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NEW RADIOCARBON EVIDENCE FOR HUMAN OCCUPATION IN CENTRAL ARGENTINA DURING THE MIDDLE AND LATE HOLOCENE: THE ONGAMIRA VALLEY CASE

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ABSTRACT. The Ongamira Valley (Córdoba, Argentina) shows a persistent occupational history of its territory. Even one of the first Argentinian radiocarbon (^{14}C) dates was calculated in this valley; for 70 years, the chronology was based on relative dates (stratigraphy and its cultural content). For this reason, since 2010 a ^{14}C dating program has been developed focusing on the chronology of eight of the 60 sites identified so far for the valley. This work reports the outcomes of this program with 27 new dates. These data have been related to characteristics of the material culture, use of space and mobility of hunter-gatherer societies. The results have allowed us to bring new insights into a continuous occupation of the valley since the Middle Holocene according to the human peopling models proposed. It has also been possible to provide greater chronological precision to various activities related to feeding practices, use of space associated with rock-shelters, palaeoenvironmental changes and incorporation of new technologies into daily practices.

KEYWORDS: central Argentina, chronology, Harris Matrix, hunter-gatherers, Ongamira.

INTRODUCTION

Since the 1940s, the Ongamira Valley has been one of the key regions for the development of explanatory models linked to the process of human occupation in South America (e.g., Schobinger 1958–1959; Willey and Phillips 1958; González 1960). Most were based on relative chronological models or a unique radiocarbon (^{14}C) date (Vogel and Lerman 1969). For almost 60 years, those models were used, as no new archaeological work was done at the site, a situation that prevailed until recently (Izeta et al. 2016).

Therefore, for in the last 10 years an archaeological research program has been implemented. A unique effort for the region, centred on surveys, controlled archaeological excavations, and determination of absolute ages by ^{14}C dating has led to understanding the process of territory occupation throughout the Holocene.

Mobility is one characteristic of hunter-gatherer people (and other types of human social organization) that enabled the occupation of new territories and thus the colonization of new spaces (e.g., Kelly 1992). Knowing to which territories they moved and at what time addresses a fundamental question that needs to be answered with new methodologies for central Argentina. To understand the societies that inhabited those places in the past requires determining the location of inhabited spaces and temporal framework. Different methodologies are key to interpreting these processes of occupation, and the use of space and resources. For this reason, the stratigraphic excavation described by systems such as

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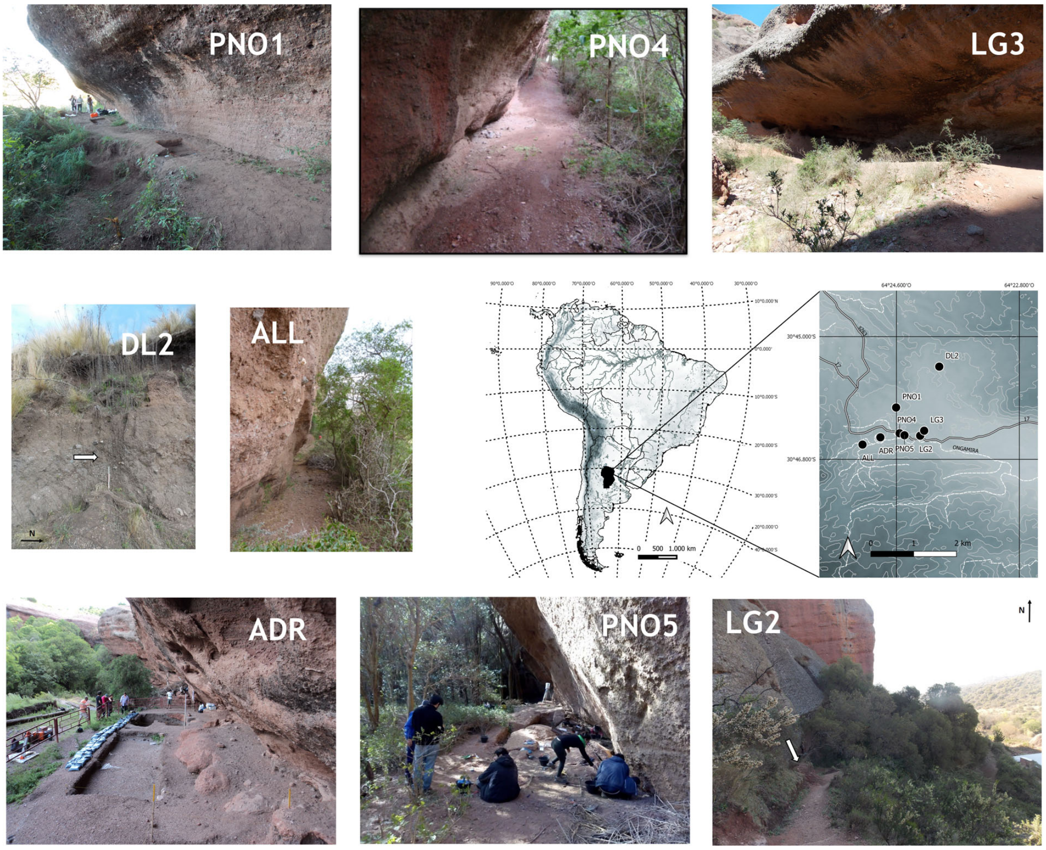

Figure 1 Location of archaeological sites in the Ongamira valley. ADR= DRR, Deodoro Roca rockshelter (Sector A and Sector B); PNO1= Ongamira Natural Park 1 -Parque Natural Ongamira 1; PNO4= Ongamira Natural Park 4 - Parque Natural Ongamira 4; PNO5= Ongamira Natural Park 5 - Parque Natural Ongamira 5; LG2= La Gruta 2; LG3= La Gruta 3; 2L2= Dos Lunas 2; ALL= La Leona rockshelter.

the Harris Matrix (Harris 1989) and ^{14}C dating and its calibration are tools that allow us to address this issue.

Hence, here we will add, from a multidisciplinary approach, recent information to contrast models of human occupation for the Southern Pampean Hills in central Argentina. Particularly, from the case study of the Ongamira Valley, where several authors have proposed population changes, discontinuities and complex cultural processes during the Holocene (e.g., Laguens and Bonnin 2009; Nores et al. 2011; Rivero 2012; Cattáneo and Izeta 2016).

The Ongamira valley is located in Córdoba Province, a vast territory of 165,321 km^2 with registered human occupations since ca. 10,000 BP (Figure 1). For that period and space, excluding the Ongamira ^{14}C dates, we have registered only 132 ^{14}C dates related to archaeological contexts (Aguilar 2019; Cattáneo et al. 2019; Izeta and Aguilar 2020). Fifty correspond to unique dating of sites or human remains recovered from rescue archaeology activities. Specifically, human remains are not linked to cultural contexts since, in many cases, only bones could be retrieved. This number of ^{14}C dates corresponds to 79 different

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places of origin, a very low quantity compared with the number of known archaeological sites for the province, which in 2015, reached 1936 (Cattáneo et al. 2015). This number shows that only 4.08% of the known archaeological sites have absolute dates. It is also clear that in this situation there are few persistent occupation sites with over one dating per component. Therefore, there is no statistical robustness when defining the different archaeological occupations at the different sites in the region.

Thus, it was necessary to develop a dating program that would allow exploring the sequence of human occupation from absolute chronologies. The Ongamira valley emerged as an option due to its major implications for the South American prehistory from the 1940s to the 1970s (González 2008; Laguens and Bonnin 2009; Cattáneo and Izeta 2016).

During the 1940s and 1950s, researchers reported at least five different sites at the valley (Menghin and González 1954). However, they mostly focused on the Deodoro Roca Rockshelter (González 1943; Montes 1943; Menghin and González 1954). In 2010, we resumed archaeological research in the valley, after 50 years of abandonment. Since then, at least 60 new sites with distinctive characteristics have been identified, from which eight have been dated so far (Figure 1).

This work reports new dates from archaeological sites with controlled excavations. Those are integrated with dates previously obtained and correlated with the changes and continuities interpreted in the material culture, in addition to the paleoenvironmental changes associated with humidity and temperature throughout the Holocene (Yanes et al. 2014; Izeta et al. 2017a).

THE ARCHAEOLOGICAL SITES OF THE ONGAMIRA VALLEY

Deodoro Roca Rockshelter (DRR)—Alero Deodoro Roca (ADR)

This rockshelter develops on the outcrop of the Saldán Formation (Zárate 2016). It is an amphitheater-shaped formation with faces to the south and east. It is about 100 m long. Montes (1943) divided the rockshelter into two sectors (A and B) from a small semi-permanent waterfall. This causes a small stream that drains into the Ongamira River network, located about 1200 m above sea level.

Deodoro Roca Rockshelter—Sector A

The sector lies in the west of the rockshelter. During the 1940s and 1950s, researchers excavated almost all of Sector A (Montes 1943; Menghin and González 1954). This implied the removal of sediments of up to 6 m deep. González collected charcoal from the sector where excavations showed the greatest depth. In the 1960s, he sent the sample at the Groningen Laboratory to ^{14}C date the site's human occupation (Vogel and Lerman 1969). The Heritage Reserve of the Anthropological Museum (Universidad Nacional de Córdoba, Argentina) hosts some objects from those excavations. Faunal (camelids, snails) and human remains (Izeta and Bonnin 2009; González et al. 2016) are the more frequent ones in the collections. We dated some human remains to determine some absolute chronology from this rockshelter in Sector A (Table 1, samples YU-7740, YU-7739, YU-7738).

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Table 1 Radiocarbon dating for archaeological sites in the Ongamira Valley. Calibrated ages rounded at 5 years (Error <25) and 10 years (Error ≥25). Provenance (DRR, PNO 1, PNO 4, and PNO 5 sites) can be seen in Figures 2 and 3.

Lab code	^{14}C ages (BP)	^{14}C ages error	Calibrated age unmodeled (68.3% confidence) cal BP	Calibrated age unmodeled (95.4% confidence) cal BP	$\delta^{13}C$ (‰)	$\delta^{13}C$ error (‰)	Type of sample	Site	Provenance	Sample code	Description
YU-2289	183	20	280–. . .	280–. . .	–25.5	0.3	Charcoal	DRR	SU15	ADR XVI-C SU15 549	Woody plant
YU-7740	673	20	650–555	655–555	–14.0	0.3	Human tooth	DRR	SECTOR A	#ADR 60-60	Premolar
YU-7749	942	20	900–765	905–735	–25.3	0.4	Charcoal	PNO5	SU3	PNO 5 - 4387	Woody plant/ *Zanthoxylum* sp (Coco)
YU-7739	995	20	915–805	925–795	–19.1	0.3	Human femur	DRR	SECTOR A	#ADR 60-98-1	Juvenile femur diaphisys
YU-7746	1905	20	1830–1745	1870–1730	–26.5	0.4	Charcoal	PNO1	SU35	PNO 1-4162-B 83-SU 35 C2 NO	Woody plant
MTC-15148	1915	45	1880–1740	1930–1700	–17.02	0.03	Camelid	DRR	SU32	ADR SU32 XVIII-BNº 614	South American camelid metapodial
YU-7747	2538	20	2720–2495	2730–2440	–23.0	0.3	Charcoal	PNO4	SU3	PNO 4- 4360-S2-0,70cm c/v	Woody plant
YU-7745	2592	20	2750–2540	2755–2495	–25.7	0.3	Charcoal	La Gruta 2	S1	La Gruta 2 4243	Woody plant/*Porliera* sp (Guayacan)
YU-2294	2628	21	2755–2720	2770–2535	–29.8	0.3	Charcoal	La Leona	S1	La Leona	Woody plant
YU-7744	2802	20	2920–2785	2950–2775	–27.3	0.3	Charcoal	PNO1	SU59	PNO1 4179-B50	Woody plant
YU-2293	2942	25	3140–2960	3170–2940	–26.8	0.5	Charcoal	DRR	SU50	ADR XIII-C SU50 386	Woody plant
YU-2291	2944	44	3150–2960	3210–2880	–26.1	0.4	Charcoal	DRR	SU7	ADR XVI-C SU7 539	Woody plant
YU-2290	2952	21	3145–2995	3165–2960	–25.7	0.3	Charcoal	DRR	SU34	ADR XVI-C SU34 320	Woody plant
YU-7750	2954	20	3145–2995	3165–2960	–25.5	0.3	Charcoal	DRR	SU149	ADR 2582, SU 149	Woody plant

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Table 1 (*Continued*)

Lab code	^{14}C ages (BP)	^{14}C ages error	Calibrated age unmodeled (68.3% confidence) cal BP	Calibrated age unmodeled (95.4% confidence) cal BP	$\delta^{13}C$ (‰)	$\delta^{13}C$ error (‰)	Type of sample	Site	Provenance	Sample code	Description
YU-7748	2971	21	3160–3005	3205–2965	−25.5	0.4	Charcoal	PNO5	SU9	PNO 5 - 4239	Woody plant/*Celtis* sp (Tala)
YU-7742	3029	20	3225–3075	3330–3065	−20.1	0.3	Camelid tooth	La Gruta 3	S1	La Gruta 3 4246	Premolar inserted in malar bone
MTC-15144	3043	41	3330–3070	3360–3000	−27.2	0.3	Charcoal	DRR	SU65	ADR SU 65 XIV-CNº 367	Woody plant
AA-93736	3390	37	3680–3490	3700–3460	−25.6	0.6	Charcoal	DRR	SU82T	ADR SU82Techo	Woody plant
YU-7738	3457	20	3815–3630	3825–3575	−17.5	0.3	Human tooth	DRR	SECTOR A	#ADR 60-98-12	Molar
AA-93737	3515	37	3830–3690	3870–3630	−17.8	0.6	Charcoal	DRR	SU82B	ADR SU82 Base	Woody plant
YU-2292	3620	27	3970–3830	4060–3720	−24.8	0.8	Charcoal	DRR	SU43	ADR XVI-C SU43 435	Woody plant
YU-2288	3969	23	4425–4295	4515–4245	−23.3	0.4	Charcoal	DRR	SU113	ADR XII-B SU113 297	Woody plant
AA-93738	3984	38	4520–4290	4530–4240	−24.2	0.6	Charcoal	DRR	SU80	ADR SU80	Woody plant
YU-7741	4216	21	4830–4645	4840–4580	−17.9	0.4	Human bone (Malar)	DRR	SU111	#ADR-B XB-SU 111	With theet (erupted & unerupted)
AA-93739	4562	39	5310–5050	5320–4980	−27.6	0.5	Charcoal	DRR	SU74	ADR SU74	Woody plant
YU-7743	4654	22	5445–5305	5465–5285	−18.5	0.4	Camelid	Dos Lunas 2	S1	Dos Lunas 2 -4365	First phalange, Juvenile complete diaphisys
YU-7751	5782	24	6625–6490	6650–6445	−26.3	0.4	Charcoal	PNO1	SU82	PNO-1 4467, SU82	Woody plant
GR-5414	6510	100	7570–7280	7680–7020	−17.1	—	Charcoal	DRR	SECTOR A	ADR Sector A	—

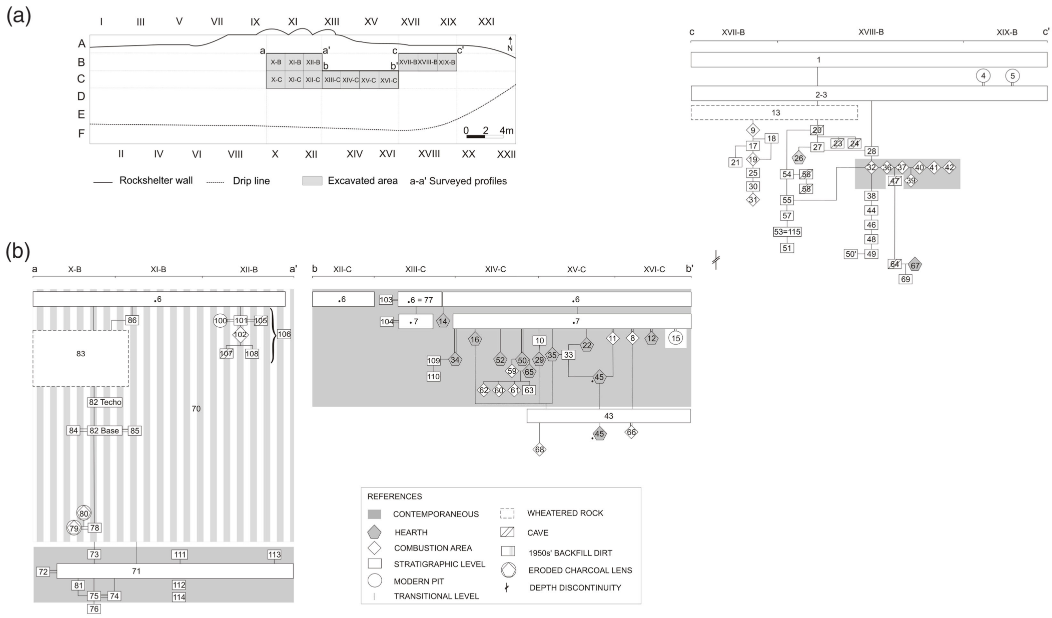

Figure 2 Harris Matrix. Deodoro Roca Rockshelter Sector B. (a) Plan of Sector B. The areas intervened since 2010 are highlighted in gray; (b) Scheme of the northern profile of Sector B (modified from Cattáneo and Izeta 2016).

Deodoro Roca Rockshelter—Sector B

Sector B is located in the northern area of the rockshelter. In the 1950s, Menghin and González (1954) excavated several areas with more controlled methodologies than those employed in Sector A. For that intervention, they used a grid comprising 220 squares (4 m^2 each) from where they excavated 31. Artificial levels, 0.20 m depth, allowed interpreting the stratigraphic sequence and its cultural content resulting in the outline of four cultural horizons (Menghin and González 1954; Cattáneo et al. 2013; Cattáneo and Izeta 2016; Laguens and Bonnin 2009). Since 2010, excavation has resumed using the Harris Matrix (Harris 1989) in sectors not affected by previous interventions. During fieldwork, the original grid system was identified. This allowed us to relate the material culture recovered in the 1950s to those from modern excavations. These excavations cover an area of ~24 m^2 and ~3.80 m deep in its deepest part. In this new area, 149 stratigraphic units were interpreted (Figure 2) (Cattáneo and Izeta 2016). Sector B comprises 14 ^{14}C dates, mainly associated with combustion units (structured and unstructured hearths) and, in one case, the burial of an infant (González et al. 2016).

To date, this is the most complete and extensively worked multi-component site in the valley, from which we interpreted the main occupation sequence.

Within a depth of less than a meter at the center of Sector B, we registered 19 combustion areas, more than 12,000 gastropod shells, 5000 charcoal fragments, 17,000 animal bone fragments and more than 10,000 lithic remains (Cattáneo and Izeta 2016). This enabled us to characterize the site as a persistent place used by hunter-gatherers throughout the Holocene.

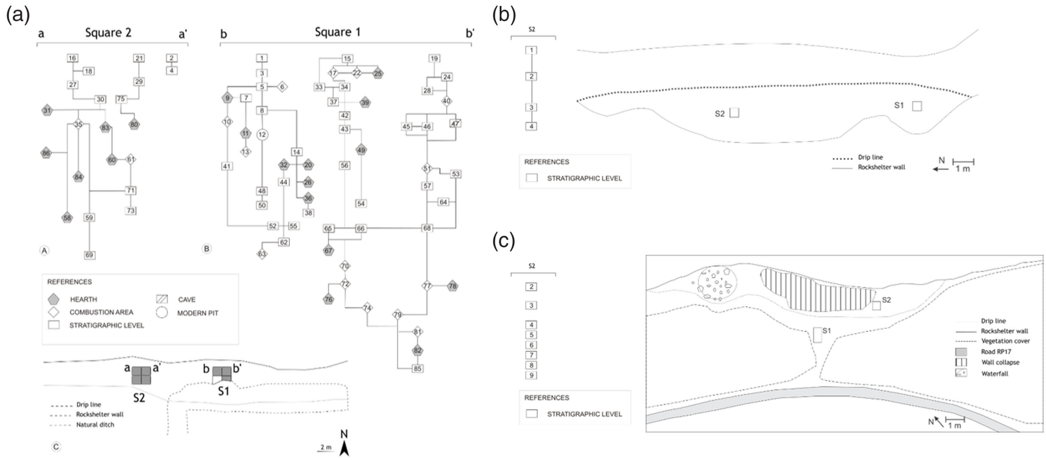

Figure 3 (a) Harris Matrix. Ongamira Natural Park 1- Parque Natural Ongamira 1, Square 1; Harris Matrix. Ongamira Natural Park 1 - Parque Natural Ongamira 1, Square 2; Harris Matrix. (b) Ongamira Natural Park 4 - Parque Natural Ongamira 4; Harris Matrix. (c) Ongamira Natural Park 5 - Parque Natural Ongamira 5. Modified from Robledo (2020).

La Leona

This rockshelter is located approximately 400m southwest of DRR Sector A. In 1990, a survey was carried out recovering archaeological material from a single square.

Camelid and cervid faunal remains were described, as well as quartz flakes and some pottery fragments.

Ongamira Natural Park

Several sites (mainly rockshelters) are combined under this nomenclature. Ongamira Natural Park 1, 4 and 5 are presented here (Figure 3)

Ongamira Natural Park 1—Parque Natural Ongamira 1 (PNO1)

Rockshelter at 1222 m above sea level, placed in the northern sector of the conglomerate outcrop (Saldán Formation). Two sectors of the rockshelter were excavated covering a surface of 10 m^2. In square 1 a depth of 2.20 m was reached, while in square 2 only 0.50 m was excavated. Sedimentary composition and material evidence of past human activities allowed us to distinguish 86 stratigraphic units (Figure 3.a).

Occupation levels characterized by ceramic technology were found at the upper levels of the site and later associated with ^{14}C dates. Square 2 shows this type of material culture at 0.15 m depth (SU35). For this occupation, processing and consumption of camelids, deer and smaller animals were interpreted. In addition, "debitage" from the last stages of the sequence of reduction of lithic instruments was recovered, such as quartz, it being the predominant raw material found, followed by silcrete and chalcedony. Further recorded elements included combustion features, (structured) characterized by charcoal and in situ ash lenses. From these features, high variability of woody taxa was observed. Nevertheless, most species could have been collected nearby.

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The oldest date comes from a 2-m-deep stratigraphic unit (SU82). The dated sample was retrieved from a delimited combustion structure comprising charcoal, thermo-altered camelid bone fragments and lithic quartz flakes (Figure 3.a).

Ongamira Natural Park 4—Parque Natural Ongamira 4 (PNO4)

This is the rockshelter placed in the larger sandstone conglomerate at 1191 m above sea level. It has a north-south orientation. The surface shows heavy erosion resulting from modern trails connecting the rockshelter to other spaces. Archaeological excavations included two sectors of the rockshelter. Four different stratigraphic units were interpreted according to sediment changes (Figure 3.b). In stratigraphic unit SU3 (0.60–0.80 m deep), land-snail shells, small vertebrate bone remains, quartz core, flakes, and charcoal fragments were recovered.

Ongamira Natural Park 5—Parque Natural Ongamira 5 (PNO5)

This site is situated 100 m west from PNO 4 and at 1189 m above sea level, having an NW-SE orientation. It is a large amphitheater-shaped rockshelter similar to DRR. A semi-permanent waterfall at the west side disturbed much of the accumulated sediment. Outside the drip line there is a south-oriented esplanade currently covered by dense vegetation.

Two sectors of the site were excavated: one inside the drip line and the other, outside. Inside the rockshelter, nine stratigraphic units were identified. Occupation levels with variations in archaeological material density overlaps with sterile strata gaps without archaeological material. These last levels are events related to sedimentary processes such as the action of running water (Figure 3).

In the units with the highest concentration of materials (SU3 and SU9), two ^{14}C dates were obtained. The first refers to rockshelter occupations showing the processing and consumption of major fauna such as camelids and cervids, manufacture of quartz instruments and concentration of charcoal in unstructured features.

The SU9, an in-situ combustion structure confined by granite rocks, contained nine different plant taxa (Robledo 2020). Faunal remains such as camelids and bone fragments of small vertebrates, fragments of ñandú (*Rhea pennata*) eggshells and land-snail shells were also inside the combustion feature.

Dos Lunas 2 (DL2)

DL2 is in a 2.5-m-high profile inside a creek with running water, at a height of 1192 m above sea level and in the northernmost part of the geological formation of conglomerates. In the profile, an archaeological material accumulation was observed, characterized by fragments of charcoal, dispersed ash, bone fragments and broken land-snail shells. A date on a complete juvenile camelid shaft was obtained from that sample. The bone was part of an assemblage showing *Lama* sp. specimens with cut marks and evidence of thermo-alteration. Lithic quartz material was also recovered, including cores, tools and *debitage*.

La Gruta Locality

At a height of 1188 m above sea level and close to the Ongamira river stream, we can find La Gruta. Menghin and González (1954) previously surveyed the place. It comprises a large central amphitheater-shaped rockshelter and other smaller eaves. These rockshelters do not show sediments as they are heavily eroded by tourism-related activities. Therefore, places still having pre-Hispanic human occupation remnants were searched for. Two shelters locally known as *Las cuevas del Indio* and *La Cocina de los Indios* were named as the archaeological sites La Gruta 2 and 3.

La Gruta 2 (LG2) corresponds to a remnant of a stratified profile in the easternmost part of the big amphitheater that shapes the south side of the Saldán geological formation. The recovered archaeological material is characterized by the presence of quartz flakes, unidentifiable charcoal fragments, land-snail shell fragments (*Plagiodontes* sp.) and micro-vertebrates bone remains. One of the dates was obtained from a charcoal sample recovered.

La Gruta 3 (LG3) is also a remnant of the original stratification. It is located outside the drip line and showed remains of charcoal, fragments of camelid bones and quartz flakes. Radiocarbon dating was carried out from a guanaco molar (*Lama guanicoe*).

MATERIALS AND METHODS

Archaeological work involves adopting a series of decisions that will determine the methodological approach to be implemented, both in the field and in cabinet. For this reason, we defined standard parameters that would allow comparing archaeological interventions in different archaeological sites in the valley. Hence, we planned, from the outset, a standardized registry that would allow not only recovering as many elements of the material culture as possible, but also providing data that would serve as input to interpret the various human occupations at the valley (Cattáneo and Izeta 2016).

During fieldwork planning, we used different resources for the registry of excavations. First, we kept a general record of daily activities, written on paper and in other formats. These were field diaries, where fieldwork directors made general annotations on researchers' work, weather, advance in excavation, general ideas of the material culture recovered, general procedures, among others. (Izeta et al. 2017b). Second, we recorded Stratigraphic Units using similar record sheets as used by the MoLAS (Museum of London Archaeological Service) (Brigham et al. 1994). This worksheet is used in research projects in several regions of Argentina (e.g., including Ambato Project in Catamarca, Ongamira Project in Córdoba and Tebenquiche Project in Catamarca).

We based the registry of stratigraphic units on a description and interpretation model of the deposition sequences of the stratigraphy of archaeological sites. This mode of describing the stratigraphic sequence is the so-called "Harris Matrix" (Harris 1989), a method based on a systematic and objective description of archaeological stratigraphy. Here we attempted to define stratigraphic units, facies, interfaces and features. This description was then plotted using diagrams that showed the relationships between the various components (Figures 2 and 3). As a result, we developed a sequence that considers superposition, interventions and a temporal succession of the series studied. This is a first relative chronological model based on sequence diagrams devised from the definition of the stratigraphy (Dye and Buck 2015). All data were collected during fieldwork seasons starting in April 2010. During excavations, a Total Station was used to register the tridimensional positions of archaeological objects. In addition, natural and cultural features were recorded using this instrument. Fire hearths, post-holes and bioturbation areas were then added to the Harris Matrix of each site.

To develop the dating program for the Ongamira valley, we considered the provenance of the samples and the possibility offered by each for the construction of an occupation sequence in the area. Therefore, the systematic excavation of several sites aimed at completing the local chronological sequence. DRR Sector B was established in the sequence, the one to be completed, since the stratigraphic units corresponding to the end of the Late Holocene had been removed in previous excavations. The most modern date for the site held a value of 1915 ± 45 BP (MTC-15148) without association with ceramic technology (Cattáneo et al. 2013). Accordingly, similar sites were identified, such as PNO1, PNO4 and PNO5, with hunter-gatherer occupations and inside rockshelters. The samples from La Gruta 2 and 3 can be included here since the conditions in which the sites were found are similar, although excavations were limited to the sampling of profiles. Dos Lunas 2 also corresponds to a sampling in a profile; yet, unlike the others, it was not found in a rockshelter but in an open-air area (Robledo 2020).

As mentioned before, samples currently housed in museums were also used. One comes from the DRR Sector A human remains (n = 3) stored in the Heritage Reserve of the Museum of Anthropology (Universidad Nacional de Córdoba). A second sample of charcoal from Alero La Leona was retrieved from the collections of the Deodoro Roca Museum in Ongamira.

Samples with MTC and YU numbers were chemically pretreated at the University of Tokyo. Human and animal bone and dentine samples were treated with an improved of acid-alkali method and collagen extraction based on Longin's method (Longin 1971; Yoneda et al. 2002). Organic chemical contaminants were removed with sodium hydroxide and bone inorganic component was dissolved with hydrochloric acid. From the remaining bone organic components, bone gelatine collagen was taken. Condition of bone collagen preservation was estimated with carbon and nitrogen atomic ratio (C/N ratio). The range of 2.9–3.6 indicates good preservation (De Niro 1985). Charcoal samples were treated with acid-alkali-acid method using hydrochloric acid and sodium hydroxide solutions to remove inorganic carbonate and fulvic and humic acids from the organic content of soils.

Lastly, samples under AA number were pretreated as stated in Jull et al. (2006).

All the samples were measured using accelerator mass spectrometry (AMS) in three different laboratories: NSF-Arizona AMS Facility (AA), Research Center for Nuclear Science and Technology, The University of Tokyo (MTC), and AMS Center for Kaminoyama Research Institute, Yamagata University (YU).

The $\delta^{13}C$ values of bone samples were measured with an elemental analyser coupled to an isotope ratio mass spectrometer (EA-IRMS) in two different laboratories: the National Museum of Nature and Science, Tsukuba, Japan for MTC numbers, and the Laboratory of Radiocarbon Dating, the University Museum, the University of Tokyo for YU numbers. The $\delta\ ^{13}C$ values for charcoal samples were measured with AMS at each of the facilities mentioned above.

In the last 10 years, 27 ^{14}C dates were added to the local database (Table 1). Four were measured in AA and other two in MTC (Cattáneo et al. 2013); 23 were measured in YU from which 7 were reported by Izeta et al. (2016).

The ^{14}C date under GrN-5414 code was published by Vogel and Lerman (1969). Sample was chemically pretreated "before combustion, in the usual manner with dilute acid, alkali and

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acid, respectively" (Vogel and Lerman 1969: 351). These data were obtained by beta radiation measurements and the sample reported 6510 ± 100 BP (GrN-5414). A measurement method obtained differently from our new data.

This allows us to have 27 modern AMS dates. As mentioned before the date obtained at the end of the 1960s for DRR Sector A can be included here (Vogel and Lerman 1969; Cattáneo et al. 2013). We understand that contamination attributed to the chemical processing standards at that time could affect this last sample. In addition, the archaeologist selection process of the sample can offer an averaged date and therefore with relative utility for its use in the local chronological sequence. Nevertheless, as the 1960s date remains as the oldest date for the valley, we decided to use it here. In sum, 28 dates are available, 21 come from charred plant remains, 4 come from human remains, and 3 come from faunal remains (camelids). This strategy allows comparing the dates obtained through different types of samples.

To select the charcoal samples, we considered them as related to woody plant structures with a brief development period (short-lived). Where possible, their taxonomic determination was made (Robledo 2020). The samples collected from human remains correspond to both long bones and teeth (molars). For faunal remains, this last strategy (long bones and teeth) was also used.

All dates were calibrated considering the SHCal 20 Curve (Hogg et al. 2020) using the program OxCal version 4.4.2 (Bronk Ramsey 2017). Following Aranda Jiménez et al. (2020), in all cases when error was fewer than 25 years, endpoints were rounded to 5 years (18 cases). On the other hand, when error was equal to or larger than 25 years, endpoints were rounded to 10 years (10 cases). An adaptation of the scripts described by Higham et al. (2014) and Manning and Hart (2019) was used to process the ^{14}C dates in Figure 4.

PROVENANCE OF THE ^{14}C DATES

As stated earlier, to build an absolute chronology of the Ongamira valley, samples from the Deodoro Roca Rockshelter Sector B were used. In 2011, six samples were selected (one corresponding to a camelid metapodial and the other five belonging to charcoal remains) from the 2010 stratigraphic excavation and the northern profile of the XB grid left by Menghin and González in 1950 (Figure 2). The latter was considered to correspond to small charred branches to avoid the "old wood" effect (e.g., Schiffer 1986) and attempt to achieve a "secure archaeological context" (Boaretto 2009; Marconetto et al. 2014).

The selected samples come from undisturbed archaeological contexts. This was important in the upper section of the site as it featured many mammalian caves with fossorial habits. For example, in one of the caves, the skull and bones of the appendicular skeleton of a skunk (*Conepatus chinga*) were retrieved. Because of this, all micro faunal remains were taphonomically analysed to understand the process of site formation (Mignino et al. 2018). Considering this, a sample of this upper part was selected from an undisturbed sector, showing a large amount of archaeological material in situ, particularly a quartz straight base triangular projectile point. This sample comes from the stratigraphic unit SU32 located in the square XVIII-B (Figure 2). The result yielded a date of 1915 ± 45 BP (MTC15148, camelid metapodial).

A second dating was performed on a sample from a combustion structure having a large amount of charred remains of small branches. The sample corresponds to a branch

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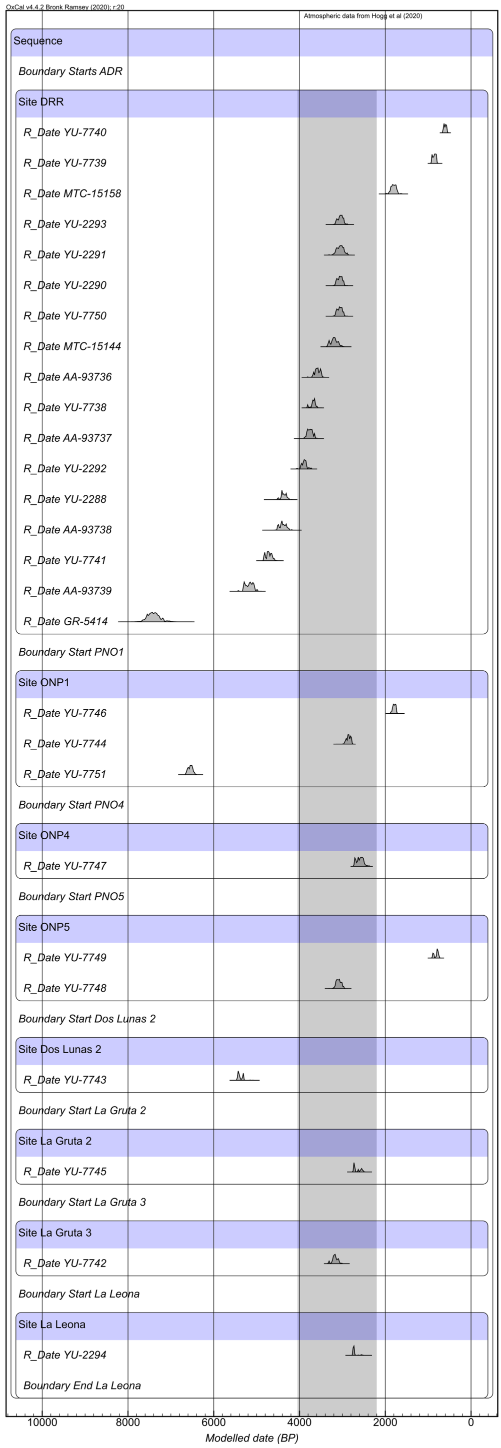

Figure 4 Probability distribution plot of unmodeled calibrated dates of all Ongamira samples, listed according to ^{14}C age. Gray strips show the presence of land-snail shells related to structured hearths or combustion areas.

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fragment of an indeterminate taxon (Cattáneo et al. 2013) and was retrieved from stratigraphic unit SU65 from the square XIV-C, a combustion structure made up of many twigs with a diameter of less than 0.5 cm. The result yielded a date of 3043 ± 41 BP (MTC15144, charcoal).

Another set of four ^{14}C dates (NSF-Arizona AMS Laboratory) was obtained from the northern profile of the X-B square, being exposed by emptying the back dirt fill left after the 1950 excavation. As stated above this profile was expanded by about 0.70 m depth to reach its base-rock and thus have the most complete possible sequence (Figure 3).

Accordingly, four charcoal samples with the same characteristics as those of the squares described above were selected. Starting from the base rock, a reddish component called SU75 could be identified. It is 0.60 m deep and contains the SU74, a bucket-shaped unit in which a large amount of charcoal and bone remains was found. Both stratigraphic units show similar sedimentological characteristics. A date of 4562 ± 39 BP (AA93739, charcoal) was obtained in this unit.

At about 0.20 m above SU74, a difference can be seen in the tonality and structure of the sediments. Although the matrix is similar, its colour is no longer reddish and turns grayish red. This forms a package of 0.40 m thick in average. The charcoal sample was retrieved from the base of this stratigraphic unit (SU80). A result yields a date of 3984 ± 38 BP (AA93738, charcoal).

At 0.40 m above the previous stratigraphic unit, another one begins. It is formed by a large amount of archaeological material (bone, lithic, land-snail shell, etc.) included in a gray matrix with charcoal and ash lenses. Charcoal samples were extracted from two concentrations: one at the base of this sedimentary package and another at the top. The one at the top coincides with the collapse of the eave wall, thus this event is sealing the occupations of this part of the sector. This stratigraphic unit was named SU82 (Figure 2). A date of 3515 ± 37 BP (AA93737, charcoal) was acquired/determined/established from the SU82 base. On the SU82 top, a date of 3390 ± 37 BP was obtained (AA93736, charcoal).

In 2014, new ^{14}C dates from Alero Deodoro Roca Sector B were carried out at the Yamagata University (Japan). Previous dates had allowed observing a chronological sequence from which a persistent occupation of space was interpreted. The stratigraphic units were grouped into various components, which have allowed us to understand the site formation processes in which natural and cultural post-depositional processes occur. However, these have not disturbed the integrity of the stratigraphy, developed following a logical temporal sequence. This, in the words of Harris (1979) allows us to assume that the sector would comply with the law of superposition where,

> "in a series of layers and interfacial features, as created, the upper units of stratification are younger and the lower are older, for each must have been deposited on, or created by the removal of, a pre-existing mass of archaeological stratification" (Harris 1979: 112).

The new ^{14}C dates presented here complement the previous ones, providing statistical support to some areas in which analyses were being carried out at a finer grain (e.g., Izeta et al. 2014; Yanes et al. 2014; Costa 2015; Caminoa 2016; Robledo 2016). For instance, samples were taken from units related to the SU65 date (MTC-15144, 3043 ± 41 BP, charcoal), particularly the SU7 (Figure 2). Therefore, in this case, the selected stratigraphic units correspond to SU7, SU34, and SU50.

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Two other dates were connected to assemblages from greater depths. One was retrieved immediately below the component linked to SU7 (this is SU43). The other was related to an area where Zárate (2016) defined, following geological attributes, a change between units 1 and 2 (SU82 base). A charcoal fragment was selected from stratigraphic units that we estimated to be contemporary with the date MTC15144, showing the same characteristics of the samples analysed previously (fine branch, small size, with structural integrity, etc.) for units SU7, SU34 and SU50.

Stratigraphic Unit 7 corresponds to a sediment of black coloration, mainly composed of silts and clays with gravel-size material from the eave walls. In some sectors, there is heavily fragmented land-snail shell, whereas in others we can find many whole snail shells, especially under bone remains, scattered charcoal and small lens-shaped hearths. These lenses were defined as other features: SU8, SU11, SU12, SU34, and SU50. Moreover, as detailed previously, these stratigraphic units show combustion features and land-snail shell concentrations (SU8 and SU11). The ^{14}C date obtained for SU7 was 2944 ± 44 BP (YU-2291, charcoal).

Stratigraphic Unit 34, as seen previously, developed between squares XIII-C and XIV-C. It corresponds to the aggregation of small combustion areas. It also contains bone remains (some burned), whole land-snail shells and many quartz flakes. For this unit, an absolute date of 2952 ± 21 BP (YU-2290, charcoal) was obtained. This stratigraphic unit is contained in the SU7 matrix.

SU50 was defined as a combustion feature containing remains of ash and entire land-snail shells. It was surrounded by part of the rock structure and sparse thermo-altered skeletal remains. It is contained in SU7. This hearth was dated to 2942 ± 25 BP (YU-2293, charcoal).

In square XVI-C, SU 15 was interpreted as a pit containing charcoal and ash, land-snail shell fragments and large mammal bone fragments, long rodent bones and lithic material. It was shown as a discrete unit, easily recognizable from the units surrounding it. For this reason, it was included in the dating program, although we understood that this was a different stratigraphic unit. The ^{14}C dating obtained shows that it is modern: 183 ± 20 BP (YU-2289, charcoal). Hence, we interpreted this trait as belonging to a sub-actual pit developed on a pre-existing stratigraphic unit (6/7). It is now interpreted as a fence post pit made after the 1950s excavation.

Below the previous stratigraphic units, two further dates were obtained. The first corresponds to a small-diameter charcoal fragment. This comes from the stratigraphic unit SU43 that is characterised by a dark brown sediment with many charcoal spicules and ground shell. There is a transitional limit with the SU7, in the SW sector of the square XV-C, where it appears below SU50, a stratigraphic unit composed of gravel, silt and fragments of bedrock. Considerable amounts of bone and stone remains with ash spots are found. An absolute dating was obtained from charcoal for SU43 (3620 ± 27 BP, YU-2292, charcoal).

Stratigraphic Unit 113 is a unit described on square XII-B north profile (after cleaning the landfill from the Menghin and González excavation in 1950). At the same level as SU111, there is an ash lens featuring charcoal and bones dated to 3969 ± 23 BP (YU-2288, charcoal).

In 2018, new samples were processed. In addition to those from ADR (from stratigraphic excavations and historic collections), samples from the sites PNO1, PNO4, PNO5, Dos

Lunas 2, La Gruta 2 and La Gruta 3 were added. The analyses were again made at the Yamagata University (Japan).

Here we selected fragments of human remains recovered by Aníbal Montes in his excavations of ADR Sector A during the 1940s and 1950s. The samples were identified with the ADR inventory numbers 60-60 (YU-7740, 673 ± 20 BP, human remain); ADR 60-98-1 (YU-7739, 995 ± 20 BP, human remain); ADR 60-98-12 (YU-7738, 3457 ± 20 BP, human remain). The first case corresponds to a premolar; the second, to a juvenile femur diaphysis; and the third, to a molar. In two cases, dates correspond to the last millennium, not represented in the site stratigraphy (Table 1). A third case is contemporary with already excavated areas of Sector B, which allows us to interpret the simultaneous use of the two sectors of the rockshelter. A fourth date was delivered from remains of the malar of a juvenile individual recovered during archaeological excavations in stratigraphy (YU-7741, 4216 ± 21 BP, human remain).

A date from Alero La Leona was obtained. As explained above, this rockshelter is located around 400 m southwest of ADR Sector A. In the 1990s, a survey was carried out recovering archaeological material from a single square. A sample of the deepest sector of the survey was part of the material culture of the valley kept at the local museum (Deodoro Roca Museum). Although this eave has not yet been intervened by us, using a dated sample enables getting closer to the temporality of the occupation of this space. The result yielded a value of 2628 ± 21 BP (YU-2294, charcoal).

The PNO1 site presents three ^{14}C dates. The first corresponds to square 2, sector NW, Stratigraphic Unit 35 considered as a sedimentary matrix of dark colouration composed of thermo-altered bone remains in different degrees of fragmentation, dispersed charcoal fragments, lithic material and ceramic fragments. This unit has a ^{14}C dating of 1905 ± 20 BP (YU-7746, charcoal).

The second also corresponds to the NW sector of square 2 in SU59, a unit showing a redder layer of thermo-altered hearth with scattered carbon spicules. It is dated 2802 ± 20 BP (YU-7744, charcoal).

The third date comes from Stratigraphic Unit 82 (square 1). It was defined as a delimited combustion sector with an in situ structure, associated bone remains and granite rocks with evidence of thermo-alteration. The result obtained was 5782 ± 24 BP (YU-7751, charcoal).

PNO4 has a date (YU-7747, 2538 ± 20 BP, charcoal) from stratigraphic unit SU3. This is characterised by black sediment, merged with small clasts, land-snail shells, quartz flakes and charcoal fragments.

PNO5 has two ^{14}C dates. The first comes from Stratigraphic Unit 3 of square 2. It presents a brown consolidated sediment with carbonates. Scattered archaeological material like charcoal, bone remains and land-snail shells was recovered. Regarding lithic material, various flakes and quartz cores were found. ^{14}C dating was obtained from a charcoal sample of *Zanthoxylum* sp. (Coco) at this level of 942 ± 20 BP (YU-7749, charcoal).

The second date comes from SU9. This unit shows charcoal, ash and thermo-altered soil. It corresponds to a combustion structure with associated stones. Land-snail shells, thermally altered bone remains and lithic material were recovered. A ^{14}C dating of 2971 ± 21 BP (YU-7748, charcoal) was obtained from a sample of *Celtis* sp. (Tala).

Dos Lunas 2 is the only open-air site dated so far. A complete juvenile first phalange diaphysis of Camelid dated 4654 ± 22 BP (YU-7743, charcoal) was recovered from a profile from the side of a gully.

La Gruta 2 it is characterized by a grayish sector with cultural content like quartz flakes, faunal remains, land-snail shells and charcoal fragments. ^{14}C dating was performed on a sample of charcoal from *Porliera* sp (Guayacán) (YU-7745, 2592 ± 20 BP, charcoal).

La Gruta 3, like La Gruta 2, was sampled from the remains recognised in a natural profile. The presence of faunal remains allowed dating a camelid tooth (premolar inserted in malar bone). The result yielded a date of 3029 ± 20 BP (YU-7742, charcoal).

DISCUSSION AND FINAL REMARKS

As seen, the series of dates for the archaeological sites occupy the last section of the Middle Holocene and the entire Late Holocene. The sequence is proper, and the relationship is sequential since there are no inversions in the stratigraphy. Although the latter applies to the DRR site (Cattáneo et al. 2013), it can also be interpreted for the regional occupation in the valley (Figure 4). This means that for the first time a series of ^{14}C dates allows building a chronology of the human occupations in the Ongamira valley.

Note that the characteristics of the cultural content of occupations allow more frequent dating contexts of the early-late Holocene, a period where archaeological contexts contains large assemblages of land-snail shell remains (Yanes et al. 2014; Izeta et al. 2017a). The presence of *Plagiodontes* shells coincides with an environmental change that turned from arid to a more humid condition. Indeed, for DRR Sector B, seven of the stratigraphic units dated between 3620 and 2942 years BP contained land-snail *Plagiodontes* shell remains. This gives support to the idea of contemporaneity for the stratigraphic units of DRR Sector B related to SU7 (Figure 2). Therefore, ^{14}C dates can confirm their penecontemporaneity, which we already proposed for SU7, and other stratigraphic units based on material culture specifics (e.g., Izeta et al. 2014; Costa 2015; Caminoa 2016; Robledo 2016). A similar situation can be seen for PNO 1 and PNO 5, where larger concentrations of land snails have been described in relation to the dates of 2802 ± 20 BP (YU-7744, charcoal) for the former and 2971 ± 21 BP (YU-7748, charcoal) for the latter (Robledo 2020).

This shows land-snail *Plagiodontes* as a marker for occupations from the beginning of the Late Holocene. In effect, this same evidence is found in six of the seven sites dated, allowing us to propose the contemporaneity of occupations throughout the Valley. This is somewhat expected since it confirms the mobility of human groups within the valley. Other methods have allowed observing that the mobility and circulation of people and objects affected spaces located beyond the limits of the Ongamira valley. Therefore, those circuits extend to other spaces and ecoregions (Cattáneo et al. 2020; Robledo 2020).

Regarding land-snail *Plagiodontes*, its presence in the archaeological record decreases towards the end of the Late Holocene and only appears in one site dated ca. 900 years BP.

On the other hand, combustion features and structured hearths having similar material culture assemblages also allowed us to interpret different stages in the rockshelter occupations. Indeed, some temporal differences were noticed between adjacent units with similar material culture, such as SU7 and other associated DRR Sector B stratigraphic units whose dates are between 2900 and 3000 years BP with SU43 that yielded older dates.

Other indicators of material culture also allow observing changes in technologies, although other aspects of the archaeological record do not seem to show significant changes. This is the case of ceramic technology. In excavated sites, ceramics is frequently found in the most superficial parts. However, the stratigraphically excavated contexts associated with the first occurrence of this technology are scarce for the central Argentina region. This is an issue not yet addressed; however, we obtained for PNO1 a date of 1905 ± 20 ^{14}C years BP (YU-7746, charcoal) in which at least 40 ceramic fragments were recovered. Those were classified into six diverse types based on their technical, morphological and functional characteristics, including surface treatment and decoration, manufacture and, where possible, evidence of use (Robledo 2020). This date is of interest and allows associating it with the earlier evidence of this technology in the region (Rocchietti et al. 2013). Here, Ongamira valley can be included as a part of a broader process that took place in neighbouring regions, as suggested by Marsh (2017).

The method of stratigraphic excavations considered differences in terms of their geological formation and the natural events inherent in process of site formation (see Cattáneo et al. 2013; Cattáneo and Izeta 2016; Zárate 2016; Robledo et al. 2017; Robledo 2020). In addition, the cultural factors of this process were viewed as enabling the identification of specific events in the stratigraphy. The temporal control of these units by the series of dates has made it possible to observe and interpret the spatial and temporal relationship between these stratigraphic units and their content in terms of material culture. This will allow advancing in the discussion of some classic topics in the archaeology of central Argentina, like the association of one of the most recent DRR dates (MTC 15158) projectile point designs that were traditionally included in middle Holocene occupations (e.g., Menghin and González 1954; Pastor et al. 2012).

In short, this dating program for the Ongamira Valley allows observing a high integrity of the sites and their persistent occupation throughout much of the Middle and Late Holocene. Finally, and in a regional context, the series of Ongamira dates contribute to the development of a time frame for interpreting occupation in the geography of central Argentina.

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