" core in the valley (Raffino and Cigliano 1973; Sempé 1999: Olivera et al. 2003-2005), dating of the region associated to Belén pottery is much older than dates analyzed here. The absence of early dating from the valley, together with the earliest evidence in the *puna* poses a quite interesting scenario about relationships between these regions and the origin of "Belén".

Beyond these problems, we hold that the oldest dates from the new series for Hualfín Valley, with probabilities for the first half of XVth century, represent the last moments of a local development for which we do not know its origins, and may correspond to events closer to the abandonment of structures, sections of the sites, or perhaps whole villages, for reasons related to Inka conquest. Moreover, the dates nearest to the second half of XVth century could be linked to contexts of abandonment that represent movements of local groups during Inka domination in the region. Subsequently, for dates most likely in XVIth century onwards, may be suggested the idea that some of these occupations are associated with years after Inka presence, at times when local groups resisted Spanish conquest.

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REFERENCES

Alberó MC, Angialoni FE. 1985. INGEIS Radiocarbon Laboratory Dates II. *Radiocarbon* 27(2B): 314-37.

Balesta B, Zagorodny N, Wynveldt F. 2011. La configuración del paisaje Belén (valle de Hualfín, Catamarca). *Relaciones de la Sociedad Argentina de Antropología* 36: 149-75.

Balesta B, García Mancuso R. 2010. Entierros infantiles en una habitación del Cerro Colorado de La Ciénaga de Abajo. In: Balesta B, Zagorodny N, editors. *Aldeas protegidas, conflicto y*

abandono. Investigaciones arqueológicas en La Ciénaga (Catamarca, Argentina). La Plata: Al Margen. p. 241–272.

Bayliss A. 2015. Quality in Bayesian chronological models in archaeology. *World Archaeology* 47(4): 677-700.

Bennett WC, Bleir EF, Sommer FH. 1948. *Northwest Argentine Archaeology*. Yale University Publications in Anthropology 38. New Haven: Yale University Press. 42 p.

Bronk Ramsey C, Lee S. 2013. Recent and planned developments of the program OxCal. *Radiocarbon* 55 (2–3): 720–730.

Carbonari J, Baldini MI, Huarte R, Sempé MC. 2011. Seis décadas de dataciones radiocarbónicas de las culturas agroalfareras en el valle de Hualfín, Catamarca, Argentina. In: Silvera de Buenader E, Martínez de Montiel SE, editors. *El hombre, el medio y sus relaciones*, Compilation 1, Vol. 1, N°1. San Fernando del Valle de Catamarca: Universidad Nacional de Catamarca. p. 79-102.

García Mancuso R, Iucci ME. 2008. Entierro infantil en un contexto doméstico (El Molino, Puerta de Corrral Quemado, Catamarca). *Resúmenes del X Congreso de la Asociación Latinoamericana de Antropología Biológica.* Published in CD. La Plata: Asociación Latinoamericana de Antropología Biológica.

González AR. 1955. Contextos culturales y cronología relativa en el área central del N. O. argentino (nota preliminar). *Anales de Arqueología y Etnología* 11: 7-32.

González AR. 1959. Nuevas fechas de la cronología arqueológica argentina obtenidas por el método de radiocarbón (II). *Ciencia e Investigación* 5(6):184-90. Buenos Aires.

González AR. 1960a Nuevas fechas de la cronología arqueológica argentina, obtenidas por el método del radiocarbono (III). *Ciencia e Investigación* 16(4):142-45. Buenos Aires.

González AR. 1960b. Nuevas fechas de la cronología arqueológica argentina, obtenidas por el método del radiocarbono (IV). Resumen y perspectivas. *Revista del Instituto de Antropología* 1: 303-31.

González AR. 1964. Nuevas fechas de la cronología arqueológica argentina, obtenidas por el método del radiocarbono (V). Revista del Instituto de Antropología 2-3: 289-97.

González AR, Cowgill GL. 1975. Cronología arqueológica del Valle de Hualfín, Pcia. de Catamarca, Argentina. Obtenida mediante el uso de computadoras. Actas del Primer Congreso de Arqueología Argentina. Rosario.

Hakansson S. 1971. University of Lund Radiocarbon Dates IV. *Radiocarbon* 13(2): 340-57.

Greco C. 2012. Integración de datos arqueológicos y geofísicos para la construcción de una cronología absoluta de Yocavil y alrededores [PhD thesis]. Buenos Aires: Facultad de Filosofía y Letras, Universidad de Buenos Aires. 497 p.

Hogg A, Hua Q, Blackwell P, Niu M, Buck C, Guilderson T, Heaton T, Palmer J, Reimer P, Reimer R, Turney C, Zimmerman S. 2013. SHCal13 Southern Hemisphere Calibration, 0–50,000 years cal BP. *Radiocarbon* 55(4): 1889–1903.

Lynch J. 2012. Una aproximación cronológica al centro administrativo Hualfín Inka, Catamarca, Argentina. *Revista Española de Antropología Americana* 42(2): 321-337.

Moralejo RA, Lynch J, Couso MG, Raffino RA. 2010. El ajuar como indicador de la presencia Inka en el Cementerio Aguada Orilla Norte (Provincia de Catamarca). *Intersecciones en Antropología* 11: 309-313.

Núñez Regueiro VA. 1974. Conceptos instrumentales y marco teórico en relación al análisis del desarrollo cultural del Noroeste Argentino. *Revista del Instituto de Antropología* 5: 169-190.

Ogburn DE. 2012. Reconceiving the chronology of Inca imperial expansion. *Radiocarbon* 54(2): 219-37.

Olivera D, Vigliani S, Elías A, Grana L., Tchilinguirian P. 2003-2005. La ocupación Tardío-Inka en la puna meridional: el sitio Campo Cortaderas. *Cuadernos del INAPL* 20: 257-277.

Olson EA, Broecker WS. 1961. Lamont Natural Radiocarbon Measurements VII. *Radiocarbon* 3: 141-75.

Olsson I. 1960. Uppsala Natural Radiocarbon Measurements II. *American Journal of Science Radiocarbon Supplement* 2: 112-28.

Otlet, RL, Walker AJ, Hewson AD, Burleigh R. 1980. C14 interlaboratory comparison in the UK. experiment design, preparation and preliminary results. *Radiocarbon* 22 (3): 936-46.

Raffino RA. 2004. *El Shincal de Quimivil*. San Fernando del Valle de Catamarca: Sarquis. 272 p.

Raffino RA, Cigliano M. 1973. La Alumbrera: Antofagasta de la Sierra. Un modelo de ecología cultural prehispánica. *Relaciones de la Sociedad Argentina de Antropología* 7: 241-258.

Schiappacasse V. 1999. Cronología del Estado Inca. *Estudios Atacameños* 18:133-40.

Scott EM, Aitchison T, Harkness D, Cook G, Baxter M. 1990. An overview of all three stages of the International Radiocarbon Intercomparison. *Radiocarbon* 32 (3): 309-19.

Sempé MC.1999. La cultura Belén. *Actas del XII Congreso Nacional de Arqueología Argentina*, tomo II: La Plata. p. 250-58.

Spina J, Giovannetti MA. 2014. Metalurgia prehispánica en el valle de Hualfín. Nuevos datos sobre Quillay. *Intersecciones en Antropología* 15: 473-477.

Stuiver M, Deevey ES, Gralenski LJ. 1960. Yale Natural Radiocarbon Measurements V. *American Journal of Science Radiocarbon Supplement* 2, 49-61.

Valastro S, Davis EM, Varela AG. 1972. University of Texas at Austin, Radiocarbon Dates IX. Radiocarbon Laboratory, Balcones Research Center, The University of Texas at Austin. *Radiocarbon* 14(2): 461-85.

Williams V, D'altroy T. 1998. Al sur del Tawantinsuyu: Un dominio selectivamente intensivo. *Tawantinsuyu* 5: 170-78.

Valencia MC, Fernández M, Barberis C. 2010. Evidencias de incendios en el registro arqueológico de la localidad de La Ciénaga. In: Balesta B., Zagorodny N, editors. *Aldeas protegidas, conflicto y abandono. Investigaciones arqueológicas en La Ciénaga (Catamarca, Argentina)*. La Plata: Al Margen. p. 161–199.

Valencia, María Celeste, and Bárbara Balesta

2013 ¿Abandono planificado? Restos forestales carbonizados en sitios arqueológicos de La Ciénaga (Catamarca, Argentina). *Bulletin de l'Institut Français d'Études Andines* 42(2): 145–172.

Wynveldt F. 2009. *La Loma de los Antiguos de Azampay. Un sitio defensivo del Valle de Hualfín (Catamarca, Argentina)*. Sociedad Argentina de Antropología, Buenos Aires. 366 p.

Wynveldt F, Flores M. 2014. La obsidiana en el paisaje Tardío del Valle de Hualfín (Depto. de Belén, Prov. de Catamarca). *Arqueología* 20 Dossier: 193-216.

Wynveldt F, Iucci ME. 2013. La cronología Belén en el norte del Valle de Hualfín: viejos problemas, nuevas perspectivas. *Arqueología* 19(1): 187-95.

FIGURE CAPTIONS

Figure 1. Map of Hualfín Valley, showing late archaeological sites with radiocarbon dating (empty circles) and Inka installations (filled circles).

Figure 2. Summed probabilities for ^{14}C dates since 1996 until present for late sites in Hualfín Valley. In different colors the proposed periods from late to modern times. References: P-I (Preinka-Inka); Hip-Ind. (Hispanic indigenous); H-C (Hispanic indigenous-Colonial); Col. (Colonial).

Figure 3. Calibrated ^{14}C graphics elaborated with OxCal v4.2.4 (Bronk Ramsey and Lee 2013), including ^{14}C dates for late sites in Hualfín Valley, obtained since 1996 until present.

Figure 4. ^{14}C dates for Hualfín Valley late sites from 1996 until present, modeled using the tool Span with OxCal v.4.2.4, considering a single phase.

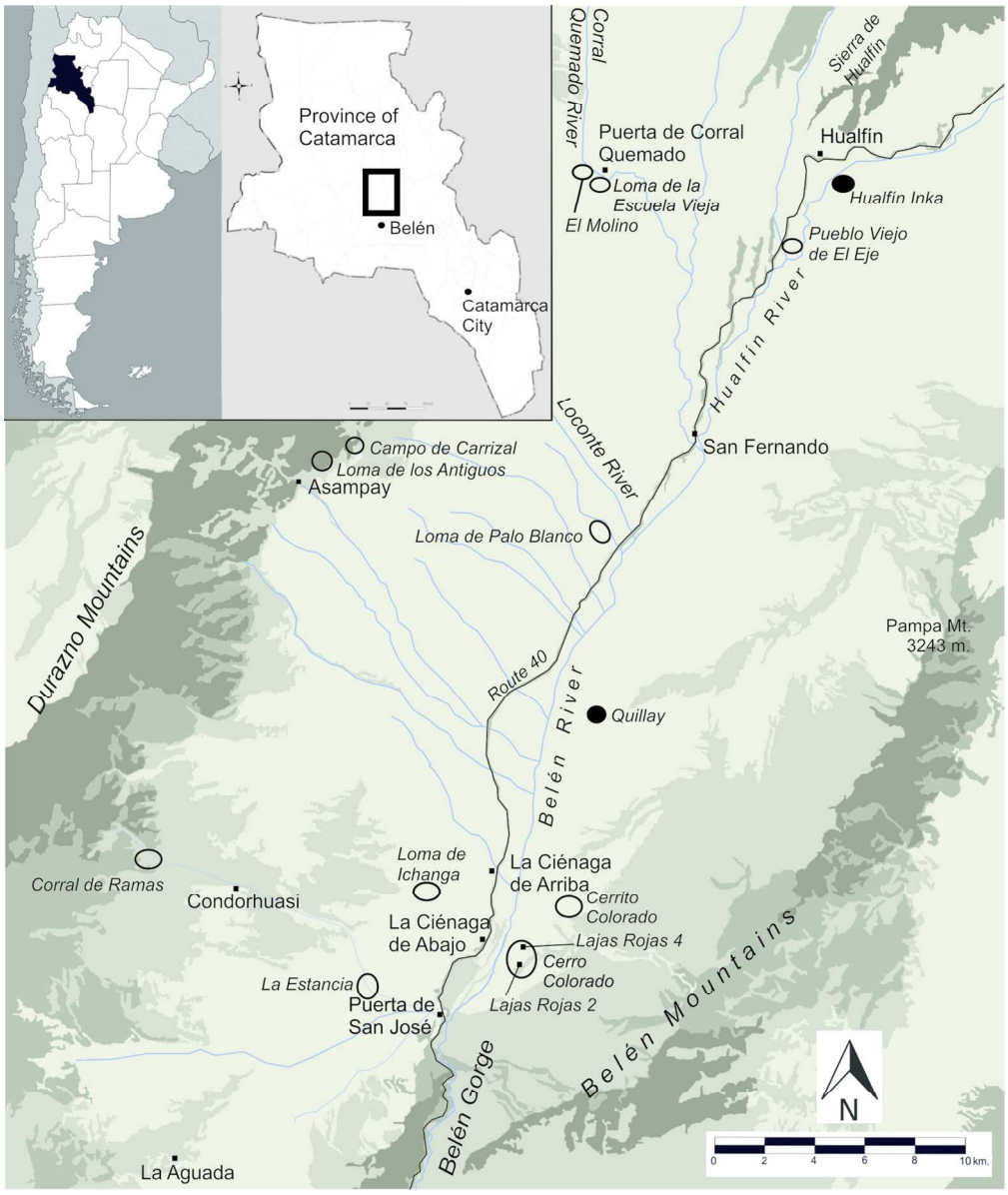

Figure 1. Map of Hualfín Valley, showing late archaeological sites with radiocarbon dating (empty circles) and Inka installations (filled circles).
139x165mm (300 x 300 DPI)

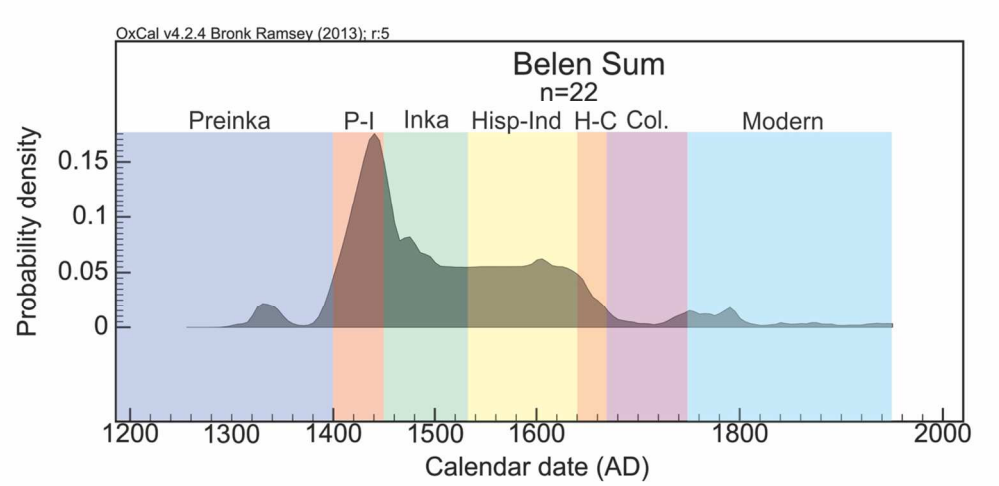

Figure 2. Summed probabilities for 14C dates since 1996 until present for late sites in Hualfín Valley. In different colors the proposed periods from late to modern times. References: P-I (Preinka-Inka); Hip-Ind. (Hispanic indigenous); H-C (Hispanic indigenous-Colonial); Col. (Colonial).
129x66mm (300 x 300 DPI)

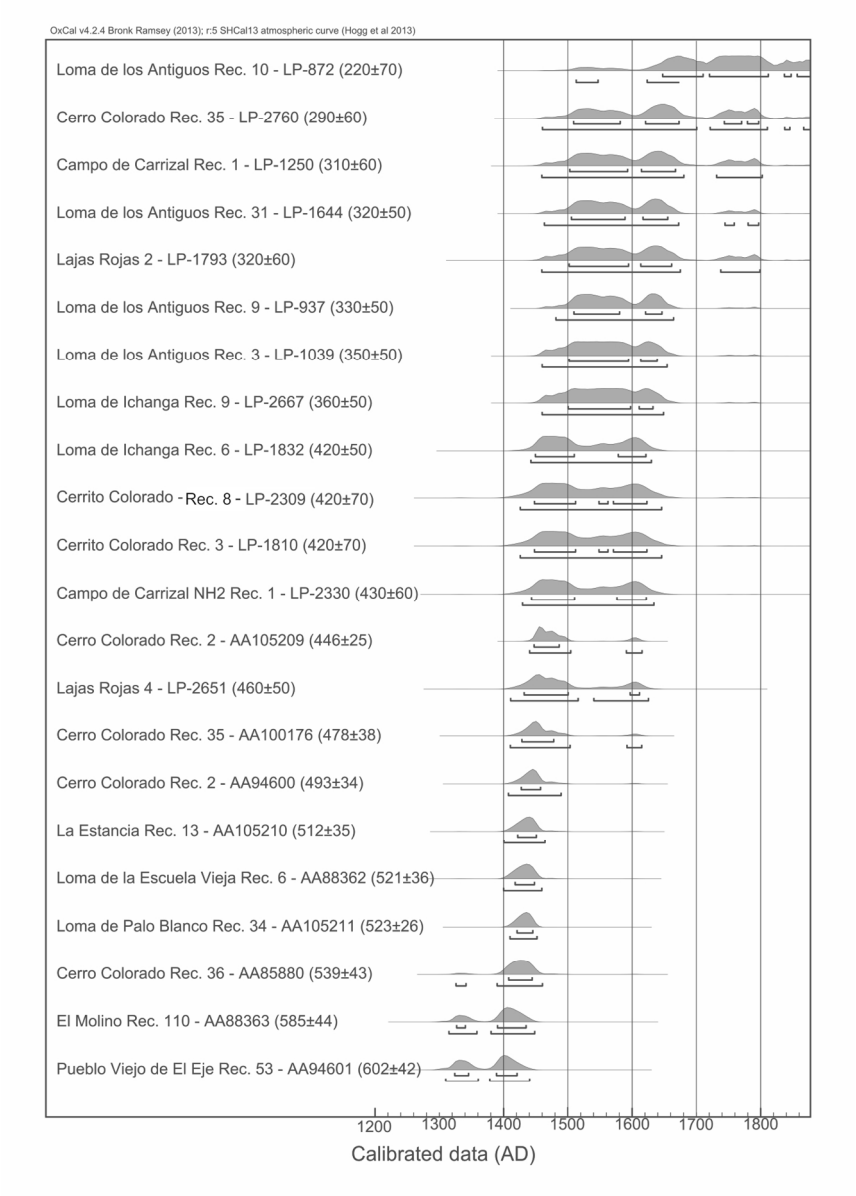

Figure 3. Calibrated 14C graphics elaborated with OxCal v4.2.4 (Bronk Ramsey and Lee 2013), including 14C dates for late sites in Hualfín Valley, obtained since 1996 until present.
119x168mm (300 x 300 DPI)

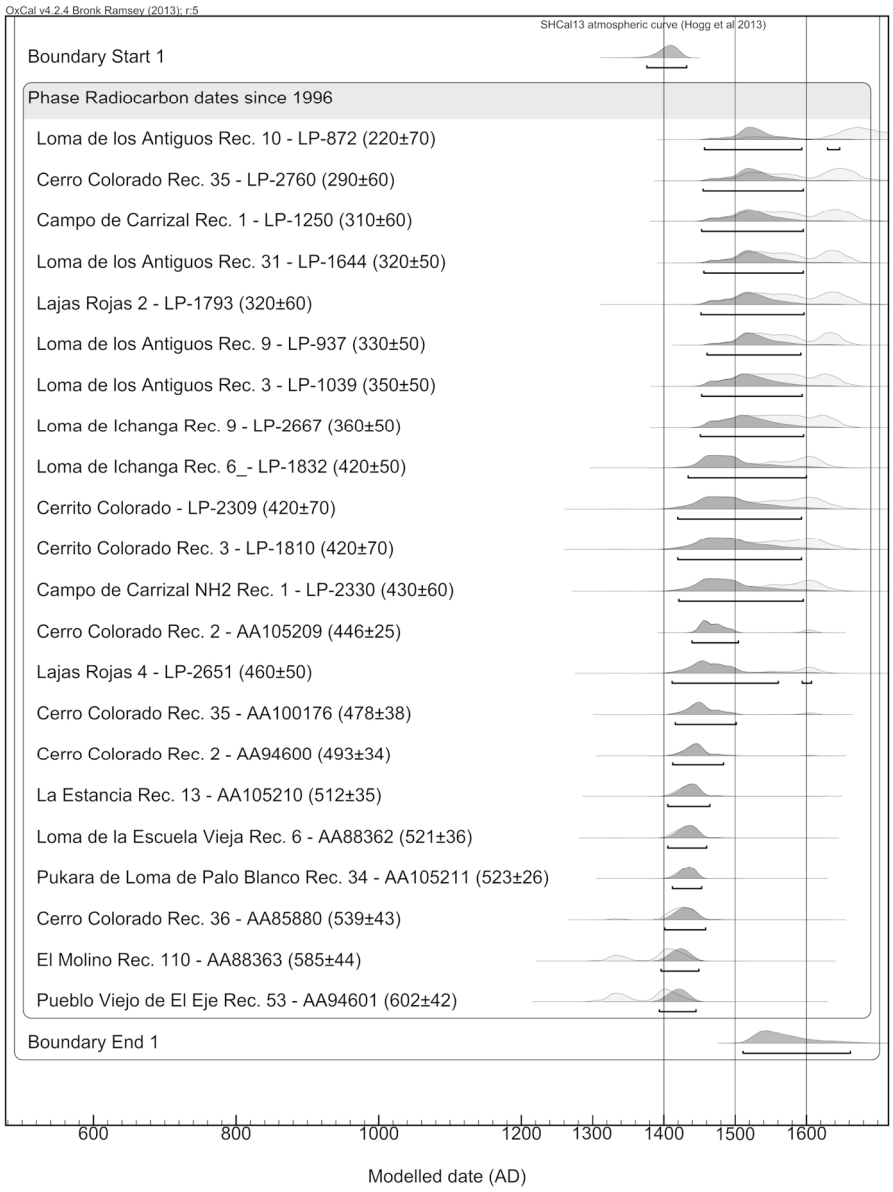

Figure 4. 14C dates for Hualfín Valley late sites from 1996 until present, modeled using the tool Span with OxCal v.4.2.4, considering a single phase.
139x182mm (300 x 300 DPI)